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This training manual contains the lesson plans and outlines the course of study that the Agricultural Officers, who are members of the On-Farm Water Management Development Project in Pakistan, complete before being assigned to a field team. Although the title Agricultural Officer is used in Pakistan, a more descriptive title is Water Management Extension Specialist. The major objectives of the course are to: (1) develop confidence in the participant's ability to communicate and work with farmers; (2) provide him with the skills necessary to convince the farmers to undertake a watercourse improvement or cleaning and maintenance program and how to supervise these activities; and (3) equip him with the knowledge and skills so he can show farmers how to use their irrigation water more effectively to increase crop production.

This interdisciplinary training program encompasses seven professional areas: Irrigation and Drainage; Agricultural Extension; Agronomy; Soil Science; Farm Power and Machinery; Farm Management; and Rural Sociology. The lesson plans are developed for an audience that has a B.S. degree. The course is 103 days in length, of which 71 days are spent in the field where the trainee learns by doing.

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TRAINING MANUAL FOR AGRICULTURAL WATER MANAGEMENT SPECIALISTS

Edited by
Dwayne G. Westfall

Water Management Research Project
Colorado State University
Fort Collins, Colorado
March, 1980

WATER MANAGEMENT TECHNICAL REPORT NO. 60

TRAINING MANUAL FOR

AGRICULTURAL WATER MANAGEMENT SPECIALISTS

Water Management Technical Report No. 60

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Edited by

Dwayne G. Westfall

Water Management Research Project
Engineering Research Center
Colorado State University
Fort Collins, Colorado

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No.	Title	Author	No. of Pages	Cost
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**2	Organization of Water Management for Agricultural Production in West Pakistan (a Progress Report) ID70-71-1, May 1970	P.O. Foss J.A. Straayer R. Dildine A. Dwyer R. Schmidt	148	$3.00
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No.	Title	Author	No. of Pages	Cost
	Volume IV - Major Constraints Confronting Farmers Explaining the Consequent Low Crop Yields	Max K. Lowdermilk David M. Freeman Alan C. Early	250	
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57	Optimization of Lengths of Alternative Watercourse Improvement Programs	John O. Reuss	49	$3.00
58	Watercourse Improvement Manual	Thomas J. Trout W. Doral Kemper	258	$9.00
59	Field Evaluation of Methods for Measuring Basin Irrigation Performance	Satyansu S. Kundu Gaylord V. Skogerboe	135	$6.00
60	Training Manual for Agricultural Water Management Specialists	Edited by Dwayne G. Westfall		$9.00

ABSTRACT

This training manual contains the lesson plans and outlines the course of study that the Agricultural Officers, who are members of the On-Farm Water Management Development Project in Pakistan, complete before being assigned to a field team. Although the title Agricultural Officer is used in Pakistan, a more descriptive title is Water Management Extension Specialist. The major objectives of the course are to: (1) develop confidence in the participant's ability to communicate and work with farmers; (2) provide him with the skills necessary to convince the farmers to undertake a watercourse improvement or cleaning and maintenance program and how to supervise these activities; and (3) equip him with the knowledge and skills so he can show farmers how to use their irrigation water more effectively to increase crop production.

This interdisciplinary training program encompasses seven professional areas: Irrigation and Drainage; Agricultural Extension; Agronomy; Soil Science; Farm Power and Machinery; Farm Management; and Rural Sociology. The team of trainers that conduct this course must work closely together because coordinated training is a major component of this course. The lesson plans are developed to be used with an audience that has a B.S. degree or higher. Depending upon the logistical support, from 15 to 25 students can be handled effectively. The course is 103 days in length, of which 71 days are spent in the field where the trainee learns by doing.

FOREWORD

Based upon results from on-farm water management research activities in Pakistan, the On-Farm Water Management Development Project was implemented in the three provinces of Sind, North West Frontier, and Punjab during 1976 and 1977. The objectives of the project are to: (a) improve earthen watercourses, including some lining; (b) precision land level farmers' fields' and (c) advise farmers on maintaining watercourses, along with improved agronomic and irrigation practices, so as to maximize the benefits of watercourse improvement and land leveling. To accomplish these objectives, field teams were placed at various locations in the three provinces. A field team consists of: a Team Leader; two Watercourse Development Officers (Agricultural Engineers); five Land Development Officers (Agriculturalist); and an Agricultural Officer (Agriculturalist), who could be more descriptively called a Water Management Extension Specialist.

The University of Agriculture, Faisalabad was given the responsibility of training the Water Management Specialists (Agricultural Officers). The Colorado State University Water Management Research Project Field Party, located in Pakistan, provided assistance in developing the training course and materials. This interdisciplinary training program encompasses seven professional areas: Irrigation and Drainage; Agricultural Extension; Agronomy; Soil Science; Farm Power and Machinery; Farm Management; and Rural Sociology.

Many faculty members at both the University of Agriculture, Faisalabad and Colorado State University participated in the development of the course materials reported herein. The course was first given in June-October, 1977 and is continuing at the present time.

Although these training course materials are peculiar to Pakistan, similar courses could be prepared for other countries by compiling "site specific" information needed for such a course. Then, this information would need to be rewritten to suit the needs of a water management extension program, either regionally or nationally.

Gaylord V. Skogerboe
Project Coordinator
Water Management Research Project
Colorado State University

TABLE OF CONTENTS FOR AGRICULTURAL OFFICER (WATER MANAGEMENT SPECIALIST) TRAINING COURSE

Code	Subject	Lecture (Hours)	Field (Days)	Page
	Examinations	3	-	-
	<u>Rural Sociology Department</u>			
	Organizing of a Watercourse Committee			
OWCC-1	Rural Sociology	-	2	596
OWCC-2	Sociological Determinants of Success of Watercourse Improvement Project	-	2	624
OWCC-3	Research Methods: Choosing a Watercourse and Learning About its Social Organization	1	2	630
OWCC-4	How to Work With Farmers: Lessons From the Surveys Carried Out by Trainees	1	-	643
OWCC-5	Institutional Development: The Concept of Water Users Associations	2	-	645
OWCC-6	Institutional Development: Organizing Watercourse Committees	1	1	625
	Watercourse Cleaning and Maintenance			
WCCM-1	Implementation of a Cleaning and Maintenance of an Improved Watercourse	-	6	327
	Examination	3		
	<u>Agricultural Extension Department</u>			
	Organizing a Watercourse Cleaning and Maintenance Program			
OWCCM-1	Extension Methods	3	-	315
OWCCM-2	Convincing Farmers to Undertake a Cleaning and Maintenance Program and Using the Increased Water Supply	4	1	299
OWCCM-3	Planning and Organizing a Watercourse Committee to Accomplish a Cleaning and Maintenance Program (conducted in cooperation with Irrigation and Drainage Department and Rural Sociology)	-	1	327

TRAINING SCHEDULE FOR AGRICULTURAL OFFICER (WATER MANAGEMENT SPECIALIST) TRAINING COURSE

DAY	LESSON NO.[1/]	TITLE	LECTURE[2/] Periods	FIELD Days	TRAINER
1	WCI-1	Introduction to On-Farm Water Management	5-6	-	Project Leader
2		Evaluation of Knowledge Level of Trainees (Engineering Examination)	1	-	Agricultural Engineer
	OWCC-1	Introduction to Basic Social Science Concepts	2-3	-	Rural Sociologist
		Evaluation of Knowledge Level of Trainees (Sociology Examination)	4-5	-	Rural Sociologist
	WCI-2	Units of Measurement	6-7	-	Agricultural Engineer
3	WCI-3	Flow Measurement Devices	1-2	-	Agricultural Engineer
		Evaluation of Knowledge Level of Trainees (Extension Examination)	3	-	Agricultural Extension
	CWCCM-1	Extension Programs-Methods	4-6	-	Agricultural Extension
	OWCC-2	Sociological Determinants of Success of Watercourse Improvement Projects	8-9	-	Rural Sociologist
4	WCI-4	Cutthroat Flumes and Conveyance Losses	1-4	-	Agricultural Engineer
	OWCCM-2	Convincing Farmers to Undertake a Cleaning and and Maintenance Program and Using the Increased Water Supple	5-6	-	Agricultural Engineer
5		Evaluation of Knowledge Level of Trainees (Agronomy Examination)	1	-	Agronomist
	CPG-1	Crop Production Guidelines for Cotton	2-4	-	Agronomist
	OWCC-3	Research Methods: Choosing a Watercourse and Learning About its Social Organization	5	-	Rural Sociologist
	WCD-6	Watercourse Structures	6-7	-	Agricultural Engineer
6	WCD-2	Use of Levels	1-2	-	Agricultural Engineer
	WCD-1	Watercourse Design Aids	3-5	-	Agricultural Engineer
		Evaluation of Knowledge Level of Trainees (Soil Science Examination)	6	-	Soil Scientist

DAY	LESSON NO. 1/	TITLE	LECTURE 2/ Periods	FIELD Days	TRAINER
	WCD-6	Watercourse Structures	8-9	-	Agricultural Engineer
7-8	OWCC-3	Research Methods: Choosing a Watercourse and Learning About its Social Organization	2	-	Rural Sociologist & Agricultural Engineer
9-10	WCI-4	Cutthroat Flumes and Conveyance Losses	1-4	2	Agricultural Engineer
11	WCI-5	Data Reduction from Flume Measurement and Conveyance Losses	1-4	-	Agricultural Engineer
		Importance of Cleaning and Maintenance	5-6	-	Guest Lecturer
		Evaluation of Knowledge Level of Trainees (Farm Management Examination)	8	-	Agricultural Economist
	FM-1	Introduction to Farm Management	9	-	Agricultural Economist
12	OWCCM-1	Convincing Farmers to Undertake a Cleaning and Maintenance Program	-	1	Agricultural Extension
13	WCI-6	Field Trip to Improved Watercourse at Thikriwala	-	1	Agricultural Engineer
14	WCI-7	Field Trip to Improved Watercourse at Mona	-	1	Agricultural Engineer
15	WCCM-1	The Need for Watercourse Cleaning and Maintenance	1-6	-	Agricultural Engineer
	FM-2	Farm Business Analysis	8-10	-	Agricultural Economist
16-17	WCCM-1	The Need for Watercourse Cleaning and Maintenance	-	2	Agricultural Engineer & Rural Sociologist & Agricultural Extension
18	FM-3	Economic Principles of Farm Management	1-3	-	Agricultural Economist
	WCD-3	Bench Mark Survey	4-6	-	Agricultural Engineer
		Irrigation System of Pakistan	8-9	-	Guest Lecturer
19	FM-4	Supporting Information for Farm Business Analysis	1-2	-	Agricultural Economist
	SS-1	Soil Science Terminology	3	-	Soil Scientist
	CPG-4	Crop Production Guidelines for Sugar Cane	4-5	-	Agronomist
	EIIP-1	Methods of Irrigation	7-9	-	Agricultural Engineer
20	SS-2	Soils of Pakistan	1-2	1	Soil Scientist

DAY	LESSON NO.[1/]	TITLE	LECTURE[2/] Periods	FIELD Days	TRAINER
21	AII-1	Method and Result Demonstration as Related to OFWM	1	-	Agricultural Extension
	AII-2	Conducting a Method and Results Demonstration Related to Agronomic and Irrigation Improvement	2-4	-	Agricultural Extension
	OWCC-4	How To Work With Farmers From the Survey Carried Out by Trainees	5	-	Rural Sociologist
	SS-1	Essential Nutrients Functions and Symptoms	6-7	-	Soil Scientist
22	EIIP-2	Water Management Aspects of Land Leveling	1-2	-	Agricultural Engineer
23-26	EIIP-3	Precision Land Levelling, Data Collection and Computations	3-6	-	Agricultural Engineer
27	CPG-2	Crop Production Guidelines for Rice	1-3	-	Agronomist
	FM-5	Farm Budgeting	4-7	-	Agricultural Economist
28	SS-4	Fertilizer Nutrients in the Soil	1-2	-	Soil Scientist
	AII-3	Packaging Extension Methods to Meet a Single Program Objective and Evaluation of these Objectives	3-4	-	Agricultural Extension
	EIIP-5	Determining Irrigation Requirements and Irrigation Scheduling	5-7	-	Agricultural Engineer
	EIIP-4	Evaluating Level Basin Irrigation Systems	4-6	-	Agricultural Engineer
	CPG-1	Crop Production Guidelines for Cotton	7-9	-	Agronomist
30-31	EIIP-4	Evaluating Level Basin Irrigation Systems	-	2	Agricultural Engineer
32	CPG-12	Field Trip to PARI	-	1	Agronomist & Soil Scientist
33	EIIP-5	Determining Irrigation Requirements and Irrigation Scheduling	-	1	Agricultural Engineer
34		Examination over Agricultural Extension	1-3	-	Agricultural Extension
	CPG-8	Production Guidelines for Orchards	4	-	Agronomist
	SS-5	Making Fertilizer Recommendations	5-6	-	Soil Scientist

DAY	LESSON NO.[1/]	TITLE	LECTURE[2/] Periods	FIELD Days	TRAINER
35-36	FM-6	Economic Analysis of Selected Farms	1-3	2	Agricultural Economist
37	OWCC-5	Institutional Development: The Concept of Water Users Association	1-2	-	Rural Sociologist
	CPG-5	Production Guidelines for Fodder Crops	3-4	-	Agronomist
	SS-6	Salt Affected Soils	5-6	-	Soil Scientist
	OWCC-6	Institutional Development: Organizing a Watercourse Committee	8	-	Rural Sociologist
38	CPG-6	Production Guidelines for Oil Seeds	1	-	Agronomist
	WCCM-2	Implementation of a Cleaning and Maintenance Program	2-4	-	Agricultural Engineer
39	OWCC-6	Institutional Development: Organizing a Watercourse Committee	-	1	Rural Sociologist
40-45	WCCM-2	Implementation of a Cleaning and Maintenance Program	-	6	Agricultural Engineer, Agricultural Extension & Rural Sociologist
46	CPG-13	Field Trip to NIAB	-	1	Agronomist
47	SS-7	Quality of Irrigation Water	1-2	-	Soil Scientist
		Irrigation Systems of Pakistan	3-4	½	Guest Lecturer
48		Irrigation Laws	1-3	-	Guest Lecturer
		Plant Protection Measures	4-6	-	Guest Lecturer
49		Examination over Farm Management	1-3	-	M. Akhtar Bajwa
		Warabundi Schedule	4-5	-	Guest Lecturer
		Plant Protection Measures	6-7	-	Guest Lecturer
50-54	WCD-3	Bench Mark Survey	-	5	Agricultural Engineer
55		Examination over Soil Science	1-3	-	Soil Scientist
	WCD-5	Topographic Survey of a Watercourse Command Area	4-5	-	Agricultural Engineer

DAY	LESSON NO.[1]	TITLE	LECTURE[2] Periods	FIELD Days	TRAINER
	WCD-3	Computation of Bench Mark Survey	6-9	-	Agricultural Engineer
56		Examination over Farm Management	1-2	-	Agricultural Economist
	FPM-1	Machinery for Agriculture and Operational Aspects under Field Conditions	3-6	-	Farm Machinery Engineer
57-64	FPM-1	Machinery for Agriculture and Operational Aspects under Field Conditions	1-3	7½	Farm Machinery
65-67	CPG-9	Implementation of a Rice, Cotton or Wheat Planting and/or Fertilizer Demonstration	-	3	Farm Machinery & Agronomist
68		Examination over Farm Machinery	1-3	-	Farm Machinery Engineer
		Field Problem of OFWMD Project	4-6	-	Coordinator OFWMD Project Faisalabad
69		Field Problems Pointed out by Trainees and Their Solutions (Agr. Ext.)	1-2	-	Agricultural Extension
		Field Problems Pointed out by Trainees and Their Solutions (Rural Sociology)	3-4	-	Rural Sociologist
		Field Problems Pointed out by Trainees and Their Solutions (Farm Management	5	-	Agricultural Economist
		Field Problems Pointed out by Trainees and Their Solutions (Soil Science)	6-7	-	Agronomist
70-75	WCD-4	Profile Survey of Watercourses	1-2	6	Agricultural Engineer
76-77		Data Reduction of Profile Survey and Plotting	1-9	-	Agricultural Engineer
78-91	WCD-5	Topographic Survey of Watercourse Command Area	1-2	14	Agricultural Engineer
92	CPG-10	Field Trip to Cotton Research Institute at Multan	-	1	Agronomist
93	CPG-11	Field Trip to Maize Research Center - Yousafwala	-	1	Agronomist
94-95		Data Reduction of Topographic Survey and Preparation of Design Sheets	1-9	-	Agricultural Engineer

DAY	LESSON NO. 1/	TITLE	LECTURE 2/ Period	FIELD Days	TRAINER
96		Field Trip to improved Watercourse Technology Demonstration Plots	-	1	Agricultural Engineer
97	CPG-14	Field Trip to Rice Research Institute at Kala Shah Kaku	-	1	Agronomist
98		Field Problems pointed out by Trainees and Their Solutions (I&D and Water Management)	1-4	-	Agricultural Engineer
		Field Problems pointed out by Trainees and Their Solutions (Agronomy)	5-6	-	Agronomist
99	WCD-6	Field Trip to On-Farm Water Management Research and Training Institute - Lahore	-	1	Agricultural Engineer
100		Field Trip to On-Farm Water Management Research for Rural Development Stations	-	1	Project Leader
101		Examination over Agronomy and Discussion on Subject	1-3	-	Agronomist
		Examination over Irrigation and Precision Land Leveling	4-6	-	Agricultural Engineer
102		Examination over Water Management, Watercourse Design, Cleaning and Maintenance	1-3	-	Agricultural Engineer
103		Closing ceremony and distribution of certificates to successful trainees.			Program will be announced separately

1/ Abbreviations for lesson plan numbers.

WCI = Watercourse Improvement
WCD = Watercourse Design
EIIP = Evaluation and Improvement of Irrigation Practices
WCCM = Watercourse Cleaning and Maintenance
OWCCM = Organizing a Watercourse Cleaning and Maintenance Program
AII = Agronomic and Irrigation Improvement

CPG = Crop Production Guidelines
SS = Soil Science
FPM = Farm Power and Machinery
FM = Farm Management
OWCC = Organization of a Watercourse Committee

2/ Timing of Periods.

Period	Time
1	0830-0915
2	0915-1000
3	1000-1045
4	1045-1130
5	1130-1215
6	1215-1300
7	1300-1345
8	1345-1430
9	1430-1515

Subject: INTRODUCTION TO ON-FARM WATER MANAGEMENT

Trainer Project Leader
Class Room 2 hours
Field 0 Days

OBJECTIVES

To familiarize the students with the On-Farm Water Management Project.

MATERIALS NEEDED

16mm sound movie projecter with screen.

TRAINING AIDS

16mm movie, "Pakistan: A Land of Promise" produced by Agency for International Development.

INTRODUCTION

Water supplies have been and are deficient in Pakistan for a fully productive agriculture. A flow rate of one cusec to supply the demands of over 300 acres is inadequate for peak daily requirements even when only half the land is in production. The Salinity Control and Reclamation Projects (SCARP) have increased water supplies to the farmer and decreased waterlogging and salinity conditions.

Pakistan faces the dilemma of many countries. There is a shortage of food as evidenced by imports of wheat averaging about one million tons each year, as well as other food materials. While having the world's largest contiguous irrigation system of over 30 million acres, yields per acre are among the lowest (Table 1). Better water management is needed to solve the problems of waterlogging and salinity and to help provide the means whereby critically needed food production can be increased.

Table 1. The average yield of major crops in Pakistan from 1960-1975 compared with 1975 world averages (World Bank, 1976).

Crop	Pakistan 1960-65	Pakistan 1965-70	Pakistan 1970-75	World 1975
	---------- Long T/A	---------------		
Wheat	0.332	0.389	0.482	0.627
Rice	0.370	0.459	0.610	0.972
Maize	0.411	0.431	0.459	1.121
Cereals	0.318	0.376	0.462	1.041
Pulses	0.203	0.188	0.202	0.263
Sugarcane	13.377	15.260	14.428	20.02
Cotton	0.101	0.115	0.135	0.451
Rape/mustard	0.182	0.191	0.213	0.329

PRESENTATION

Background

Development of agriculture in Pakistan depends upon water. An area of 31.7 million acres is irrigated from the Indus River and its four major tributaries which makes the largest continuous irrigation system in the world. The watercourse, which conveys the irrigation water from the canal to the farmer's field, is the last link of this system. The system, with all its uniqueness, has an overall use efficiency of about 30%. About one acre foot of water is available annually for use by the crop, which is far less than the amount required under these climatic conditions to permit a potential cropping intensity of 200%.

In Pakistan's agricultural economy, water is therefore one of the major limiting factors for future development. Because of the shortage of water, no more land can be brought under production and the potential cropping intensity cannot be achieved.

The canal system was built at the turn of the century on a fixed flow rate allocation system. This was necessary because of lack of storage to provide flexibility, its immense size, and because it was designed for simplicity of operation. This system is not sensitive to variations in irrigation needs. Usually, a change in supply is governed by the availability of water and not by agricultural demand.

Water is conveyed from the canal, or distributary, to the field by a conveyancy ditch called a watercourse. There are about 89,000 watercourses in the four provinces of Pakistan, which range in length from 2 to 8 km. These watercourses are poorly constructed and very poorly maintained. Most of the farmers are uneducated and need guidance in the area of water management. In the past, no government or semi-government department had the responsibility to supervise on-farm water management activities.

Recent information has proven that watercourse losses are much higher than previously assumed and are nearly 50%.

Recent work on waterloss measurement began in 1973 by a Colorado State University (CSU) field party at the Mona Reclamation Experimental Project (MREP). They found a significant relationship between discharge and loss rate. The data indicated higher losses with increased initial flow and overall average loss rate was 11.6% per 1000 feet.

Realizing the magnitude of the conveyance losses, various watercourse improvement alternatives were tested by CSU and MREP in 1973-4. To test various brick masonry designs, several branches of the watercourses served by Tubewells 78 and 122 were lined. Later, the loss through leakage on some of the sections was found to be almost nil, while in others it was quite comparable to the earthen improved watercourses. After improvement, measurements were also taken on watercourse 78 and it was found that lining the Sarkari Khal would not reduce losses automatically unless the farmers' branches are enlarged to handle the increased flow. Moreover, the masonry lining was expensive (Rs. 24 to 50 per ft). Therefore, less expensive alternatives were developed and tested. First, earthen improved channels with permanent control structures were prepared on a contract basis. The cost of improvement was Rs. 10 per foot, which was judged excessive for earthen improvement. In order to cut costs, the question was asked: would the farmers supply the labor for earthen improvement if control structures were provided as an incentive? A branch of watercourse 78 was improved using this program. The farmers were willing to provide the labor and the cost of improvement was Rs. 2 per ft and the water delivery efficiency was increased by 50%. Following this improvement, the program was expanded and organized groups of farmers have improved several watercourses since December 1975 in the MREP area. Several other aspects relevant to watercourse improvement were studied such as compaction of banks, design of watercourse and nakkas and cleaning and maintenance.

Cleaning and maintenance is an integral part of earthen improvement. A study of the effect of cleaning conducted on 16 unimproved and 4 improved watercourses revealed decrease in loss rate by 8.53% per 1000 ft and 1.75% per 1000 ft, respectively, for unimproved and improved watercourses. On the average, farmers cleaned and maintained 6 ft/hr of channel at an approximate cost of Rs. 0.17/ft.

A pilot water management program which is the fore runner of a bigger project, has been launched by the Government of Pakistan with the help of USAID on a nationwide basis. The program includes realignment of watercourse channels, reconstruction of cross section and banks, lined junctions, brick and concrete check and turnout structures, up to 10% brick lining, precision land leveling and training and education of farmers in better irrigation and crop management practices. No survey or feasibility report was prepared. This pilot project provides the basis for information on feasibility for a possible follow-up program. Under this program, provision has been made for reconstruction of about 2% of Pakistan's watercourses. The goals of the pilot project are shown in Table 2.

Watercourse System

Typically, a watercourse receives water from a distributary through a "mogha", a structure which allows passage of water from the canal to the

Table 2. Yearly physical targets for the comprehensive improvement program of the On-Farm Water Management Development Pilot Project from 1976 to 1982 (Information taken from the On-Farm Water Management Development Pilot Project PC-1).

Quantity	'76-7	'77-8	'78-9	'79-80	'80-1	'81-2	Total
Punjab							
No. of men trained[1]	50	100	150	250	350	400	400
No. of wcs to be developed	5	70	120	186	250	270	900
Acres to be leveled	600	9,000	15,600	24,000	28,200	34,800	112,200
NWFP							
No. of men trained[1]	2	34	68	86	94		
Acres to be leveled	375	1,325	2,525	4,925	7,325	8,525	
Improved watercourses	1	8	--	--	--	--	
No. of wcs to be improved	--	5	10	20	30	35	
Sind							
No. of men trained[1]	5	15	25	40	60	--	60
No. of wcs to be improved	12	43	82	142	231		510
Acres to be leveled	1,800	6,450	12,300	21,300	34,650	--	76,500

[1]Accumulative total.

watercourse. There is no regulator and water always flows in every watercourse so long as there is water in the distributary. Each farmer served by the watercourse uses the full flow on turn. The length of the "turn" in terms of time is dependent on his acreage. A common watercourse commands an area 300 to 500 acres depending upon its discharge.

The construction and maintenance of the watercourse is the responsibility of the water users. The farmers themselves were given this charge in the canal and Drainage Act of 1873 which provides the basis for existing legislation. The remainder of the system is under the direct supervision of the Irrigation Department.

Watercourse Problems

Watercourse construction and maintenance have received essentially no technical considerations. Alignment, cross section, and gradient were accomplished without knowledge of hydraulic design. This has resulted in varying velocity leading to silting and overtopping of banks, and ultimately resulting in considerable delivery losses.

Poor and hap-hazard maintenance and inadequate cleaning leads to the vegetative growth, undue breaches, rodent holes and pits developed from borrowing of soil from adjoining fields at junctions which result in considerable amount of water losses in the watercourses.

In order to move the water to all fields, the watercourse system has become very complicated with many bifurcations. There are no control structures, i.e., checks and turnouts between the watercourse and the farmers fields. Farmers cut the banks when it is their turn to irrigate. This results in wastage of land in the adjoining fields along with the loss of water.

Irrigation Application Problems (Need for Precision Land Leveling)

Measurement of water is nonexistant and there is a tendency to over-irrigate. The farmer's fields are uneven. The lack of precision land levelling and the present field irrigation application method involves excessive field irrigation ditches and bunded units resulting in wastage of land and water. Uneven fields result in poor seed germination, fertilizer leaching, salt accumulation on high spots and flooding on low spots, which leads to decreased crop yields. The present bunded unit system with excessive field irrigation ditches also creates hinderance in the operation of agricultural machinery.

Magnitude of Water Losses

As shown in Figure 1, irrigation system in Pakistan operates at less than 50% overall efficiency. For each 92 MAF of river water diverted to canals plus 30 MAF pumped from the ground water aquifer, at the most, 42 MAF is effectively stored in the root zone for crop use. Most of the water losses occur in the watercourse below the "mogha" (outlet) as delivery losses and field irrigation application losses. Table 3 indicates the overall irrigation efficiency of watercourses in various districts in the Indus Basin Irrigation System as determined by the CSU Field Party.

On-Farm Water Management Development Project

The Water Management Development Project has been established with the aim at developing and implementing of an effective On-Farm Water Management Program to achieve the following objectives:

a) To bring about a significant increase in water use efficiency through:

   i) Improvement and renovation of watercourses.

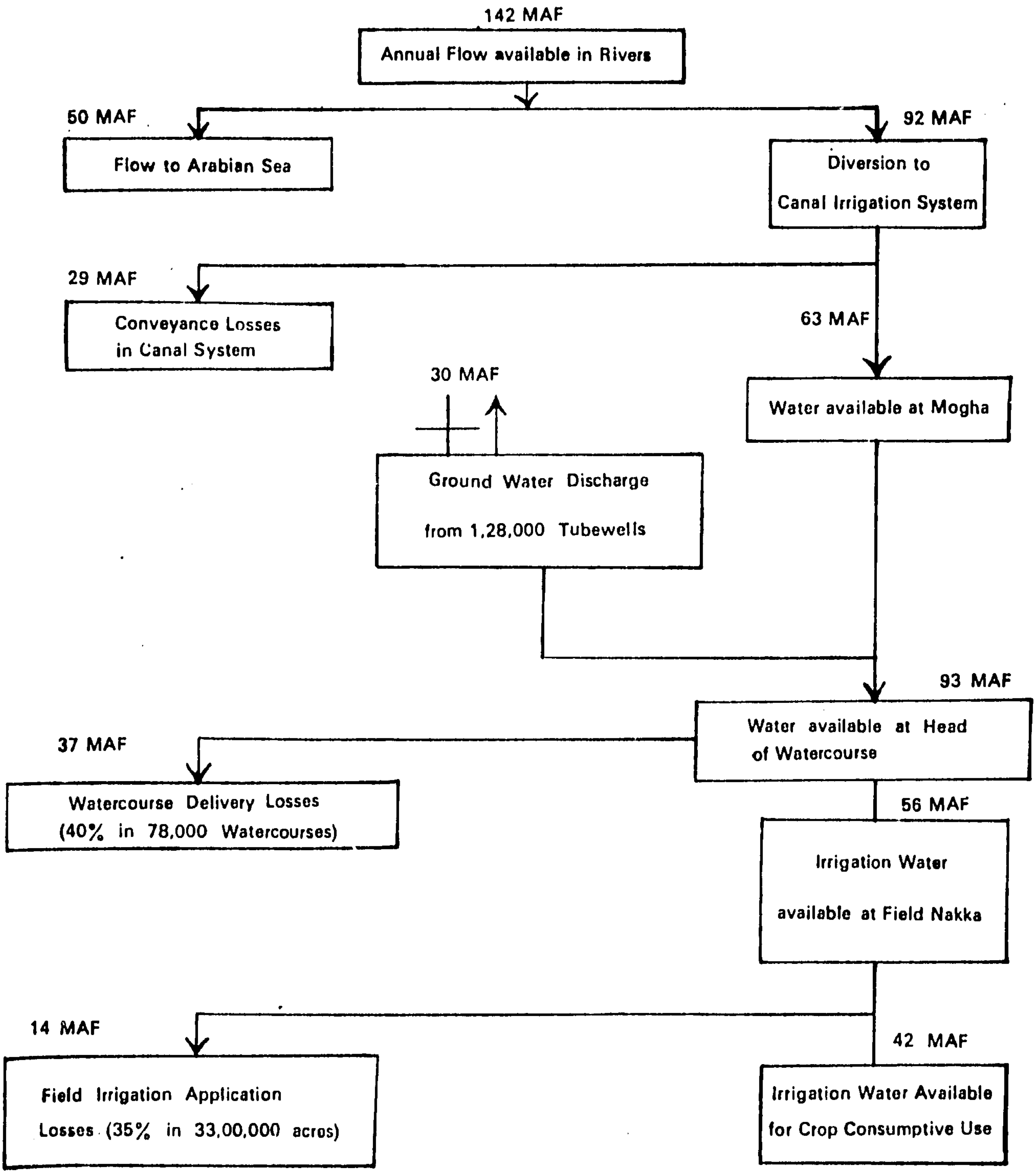


Figure 1. Flow Chart of Indus Basin Water Supply System

Table 3. Overall irrigation efficiency by watercourses and districts in Pakistan.

Location (Month of Evaluation)	Mean Delivery Efficiency%	Mean Application Efficiency%	Percentage Overall Efficiency
Lyallpur (May)	68	76	52
Multan (June)	58	96	58
Lahore (June-July)	62	97	60
Gujranwala (Sept.-Oct.)	58	51	30
Sargodha (July-August)	52	41	21
Muzaffargarh (January)	67	93	62
Bahawalpur (January)	66	96	63
Sukkur (Feb.-June)	67	97	65
Dadu (February)	60	79	47
Thar Parker (February)	56	87	49
Thatta (March)	30	58	17

ii) Precise levelling and improvement of land in and round watercourses.

iii) Training and education of the farmers regarding efficient use of irrigation water and other cultural practices.

iv) Applied research will be conducted on different aspects to develop a data base and research parameters for subsequent planning and field operations.

b) Development of an institutional network at the Provincial, Area and Field levels for carrying out a large scale long-term program. Under this Project, physical improvement, manpower training and infrastructure building and or additional works will be taken up simultaneously. The net effect of this program will appear in the form of increased agricultural production.

c) To establish training programs which include formal training at Provincial Headquarters and on-the-job training in the field. Training will be imparted to the Agricultural Officers (Extension) in water management techniques at the Agricultural University, Faisalabad.

Organization Setup

The organization setup indicating the working pattern with respect to the Punjab On-Farm Water Management Development Project is depicted in Figure 2.

The Directorate of On-Farm Water Management is under the administrative control of the Secretary to Government of the Punjab, Agriculture Department through the Director General Agriculture (Field) Punjab. The Director, On-Farm Water Management Development Project is to be assisted by a Technical Officer, Assistant Director (Technical), Administrative Officer, Assistant Accounts Officer and an Agricultural Officer in his office.

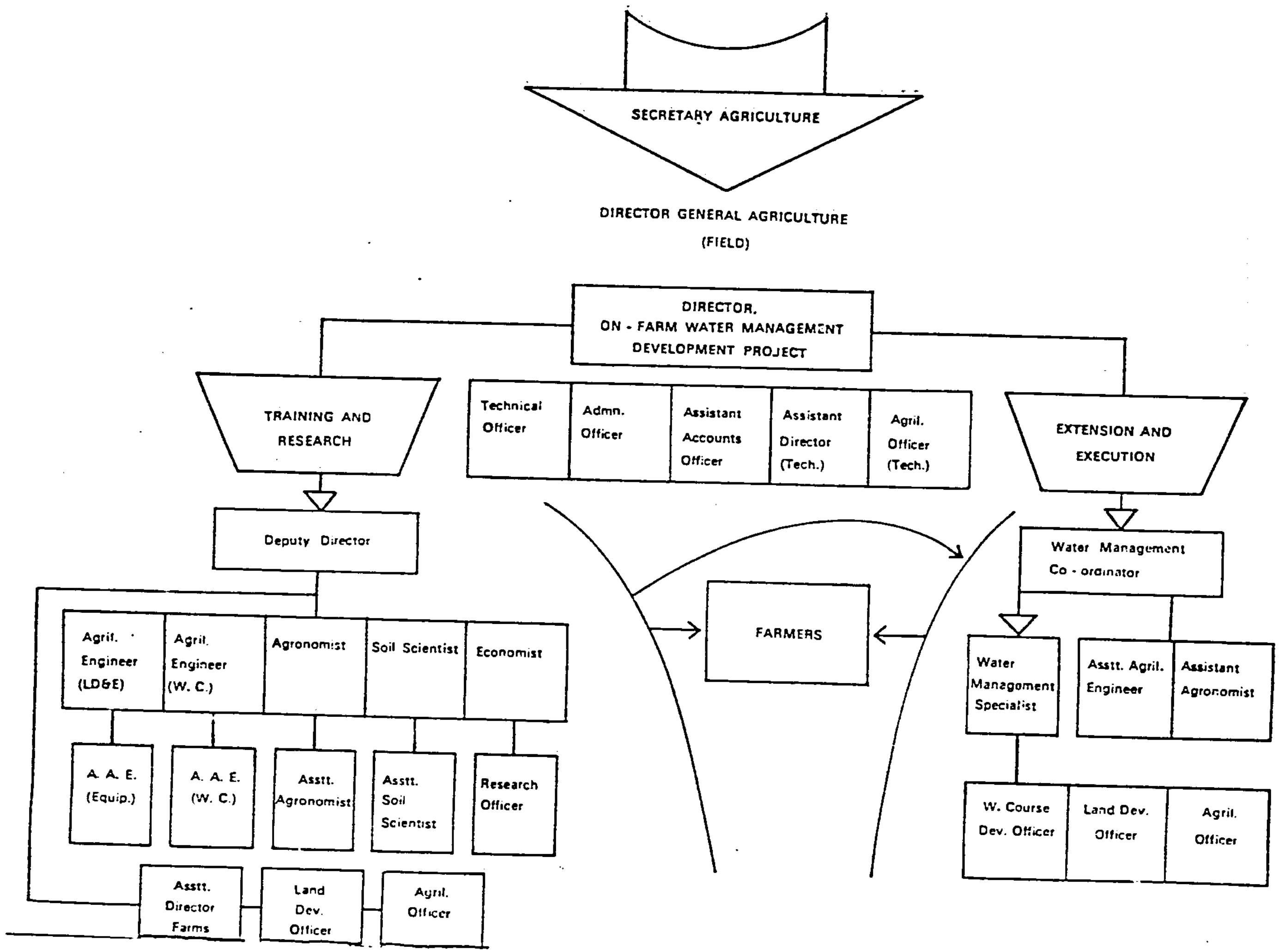


Figure 2. Organizational Chart - On-Farm Water Management Development Project

The Water Management Directorate has two broad spheres of activities in the Province:

a. Execution and Extension.

b. Training and Research.

Each execution and extension division is headed by a Water Management Coordinator (Area Team Leader), who is assisted by an Assistant Agricultural Engineer and an Assistant Agronomist in his office. Each division is comprised of ten sub-divisions with a Water Management Specialist as its Incharge (Field Team Leader). Each Field Team has two Watercourse Development Officers, 5 Land Development Officers and one Agricultural Officer.

To supply the field teams with properly trained technical staff, a Training and Research Institute has been established at the Provincial Headquarters. The Institute is headed by a Deputy Director (Training and Research), who is assisted by a Provincial Training Staff in various disciplines, namely:

a) Agricultural Engineer (Land Development and Equipment)

b) Agricultural Engineer (Watercourses)

c) Agronomist

d) Soil Scientist

e) Economist

Each of the above Officers will be assisted with a Junior Officer. The Training and Research Farm will be supervised by the Assistance Director Farms with the help of an Agricultural Officer and Land Development Officers.

APPLICATION

The movie, "Pakistan: A Land of Promise" will be shown and a discussion will follow. Field trips to improved watercourses are to be scheduled within the next few days.

QUESTIONS

1. What is the average percent water loss in most watercourses?

2. How can this loss be decreased?

3. Explain the function of the Agricultural Officer in the On-Farm Water Management Project.

Subject: UNITS OF WATER MEASUREMENT

Trainer Irrigation Engineer
Class Room 2 hours
Field 0 Days

OBJECTIVES

- Introduction of various systems used in measurement.
- Definitions of various measurement terms.
- Terminology commonly used in water measurement.
- Conversion of units from one measurement system to another.

MATERIALS NEEDED

Empty cans of 4 litre and/or one gallon capacity and a box measuring 1 foot on each side.

INTRODUCTION

Water measurement is the most important method to evaluate and quantify water management practices. Water measurement allows a determination of flow into a watercourse, losses from a watercourse, depth of water applied to a field, irrigation requirements and application efficiencies. Water measurements are made in terms of units. Two systems of units are presently in use in Pakistan: the old foot-pound-second system and the newly adapted International System (S.I.) or metric (meter-kilogram-second) system. This lesson will show how to convert from one system to the other and from one unit to another.

In any unit system, there are three basic units; length, mass and time, from which all other units are derived. For example, area is simply length squared (L x L), volume is length cubed (L x L x L), while flow rate is volume per unit of time (L x L x L/T). Often, additional units are devised for the purpose of convenience, such as a gallon, which is really 0.13 ft^3 or an acre which is 43,560 ft^2. One convenience of the metric (S.I.) system is that all units are multiples of 10 of the basic units: one liter = 1000 cm^3 and one hectare = 10,000 m^2. This makes the metric system much simpler to use. Table 1 lists conversions between the two systems. We will generally use S.I. units in this class.

PRESENTATION

Units of water measurement are considered in two classes depending if water is at rest or in motion.

I. Water at Rest

The common examples where water measurement are required at rest are water standing in fields, reservoirs, lakes, tanks, etc. When water is at rest it is measured in a volume basis, i.e., length x length x length or area x depth. The common units used are cu. meter (cu. ft.), ha-m (acre-foot), or liter (gal.), etc. An acre-inch is a volume of water required to cover one acre one inch deep. An acre-foot is the volume of water required to cover one acre one foot deep.

II. Water in Motion

The common examples where water measurements are required in motion (flowing condition) are water in a watercourse, canal, distributary, coming from a tubewell, a pipeline, culvert, and passing through a flume or over a weir, etc. When water is flowing it is measured as rate of flow and expressed as volume per unit time. The common units are cu. meter/sec (musec), (cu. ft./sec (cusec)), and litres/sec (lps) (gal./min (gpm).

Table 1. Conversion Factors for Commonly Used Units

To Convert from	To	Multiply by	To Convert from	To	Multiply by
Length			Length		
mm	Inches	0.03937	Inches	mm	25.40*
cm	Inches	0.3937	Inches	cm	2.540*
meter	Inches	39.37	Inches	meters	0.0254*
meter	feet	3.281	feet	meters	0.3048*
meter	yards	1.0936	feet	km	0.0003048*
km	feet	3280.8	yards	meters	0.9144*
km	yards	1093.6	yards	km	0.0009144*
km	furlong	4.971	furlong	km	0.2012
km	mile	0.6214	mile	km	1.609
Area and Surveyor's Square Measure			Area and Surveyor's Square Measure		
sq mm	sq inches	0.00155	sq inches	sq mm	645.16*
sq cm	sq inches	0.155	sq inches	sq cm	6.4516*
sq meter	sq feet	10.764	sq feet	sq meter	0.09290
sq meter	sq yards	1.196	sq yards	sq meter	0.8361
sq km	sq mile	0.3861	sq mile	sq km	2.590
are	acre	0.0247	acre	are	40.47
decare	acre	0.247	acre	decare	4.047
hectare	acre	2.471	acre	hectare	0.4047
Volume			Volume		
cu cm	cu inches	0.06102	cu inches	cu cm	46.387
cu meter	cu feet	35.315	cu inches	liters	0.01639
cu meters	cu yards	1.308	cu feet	cu meters	0.0283
cu meters	US gal	264.172	cu feet	liters	28.317
cu meter	IMP gal	219.976	cu yards	cu meters	0.7646
liters	cu inches	61.023	US gal	cu meters	0.003785
liters	cu feet	0.03531	US gal	liters	3.785
liters	US gal	0.264	IMP gal	cu meters	0.004546
liters	IMP gal	0.220	IMP gal	liters	4.546
Weight			Weight		
grams	grains	15.432	grains	grams	0.0648
grams	ounces	0.0353	ounces	grams	28.350
kg	ounces	35.27	ounces	kg	0.02835
kg	pounds	2.205	pounds	kg	0.4536
kg	US ton	0.001102	US ton	kg	907.2
kg	long ton	0.000984	US ton	metric t	0.9072
metric ton	US ton	1.102	long ton	kg	1016.0
metric ton	long ton	0.9842	long ton	metric t	1.016
Unit Weight			Unit Weight		
gr/sq cm	lb/sq in	0.01422	lb/ft	kg/m	1.4881
gr/cu cm	lb/cu in	0.0361	lb/sq in	gr/sq cm	70.31
kg/sq cm	lb/sq in	14.22	lb/sq in	kg/sq cm	0.07031
kg/cu m	lb/cuft	0.0624	lb/cu in	gr/cu cm	27.68
kg/m	lb/ft	0.6720	lb/cu ft	kg/cu m	16.018
Unit Volume			Unit Volume		
liters/sec	IMP gpm	13.199	IMP gpm	liter/sec	0.0758
liters/sec	IMP gpm	0.220	IMP gpm	liter/min	4.546
cu m/sec	IMP gpm	13198.532	IMP gpm	cu m/sec	7.58×10^{-5}
cu m/min	IMP gpm	219.976	IMP gpm	cu m/min	0.00455

Table 1 (continued)

To Convert from	To	Multiply by	To Convert from	To	Multiply by
liters/sec	US gpm	15.850	US gpm	liters/sec	0.0631
liters/min	US gpm	0.264	US gpm	liters/min	3.785
cu m/sec	US gpm	15850.323	US gpm	cu m/sec	6.30×10^{-5}
liters/sec	cu sec	0.0353	cu sec	liters/sec	28.317
liters/min	cu sec	0.000589	cu sec	liters/min	1698.993
cu m/sec	cu sec	35.325	cu sec	cu m/sec	0.0283
cu m/min	cu sec	0.589	cu sec	cu m/min	1.699
Power			**Power**		
watts	ft-lb/sec	0.7376	ft-lb/sec	watts	1.356
watts	hp	0.00134	hp	watts	745.7
kw	hp	1.3410	hp	kw	0.7457
cheval-vap	hp	0.9863	hp	cheval-vap	1.0139

ENGLISH CONVERSION TABLE

Length			**Length**		
inches	feet	0.0833	yards	feet	3.00
inches	yards	0.0278	yards	miles	
feet	inches	12.00	furlong	yards	220.00
feet	yards	0.3333	furlong	feet	660.00
feet	miles	0.0001894	miles	feet	5280.00
Volume			**Volume**		
cu inches	cu feet	0.0005787	cu feet	cu yards	0.03704
cu inches	cu yards	0.00002143	cu yards	cu inches	46.656
cu feet	cu inches	1728.0	cu yards	cu feet	3.00
Area			**Area**		
sq inches	sq feet	0.00694	sq yards	sq inches	1296.0
sq inches	cu yards	0.0000772	sq yards	sq feet	9.00
sq feet	sq inches	144.00	sq yards	acres	0.000207
sq feet	sq yards	0.0000	acres	sq feet	43.560
Weight			**Weight**		
grains	ounces	0.002286	pounds	US ton	0.0005
ounces	grains	437.5	pounds	long ton	0.000446
ounces	pounds	0.0625	US ton	pounds	2000.00
pounds	ounces	16.00	long ton	pounds	2240.00

Circumference of Circle = 3.1416 x dia. = 6.2832 x radius

Area of Circle = $.7854 \times (\text{dia})^2 = 3.1416 \times (\text{radius})^2$

Area of Sphere = $3.1416 \times (\text{dia})^2$

Volume of Sphere = $.5236 \times (\text{dia})^3$

1 lb. per sq in. is equivalent to .06804 atmospheres

Cusec = rate of flowing water at a rate of one cu. ft. per second.

Musec = rate of flowing water at a rate of one cu. meter per second.

Lisec = rate of flowing water at a rate of one litre (1000 cu. cm.) per second.

APPLICATION

To convert from flow measurements to volume measurements, multiply by the amount of time the flow continues. For example, 50 lps flowing into a field for 2 hours (3600 sec/hr x 2 hrs = 7200 sec) adds 360,000 liters or 360 m^3 of water to the field.

$(50 \text{ lps} \times 2 \text{ hrs.} \times 3600 \text{ sec/hr})/1000 \text{ l/m}^3 = 360 \text{ m}$

On a ¼ ha. field, this 360 m^3 is equivalent to 14 cm depth of water.

$(360 \text{ m}^3/(\tfrac{1}{4} \text{ ha} \times 10{,}000 \text{ m}^3/\text{ha})) \times 100 \text{ cm/m} = 14.4 \text{ cm.}$

To convert from 1 lps for 1 hr. to volume (ha-cm) multiply by 0.036. One cusec flowing for one hour is conveniently nearly equal to one acre-inch.

QUESTIONS

1. A flow of 1.2 cusec has been running in a 20 acre field for 48 hours. How much water has been applied if it is evenly distributed?

2. A farmer has a pump which discharges 1 cusec. If he took 50 hours to irrigate a 10 acre garden, what average depth has been applied?

3. How long will it take to apply a 6 inch depth of irrigation to a 15 acre field with a stream of 3 cusecs?

4. It takes 32 hours to irrigate an area of 12 acres to a depth of 4 inches from a watercourse. What is the discharge of the watercourse?

5. A farmer has a reservoir storage of 120 acre-feet of water. How many 24-hour days will it last if he draws a continuous flow of ½ cusec for a 60 acre farm?

Subject: FLOW MEASUREMENT DEVICES

Trainer Irrigation Engineer
Class Room 2 hours
Field 0 Days

OBJECTIVES

To familiarize the students with the various flow measuring devices available and their characteristics.

MATERIALS NEEDED

Meter rod, spirit level, Cutthroat flume and a standard float and stop watch.

TRAINING AIDS

Slides showing weirs, orifices, Cutthroat flumes, etc.

INTRODUCTION

Present-day knowledge of soil-moisture-plant relations permits irrigation systems to be designed that will apply water in correct quantities when needed and at rates based on the soil intake rates, thereby obtaining maximum efficiency of water use and preventing land damage. Applying the proper amounts of water helps produce maximum growth and yields, prevents poor growth because of insufficient water, and reduces drainage problems because of too much water. Obviously, this requires a reasonably accurate measurement of water.

The use of all available water and the increased cost of development requires that water be used economically and without waste. This cannot be accomplished without accurate water measurement.

Field trials and evaluations of existing irrigation systems are often required to determine soil intake rates, required stream sizes, maximum lengths of basin, border or furrow runs, and other factors for efficient water use. Accurate water measurement is required for making such trials and evaluations.

Many methods of measuring the rate of flow of water have been developed. Some of these methods require elaborate, complicated and expensive equipment. Others are simple and inexpensive. The best method will depend on the volume of flow, the conditions under which measurements will be made, and the accuracy required. This section considers only those methods commonly used in irrigation practice that need inexpensive equipment and that require only moderate accuracy.

Water-measurement methods may be placed into one of two classifications: Velocity-area methods or direct-discharge methods. In the first, the velocity in the open channel or pipe is measured directly and the rate of flow determined by multiplying this velocity by the cross-sectional area of the channel or pipe utilized. The weighted float method is the only method that will be discussed that falls in this classification. In the second, rates of flow are measured directly, and velocity measurements are not involved. All the remaining methods fall into this classification.

The methods to be discussed have been placed in three groups; (1) Methods of measuring small irrigation streams, (2) Method of measuring pipe flow, and (3) Method of measuring channel flow.

PRESENTATION

Methods of Measuring Small Irrigation Streams: Submerged Orifice Plates

A simple method of measuring furrow streamflow is by submerged orifice plates. The plate is placed across the furrow and the head loss through the orifice is measured under submerged flow conditions.

Orifice plates consist of small sheet iron, steel, or aluminum plates that contain accurately machined circular openings or orifices usually ranging from 2.5-9 cm (1 to 3½ inches) in diameter. Figure 1 shows construction details for an orifice plate with four orifices of such diameters that any flow between 0.3 and 5 liters per second can be measured within a head-loss range of 0.6 to 6.0 cm.

Orifice plates have several advantages. They are simple, inexpensive, and easy to install. Furrow streams can be measured with a minimum head differential or restriction to flow, thereby minimizing the increase in the wetted perimeter of the furrow above the measuring point and the probability of overtopping. With reasonable care in setting and reading, the margin of error in the measurements will not exceed 5 percent.

In use, an orifice size is selected so as to produce a head differential within the 1.30- to 6.0- centimeter range, and the plate is placed in and across the furrow with its top as nearly level as possible. Flow through the orifice must be submerged. Figure 2 shows the installation of the orifice plate. In some cases, it may be necessary to restrict the flow downstream from the plate in order to raise the water surface on its downstream side to a level slightly above the top of the orifice. Allowing a few minutes for the head differential to become constant, this differential (the difference in the distances from the top of the plate to the water surface on the upstream and downstream sides) is measured with an engineer's

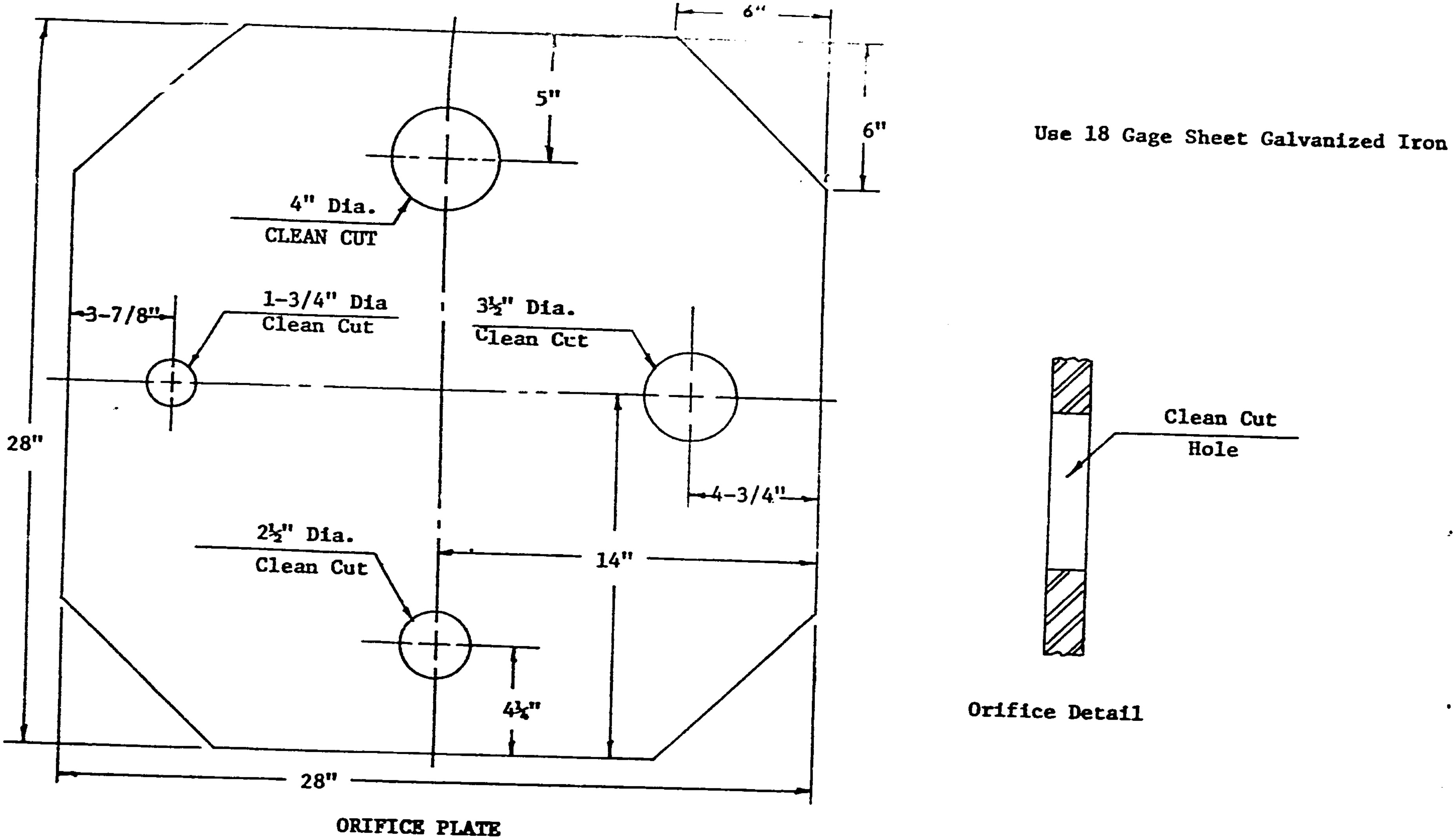


Figure 1. Construction detail for orifice plate.

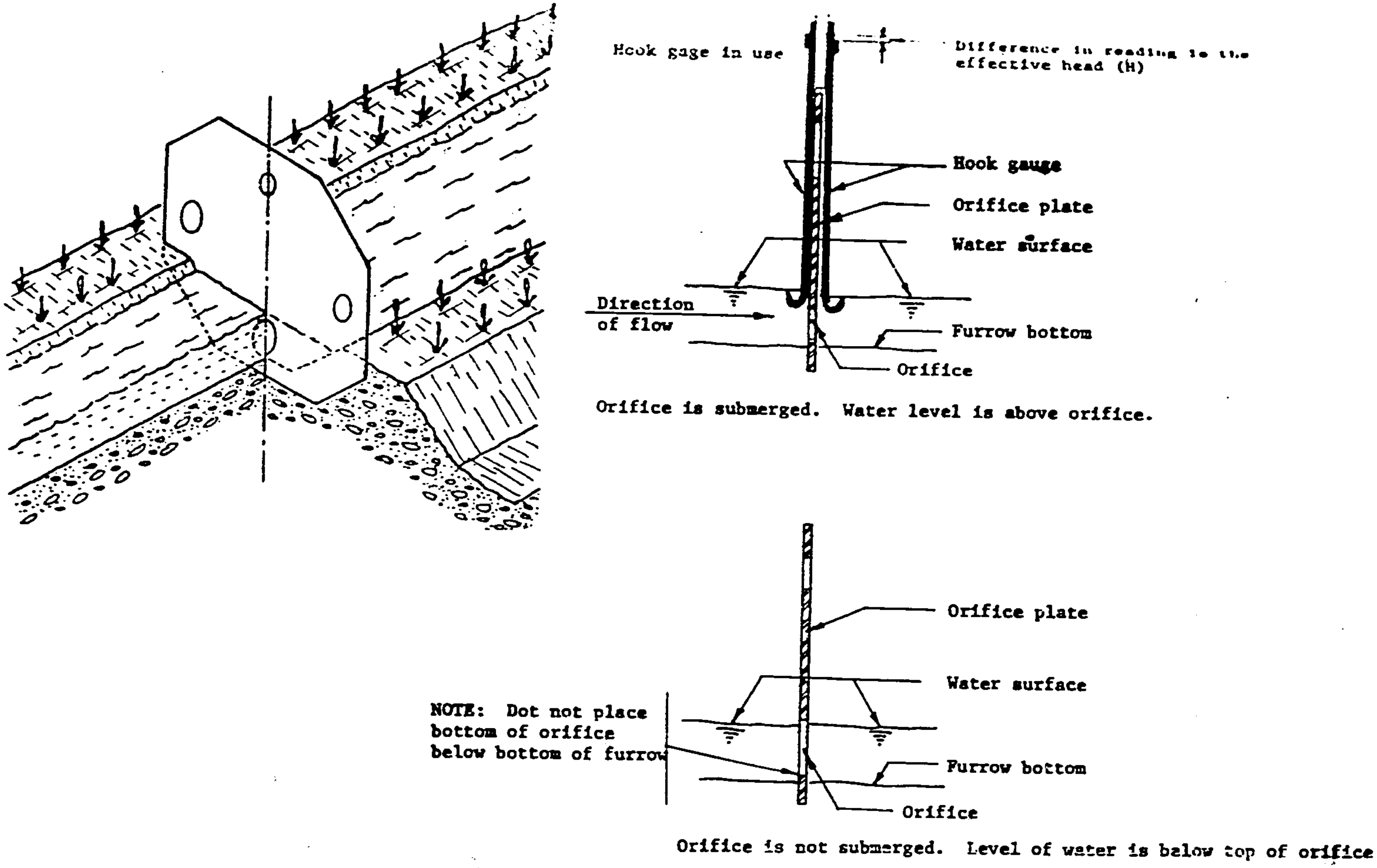


Figure 2. Installation of orifice plate in furrow for submerged flow.

scale. Readings are taken to the nearest 0.1 centimeter or 0.05 inches. Table 1 gives the discharge rates for the orifice place where the head is in centimeters and Table 2 gives the discharge where the head is measured in tenths of inches. Figure 3 shows the "Hook Gage" which can be used to measure head difference.

Method of Measuring Pipe Flow: Trajectory Method

This method determines the rate of flow discharging from the end of a pipe. It has three essential requirements for discharge determinations:

1. The discharge pipe must have a length not less than six times the pipe diameter.
2. The discharge pipe must be nearly level. Flows can be measured on a non-level pipe but it is more difficult to make measurements.
3. The pipe must discharge into the air.

For pipes flowing full three measurements are needed:

1. The inside diameter of the pipe in inches or centimeters.
2. The horizontal or vertical distances are measured from some point on the end of the pipe to a similar point in the jet. For convenience, these coordinates are measured from the top of the inside of the pipe to a point on top of the jet. (See Figure 4.) These horizontal and vertical distances are called X and Y ordinates, respectively.
3. For pipes flowing partly full, an additional measurement is needed. The vertical distance from the water surface at the end of the pipe to the inside top of the pipe must be determined.

Table 1. Discharge through submerged orifice head in tenths of inches.

Head (inches)	Diameter of Orifice (inches)			
	1-3/4 1/min	2-1/2 1/min	3-1/2 1/min	4 1/min
0.3	21.95	44.32	86.3	112.8
.4	25.36	51.17	99.9	131.0
.5	28.35	57.19	111.3	145.3
.6	31.04	62.64	122.3	159.7
.7	33.54	67.68	132.1	172.6
.8	35.84	72.33	140.8	184.0
.9	38.04	76.8	149.9	195.3
1.0	40.12	81.0	157.8	206.3
1.1	42.05	84.8	165.4	216.1
1.2	43.91	88.6	172.6	225.6
1.3	45.72	92.0	179.8	234.7
1.4	47.43	95.4	186.2	243.4
1.5	49.09	99.2	193.4	252.5
1.6	50.72	102.2	199.5	260.4
1.7	52.27	105.2	205.5	268.4
1.8	53.78	108.3	211.6	275.9
1.9	55.26	111.3	217.6	283.9
2.0	56.70	114.3	223.3	291.1
2.1	58.10	117.0	229.0	298.3
2.2	59.46	120.0	234.3	305.4
2.3	60.79	122.3	239.6	312.3
2.4	62.11	124.9	244.5	319.1
2.5	63.36	127.2	249.4	325.5
2.6	64.65	129.8	254.4	331.6
2.7	65.86	132.5	259.3	338.0
2.8	67.07	135.1	264.2	344.4
2.9	68.24	137.4	268.7	350.5
3.0	69.42	140.0	273.3	356.5
3.1	70.59	142.3	277.8	362.2
3.2	71.69	144.6	282.4	367.9
3.3	72.82	146.5	286.5	373.6
3.4	73.93	148.8	290.7	378.9
3.5	74.98	151.0	294.5	384.6
3.6	76.1	153.3	298.6	390.2
3.7	76.8	155.6	302.8	395.9
3.8	78.0	157.5	307.0	401.2
3.9	79.1	159.7	311.1	406.5

Table 2. Discharge through submerged orifice head in tenths of centimeters.

Head (cm)	Diameter of Orifice (inches) 1-3/4 l/min	2-1/2 l/min	3-1/2 l min	4 l/min
.6	19.5	39.1	76.7	100.1
.8	22.5	45.2	88.5	115.6
1.0	25.2	50.5	99.0	129.3
1.2	27.6	55.3	108.4	141.6
1.4	29.8	59.8	117.1	152.9
1.6	31.8	63.9	125.2	163.5
1.8	33.8	67.8	132.8	173.4
2.0	35.6	71.4	140.0	182.8
2.2	37.3	74.9	146.8	191.7
2.4	39.0	78.2	153.3	200.2
2.6	40.6	81.4	159.6	208.4
2.8	42.1	84.5	165.6	216.3
3.0	43.6	87.5	171.5	223.9
3.2	45.0	90.3	177.1	231.2
3.4	46.4	93.1	182.5	238.3
3.6	47.7	95.8	187.8	245.3
3.8	49.0	98.4	192.9	252.0
4.0	50.3	101.0	197.9	258.5
4.2	51.6	103.5	202.8	264.9
4.4	52.8	105.9	207.6	271.1
4.6	54.0	108.3	212.3	277.2
4.8	55.1	110.6	216.8	283.2
5.0	56.3	112.9	221.3	289.0
5.2	57.4	115.2	225.7	294.8
5.4	58.5	117.4	230.0	300.4
5.6	59.5	119.5	234.2	305.9
5.8	60.6	121.6	238.4	311.3
6.0	61.6	123.7	242.4	316.6
6.2	62.6	125.7	246.4	321.9
6.4	63.7	127.8	250.4	327.0
6.6	64.6	129.7	254.3	332.1
6.8	65.6	131.7	258.1	337.1
7.0	66.6	133.6	261.8	342.0
7.2	67.5	135.5	265.6	346.8
7.4	68.4	137.4	269.2	351.6
7.6	69.4	139.2	272.8	356.3
7.8	70.3	141.0	276.4	361.0
8.0	71.2	142.8	279.9	365.6
8.2	72.0	144.6	283.4	370.1
8.4	72.9	146.4	286.8	374.6
8.6	73.8	148.1	290.2	379.1
8.8	74.6	149.8	293.6	383.4
9.0	75.5	151.5	296.9	387.8
9.2	76.3	153.2	300.2	392.1
9.4	77.1	154.8	303.4	396.3
9.6	78.0	156.5	306.6	400.5
9.8	78.8	158.1	309.8	404.6
10.0	79.6	159.7	313.0	408.8

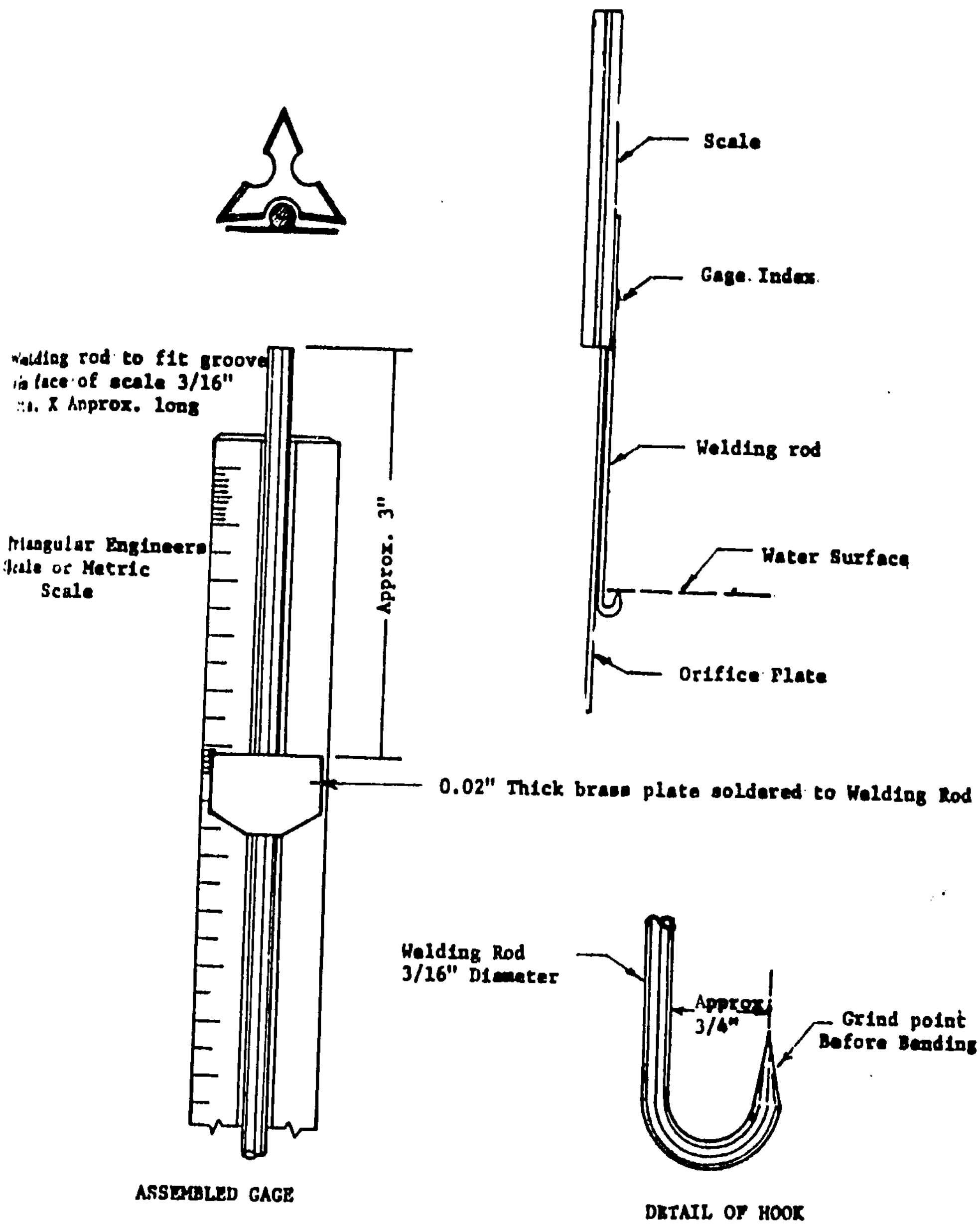


Figure 3. Hook gage: for use with orifice plates.

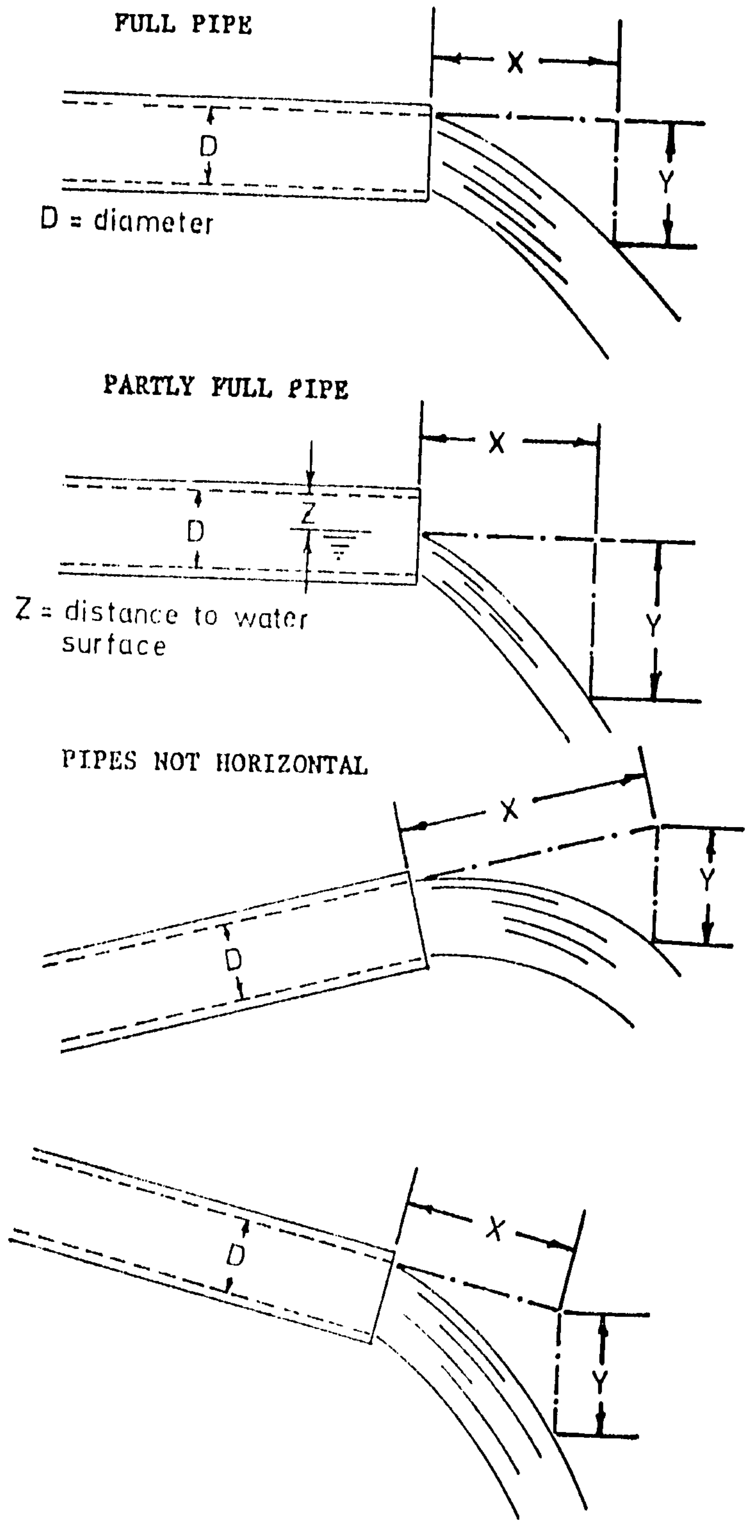


Figure 4. Pipe flow and pipe section.

After the above measurements have been made, the discharge (Q) in liters per second for pipes flowing full, can be computed by the formula:

$$Q = \frac{0.0174\ D^2X}{\sqrt{Y}}$$

Where D is the inside diameter of the pipe in centimeters and X is the horizontal distance in centimeters from the end of the pipe required for the surface of the jet to drop Y centimeters. Discharge values are given in Figure 5, 6, and 7.

For pipes flowing partly full, the formula is:

$$Q = \frac{0.0174\ D^2X}{\sqrt{Y}} \quad \frac{a}{A}$$

Where "a" is the area of the jet at the end of the pipe and "A" is the cross sectional area of the pipe. Figure 8 gives a/A values and a sample problem. Flow measurement by the trajectory method is generally not accurate enough for conveyance loss measurement purposes.

Methods of Measuring Channel Flow

Float Method

The rate of flow passing a point in a ditch or other open channel can be determined by multiplying the cross sectional area of water by the average velocity of the water. Normally, the cross sectional area can be determined by direct measurement of the channel dimensions. The velocity can be estimated by timing the passage of a small float through a measured length of channel. The procedure for estimating rate of flow by the float method is as follows:

1. Select a straight section of ditch with fairly uniform cross sections. The length of the section will depend on the current, but 30 meters usually will be adequate.

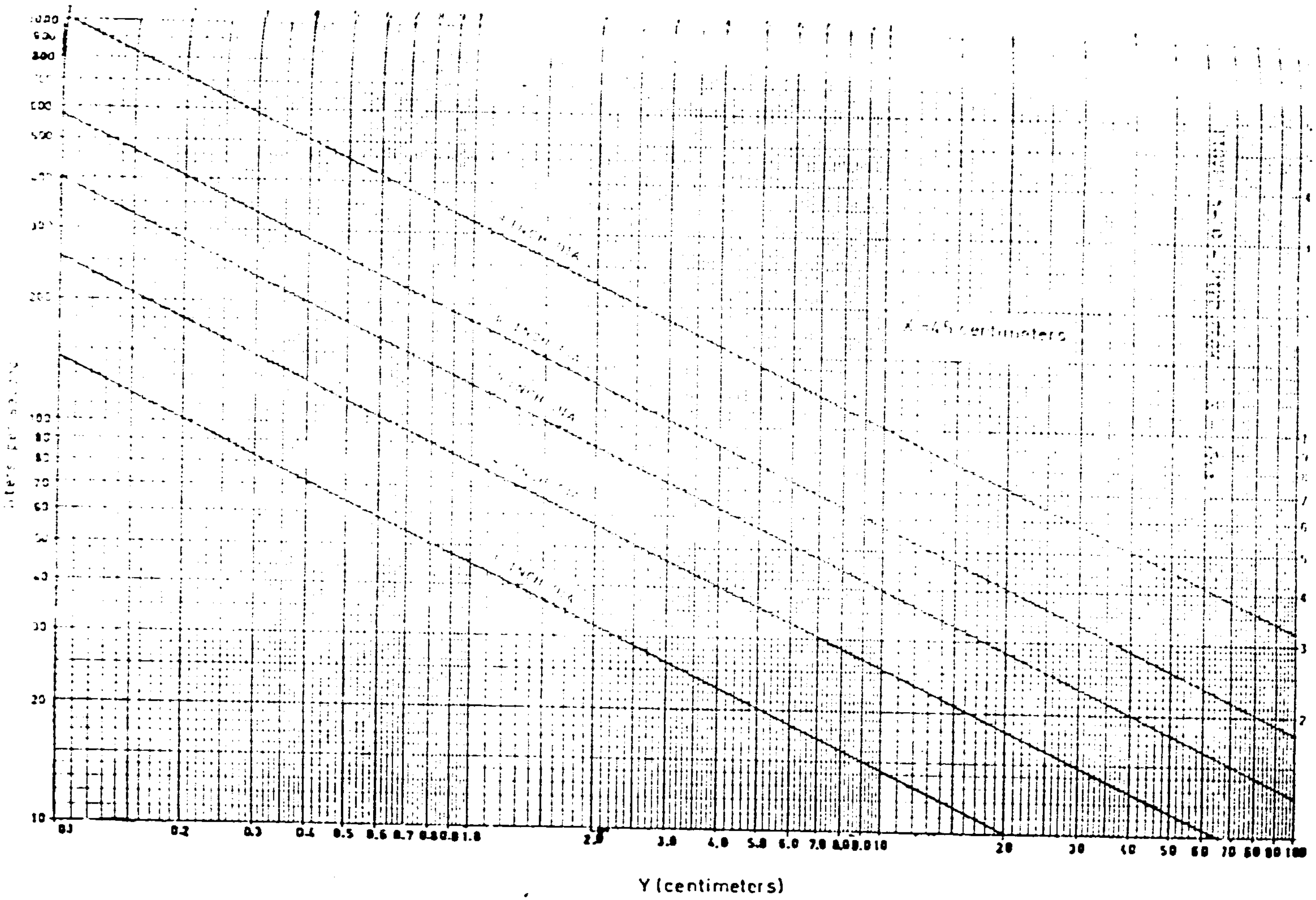


Figure 5. Pipe flow X = 45cm.

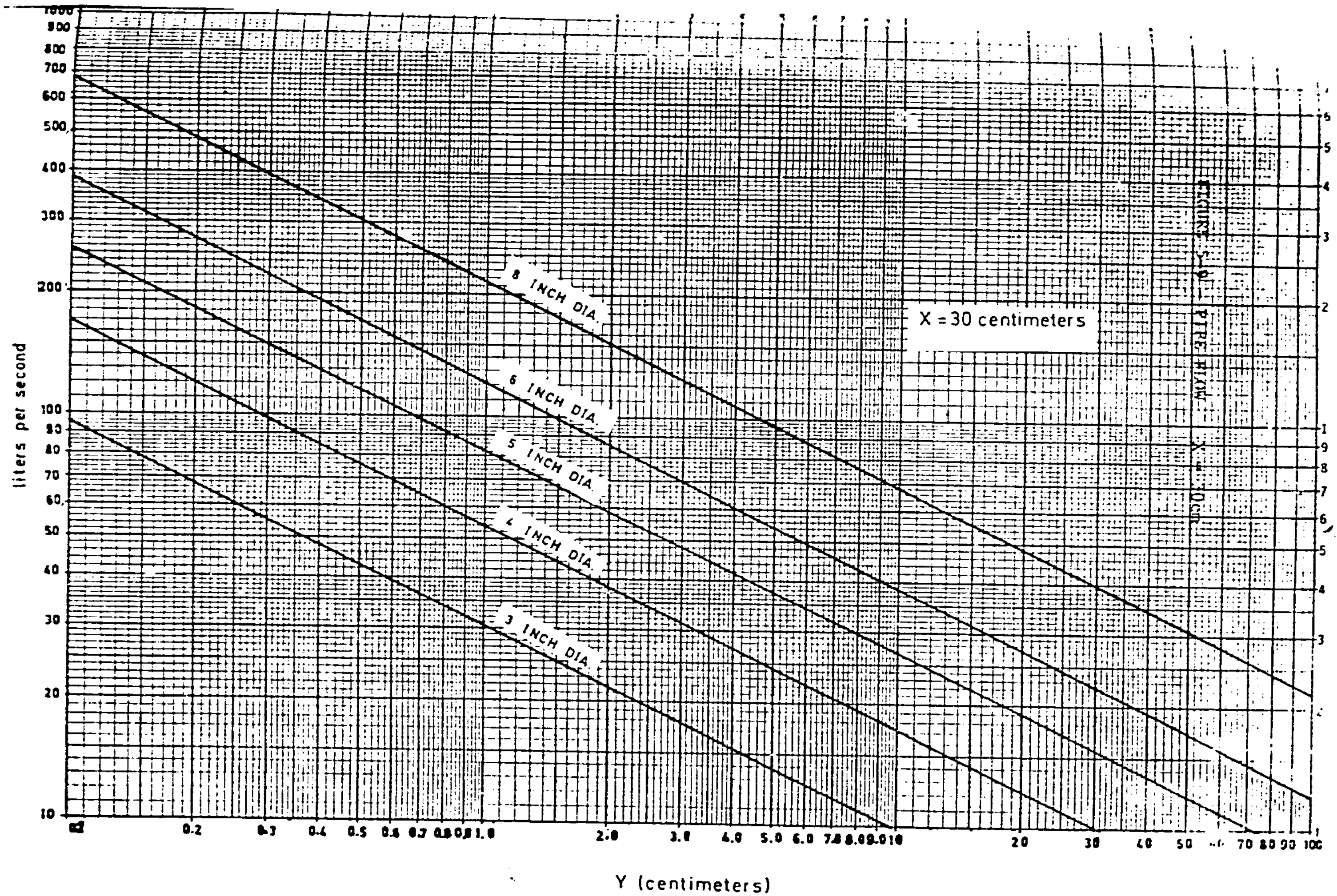


Figure 6. Pipe flow X = 30cm

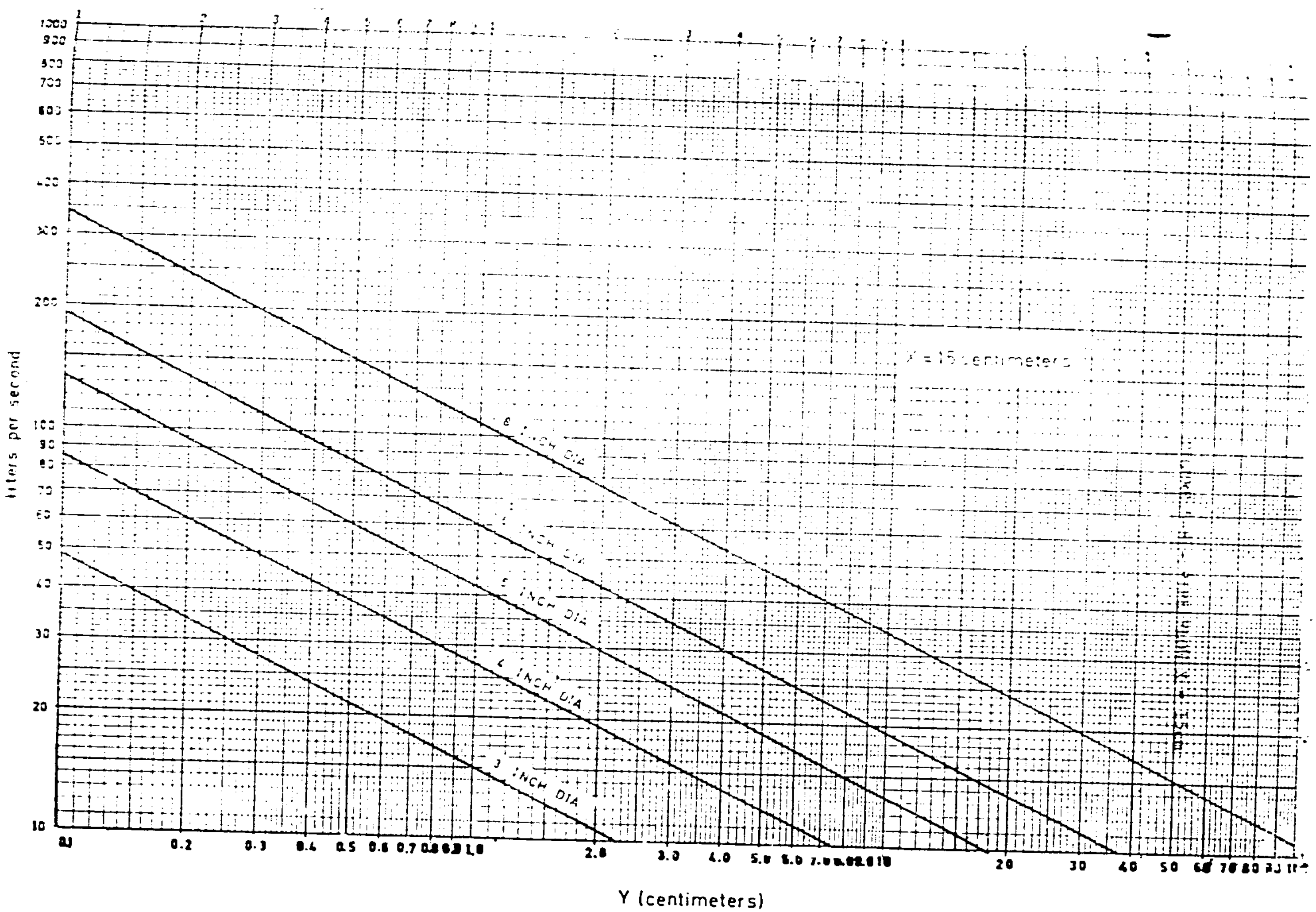
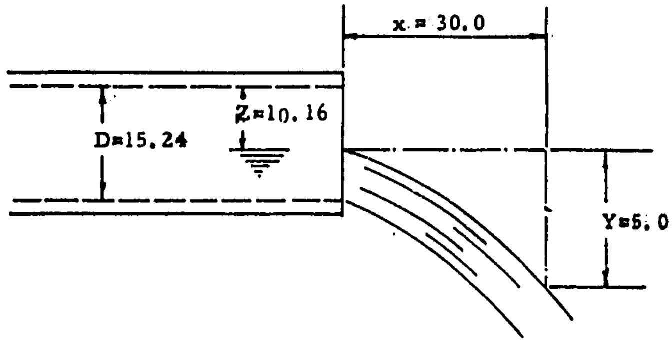


Figure 7. Pipe flow X = 15cm.



Ratio of a/A for pipes flowing partly full

Z/D	a/A	Z/D	a/A
.05	.98	.45	.56
.10	.95	.50	.50
.15	.91	.55	.44
.20	.86	.60	.37
.25	.80	.65	.31
.30	.75	.70	.25
.35	.69	.75	.20
.40	.63	.80	.14
		.85	.09

Sample Computation

Given:

D = 15.24 cm
Z = 10.16 cm
X = 30 cm
Y = 5.0 cm

Solution:

Z/D = 10.16/15.24 = 0.67

Therefore a/A = .29 (From table by* interpertation)

$$Q = \frac{0.0172D^2 X}{\sqrt{Y}} \times \frac{a}{A} = \frac{0.0174 \times 15.24^2 \times 30}{\sqrt{5}} \times .$$

= 15.72 l/sec.

*Interpolation:

	Z/D	a/A	
.05	.65	.31	.06
.03	.67	x	
	.70	.25	

$$\frac{.03}{.05} = \frac{x}{.06}$$

.05x = .0018
X = .036

∴ a/A for .67 = .25+.036 = .286
round up to 0.29

Figure 8. Sample problem and a/A values for partly full pipe.

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A shorter length may be satisfactory for slow flowing ditches.

2. Make several measurements of depth and width within the trial section, to arrive at the average cross section area. The area should be expressed in terms of square meters.
3. Place a small float in the ditch about a meter upstream from the upper end of the trial section. Determine the number of seconds it takes for the float to travel from the upper end of the trial section to the lower end. Make several trials to get the average time of travel. The best floats are small rounded objects which float nearly submerged. They are less apt to be affected by wind or to be slowed by striking the side of the channel. Among small objects which make good floats are a long necked bottle partly filled with water and capped, a rounded block of wood, or an orange. A wooden sphere, like a croquet ball, is excellent.
4. Determine the velocity (or speed) of the float in units of meters per second by dividing the length of the section (in meters) by the time (in seconds) required for the float to travel that distance.
5. Determine the average velocity of the stream. Since the velocity of the float on the surface of the water will be greater than the average velocity of the stream, the float velocity must be multiplied by a correction coefficient to obtain a good estimate

of the true average stream velocity. The correction factor varies with the type of float used and with the shape and uniformity of the channel. With floats that sink about 2 to 5 centimeter below the water surface, a coefficient of about 0.80 should be used for most unlined farm ditches. A coefficient of 0.85 is appropriate for smooth uniform lined ditches. With floats that extend two-thirds or more of the water depth below the surface, the coefficient should be about 0.85 for unlined ditches and 0.90 for lined ditches.

6. Compute the rate of flow. The rate of flow is obtained by multiplying the average cross sectional area (item 2) by the average stream velocity (item 5). The accuracy of these estimates of flow rates is dependent upon the preciseness with which average cross sectional areas and float velocities have been determined and upon the selection of the proper correction coefficient. The method is not accurate enough for conveyance loss measurements. An example of this method of estimating flow rates is shown in Figure 9 and 10.

Cutthroat Flume

This method is used to measure the rate of flow in an open channel. The Cutthroat flume has two operating characteristics which are important:

1. Operation is satisfactory under both free and submerged flow conditions.
2. Head loss through the flume is low, even less than the long-used parshall flume.

Assume straight section of unlined irrigation ditch 30 meters in length. Representative cross sections at stations 00+0, 12+0, and 28+0.

Cross Section Data

Station 00+0

Distance from left water edge	(m)	0.00	0.45	1.00	1.50
Water depth	(m)	0.00	0.33	0.35	0.00

(See Figure 5-13) Area $= \frac{0.33X0.45}{2} + \frac{0.33+0.35}{2} .55^* + \frac{0.35X0.50^*}{2}$

$= 0.07+0.19+0.09 = 0.35m^2$

* (1.00-0.45 = 0.55 and 1.50-1.00 = 0.50)

Station 12+0

Distance from left water edge	(m)	0.00	0.40	1.16	1.58
Water depth	(m)	0.00	0.26	0.32	0.00

(See Figure 5-13) Area $= \frac{0.26X0.40}{2} + \frac{0.26+0.32}{2} 0.76 + \frac{0.32X0.42}{2}$

$= 0.05+0.22+0.07 = 0.34m^2$

Station 28+0

Distance from left water edge	(m)	0.00	0.27	0.58	1.00	1.46
Water depth	(m)	0.00	0.24	0.35	0.35	0.00

(See Figure 5-13) Area $= \frac{0.24X0.27}{2} + \frac{0.24+0.35}{2} 0.31+0.42X0.35+\frac{0.35X46}{2}$

$= .03+0.09+0.15+0.08 = 0.35m^2$

Average cross section area $= \frac{0.35+0.34+0.35}{3} = 0.35$

Velocity Data

Time for float (wooden sphere) to travel 30 meters

Trial No.	1	2	3	4	Average
Time (Seconds)	95	91	90	88	91

Float Velocity $= \frac{30}{91} = 0.33$ meters per sec.

Average stream velocity = 0.33X0.80 = 0.26 m/sec.

Flow Rate

$Q = AV = 0.35m^2 X0.26$ m/sec. = 0.091 cubic meters per sec.

or 0.091 cum/secX1000 l/sec/cum/sec = 91 l/sec.

Figure 9. Estimating flow rates by float method.

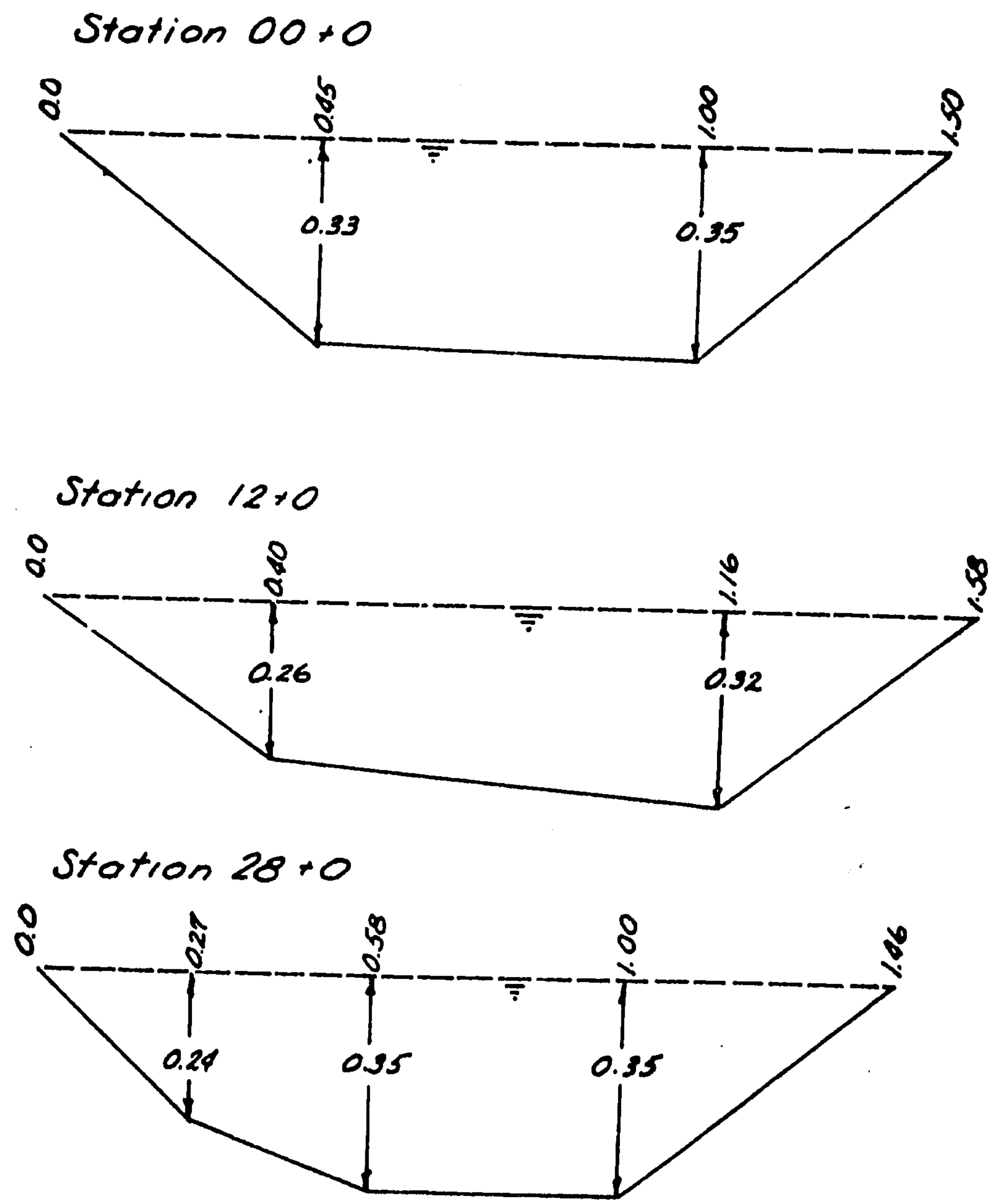


Figure 10. Ditch cross sections for Figure 9.

It gives satisfactory accuracy in water measurement in the flat gradient channels in Pakistan. Furthermore, it is easy to construct because of the flat bottom. Figure 11 shows a dimensionless design for the Cutthroat flume.

Flume Selection

In order to select a flume of the correct size, it is necessary to have some ideas of the approximate flow and the depth of flow in the channel, and the allowable head loss through the flume. The head loss may be taken as the difference in water surface elevation between the flume entrance and exit. The down-stream depth of flow will remain essentially the same after installation of the flume, but the upstream will increase by the head loss. The allowable increase in upstream should not cause additional submergence of the mogha.

Most of the channels in Pakistan have flat gradient beds with very little freeboard. Thus, in most cases, the flumes will be installed to operate under a submerged flow condition. Good discharge measurements can be made under these conditions but the submergence should not exceed 85 percent if possible. This will reduce the energy loss. The problem of upstream sections being overtopped can be minimized by careful installation and/or building up the bund. But where conditions permit, e.g., steep-gradient channels with lots of freeboard, the flume should be install for free flow conditions.

In selecting a flume, make sure the proper throat size is selected. Flow measurements are not as accurate at low heads or at high heads. Tables included in the "Cutthroat Flume and Conveyance Losses" section will assist in the selection of the proper flume. The 0.91 m (3 ft) long flume is recommended for measuring most watercourse flows. Use the best judgement in selecting the proper flume to meet the specific requirements.

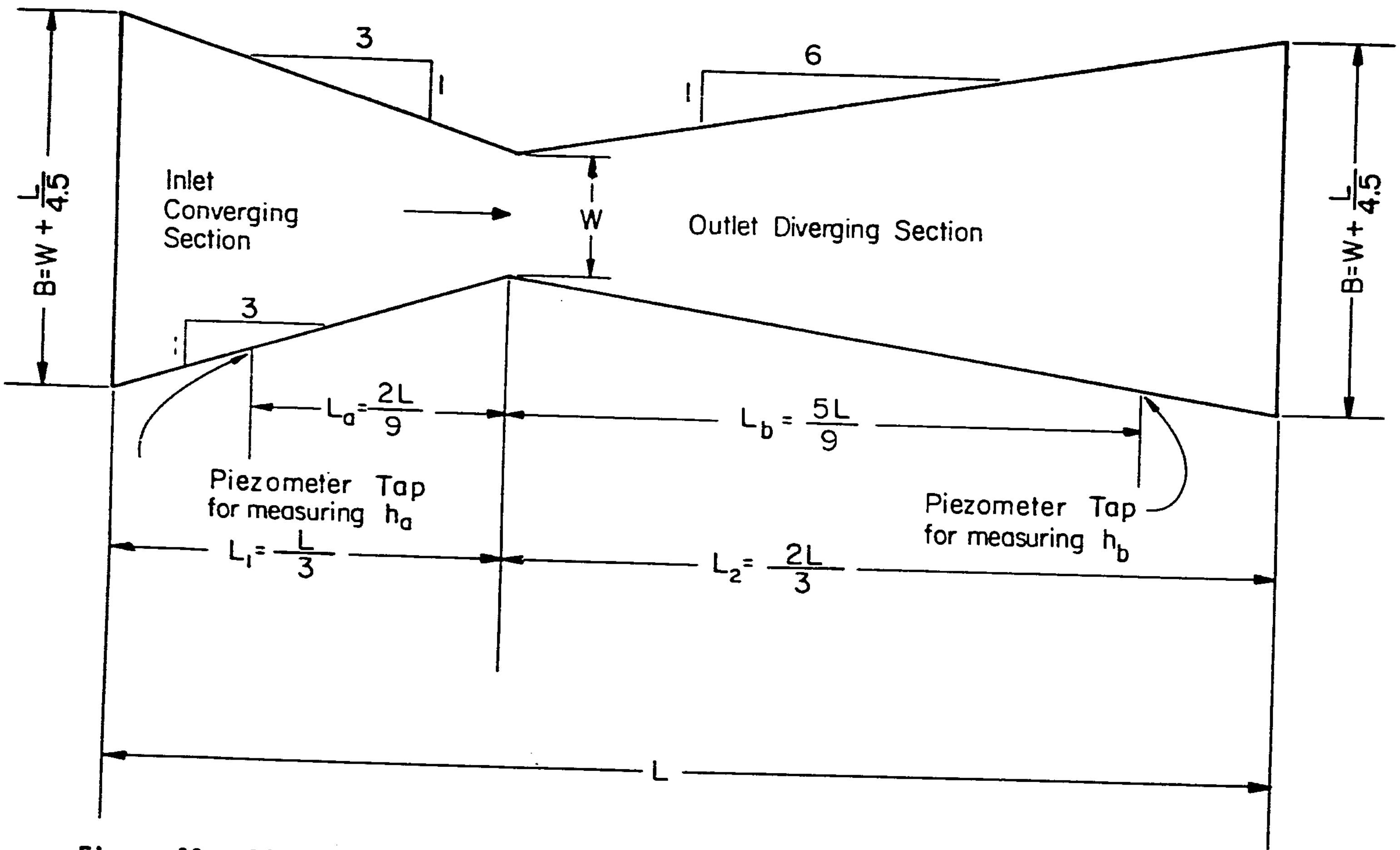


Figure 11. Dimensionless design for Cutthroat flume.

Installation

Although the Cutthroat flume is simple in appearance, it must be installed carefully and used correctly.

The first consideration prior to installing a flume, is the location or site of the structure. The flume should be placed in a straight section of channel, parallel to the direction of flow of water in the channel. Care should be taken to see that the flume is not located immediately downstream from a constriction, e.g., culvert, check structure, etc. If it is to be located near a mogha, it should not be located so it will cause mogha submergence. The mogha discharge will be reduced if submerged by the flume. After the site has been selected the flume is ready for installation.

In making the flume installation it should be placed in the center of the channel. Where the channel bottom is unlevel, it may be necessary to level it out by either cutting down the high spot and/or filling the low spots. The bottom of the flume should never be placed lower than the channel bottom, but at same level or slightly higher than the channel bottom.

After placing the flume in the channel, the floor of the flume should be properly leveled. As close to the flume throat as possible, the most desirable being the converging section of the flume, place a wooden level (about 6 inches long) in the transverse direction on the floor of the flume bringing the bubble in the center. For longitudinal leveling, place the level parallel to flume length and in the throat and bring the bubble in the center. While doing this do not disturb the transverse level. This procedure may have to be done several times until the flume is level in both directions.

Place soil on both side of flume and tamp, making sure that the sides and bottom are properly sealed so that no leaks occur. During the placement of the soil it will be necessary to check the level of flume to see that it has not been disturbed. In sandy soils, plastic sheets or cloth may be needed to obtain an effective seal against leaks.

If the flume has to be installed in a channel with water flowing in it, make sure that two locations on the flume top are parallel with two similar locations on the flume bottom. Using the same leveling procedure as above, locate and mark these two reference points for the level. Always use these two marked positions to level the flume when it is installed in flowing water. Occasionally, these positions should be checked with reference to the flume bottom, as the flume will sometimes shift after considerable use.

Weirs

A partially filled orifice is similar to the discharge over a weir. In a weir, water is open to atmospheric pressure on both upstream and down-sides. The weirs are of many types according to their shape. The most common are:

a. Rectangular weir.

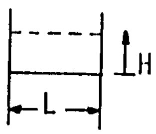
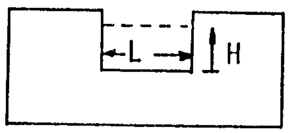
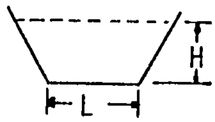
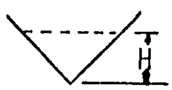
b. Trapezoidal weir.

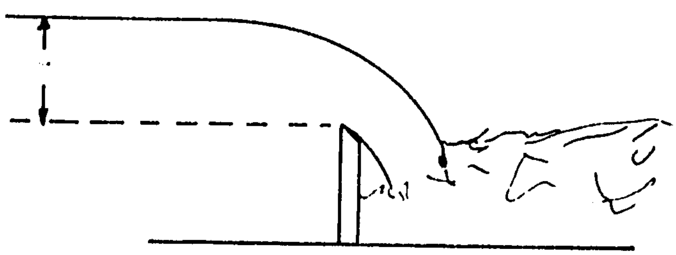
c. Triangular weir.

Table 3 summarizes the formulae used in respect of different weirs.

Normally, weirs used for measuring discharge of small channels are sharp crested and made of a sheet of iron. Plastic weirs can also be used but sometimes in high discharge these deflect in the direction of flow resulting in wrong measurements of L and H.

Table 3. SUMMARY OF WEIR FORMULAS

Measuring Device (all sharp crested)	Views	Formula
Rectangular Weir (without contraction)	 Front View	$Q = 3.33LH^{3/2}$
Rectangular Weir (with contraction)	 Front View	$Q = 3.33(L-0.2H)H^{3/2}$
Trapezoidal Weir	 Front View	$Q = 3.37LH^{3/2}$
90° Triangular Weir	 Front View	$Q = 2.49H^{5/2}$



Wier Side View

Siphon Tubes

Siphon tubes, used to remove water from a head ditch and distribute it over a field through furrows, corrugations, or borders, are also used to measure the rate of flow into these distribution systems.

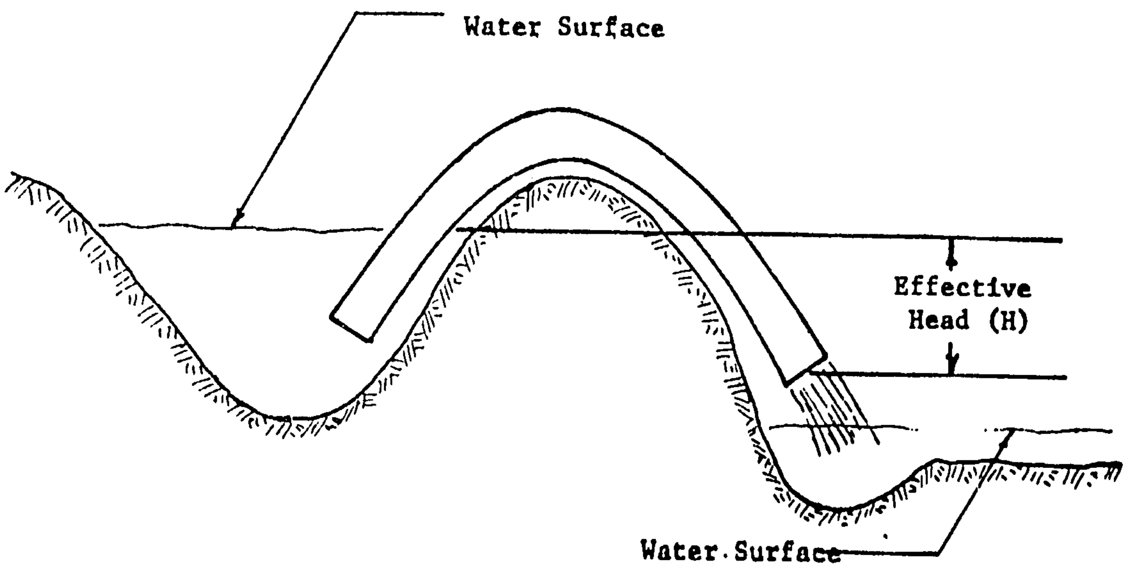
These tubes, made of aluminum, plastic, or rubber, are usually preformed to fit a half cross section of the head ditch. The normal diameter range is from 2.5 to 15 cm (1 to 6 inches), although both smaller and larger sizes are available. The smaller sizes are used with furrows and corrugations and the larger sizes with borders. Various lengths are available.

Siphon tubes are portable. For this reason, the reduced number of tubes required to irrigate a given area results in low initial cost for equipment. Flow into individual furrows or borders can be controlled effectively by using the number of tubes that will divide the total head ditch flow into individual streams of the desired size.

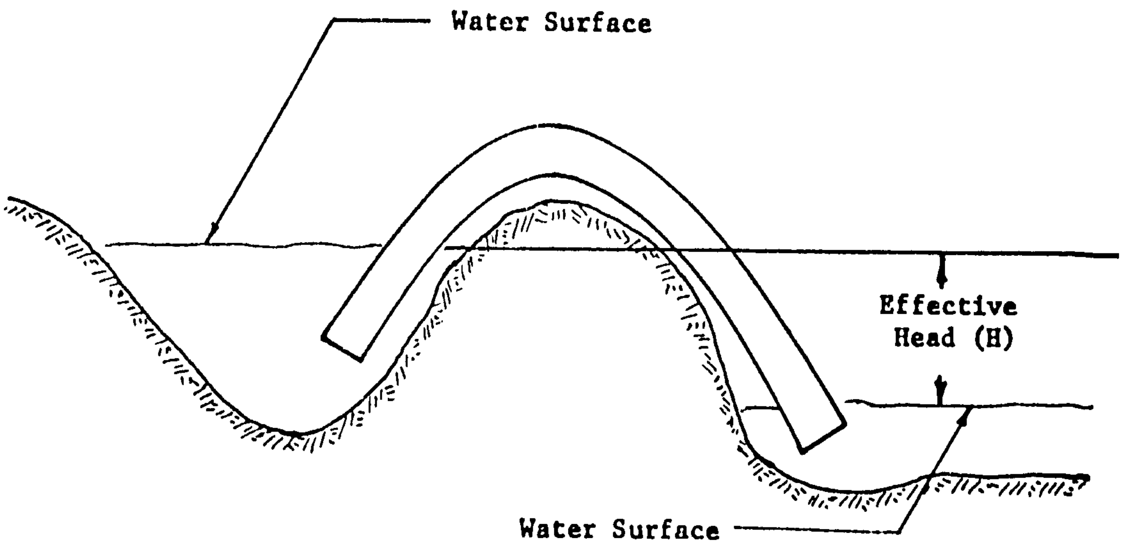
The tubes are limited to fields with little cross slope in order to maintain a near-constant operating head on each tube. A disadvantage is that they need to be primed individually. This priming is the principal labor requirement when siphon tubes are used for surface irrigation.

The discharge of a siphon tube depends on: (1) The diameter of the tube, (2) the length of the tube, (3) the roughness of the inside surface and the number and degrees of bends in the tube, and (4) the head under which the tube is operating. When the outlet end of the tube is submerged, the operating head is the difference in elevation between the water surfaces measured at the entrance and outlet ends of the tube. When the tube is flowing free, the operating head is the difference in elevation between the water surface at the entrance of the tube and the center of the outlet end (Figure 12).

Discharge rates are given in Figure 13 for small siphons and in Figure 14 for large siphons.



FREE FLOW - Outlet of Siphon is not Submerged



SUBMERGED FLOW - Outlet of Siphon is Submerged

Figure 12. Siphon tubes: head measurement.

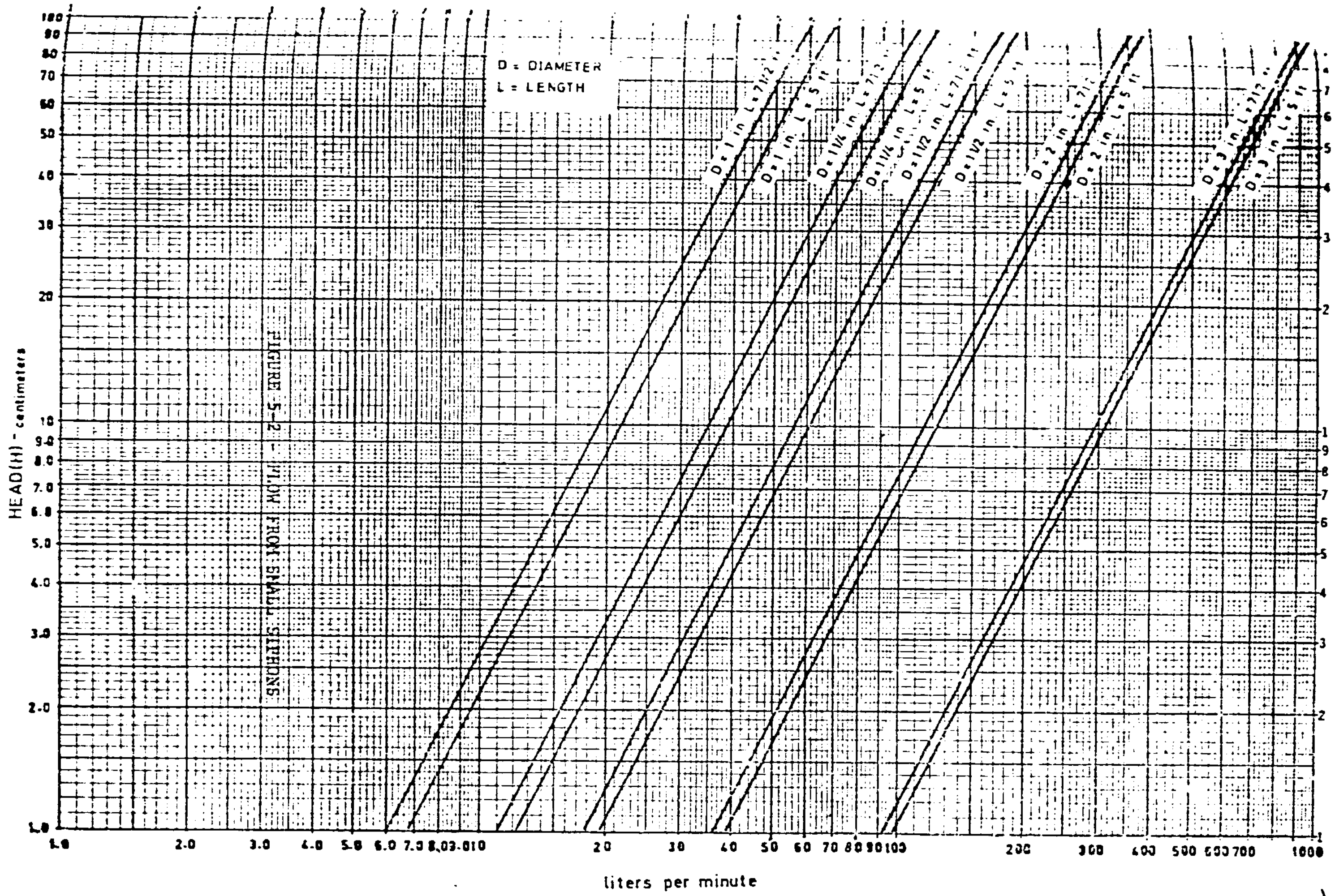


Figure 13. Flow from small siphons.

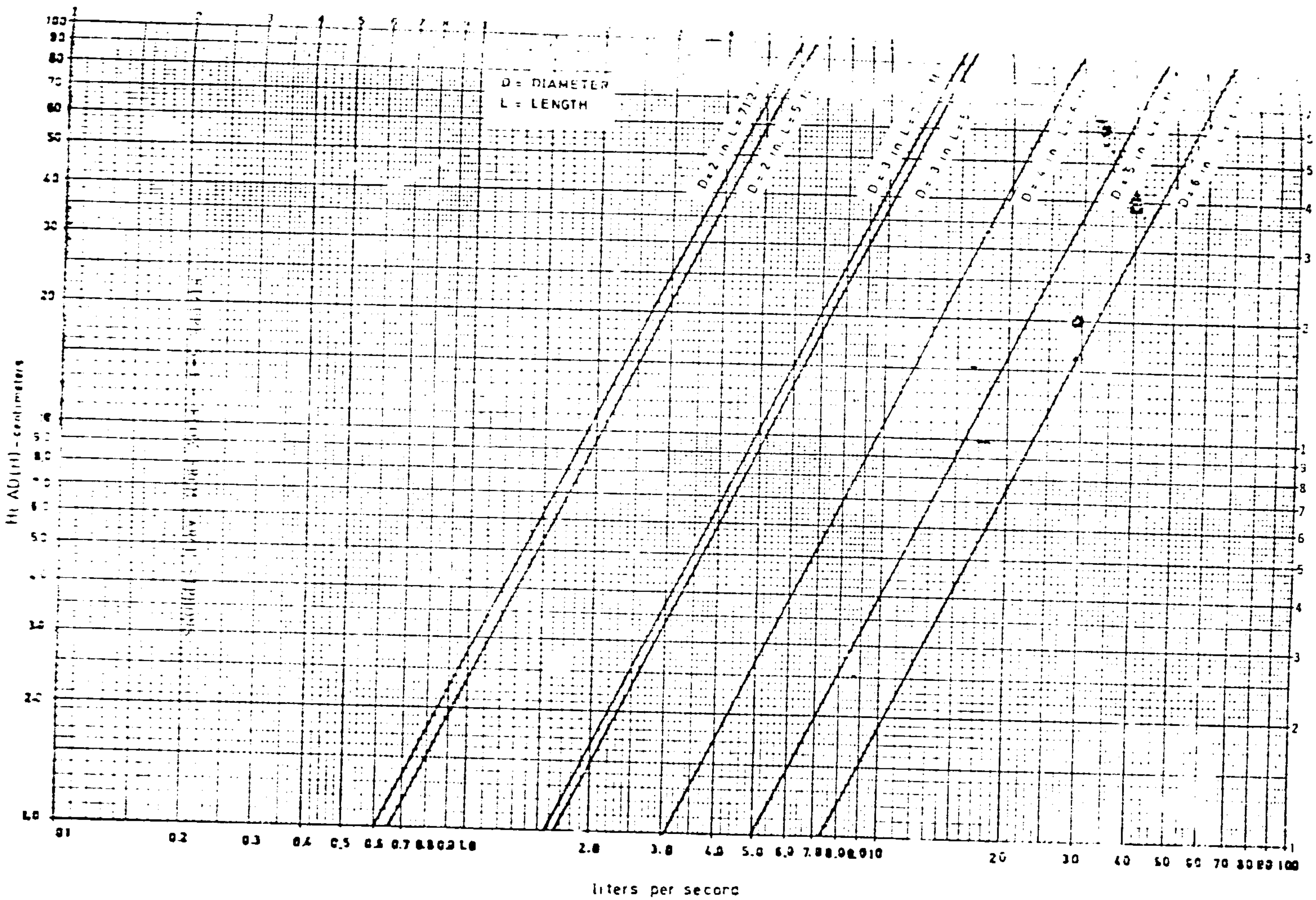


Figure 14. Flow from large siphons.

Subject: CUTTHROAT FLUME AND CONVEYANCE LOSSES

Trainer Agricultural Engine
Class Room 4 hours
Field 2 D

OBJECTIVES

To enable the trainees

1 - To check, install and use a Cutthroat flume

2 - To measure the discharge of the watercourse

3 - To measure the water loss as well as the conveyance efficiency

4 - To determine the application efficiency

5 - To evaluate the overall efficiency of a given irrigation system

MATERIALS NEEDED

1 - Cutthroat flume

2 - Spade

3 - Spirit level

4 - Square set and a ruler to check the standard dimensions and angles of a given flume

5 - Engineer's field book

6 - Pencil

7 - Watch

TRAINING AIDS

1 - Movie regarding the procedure of flume installation

2 - Slides showing various problems encountered in the use of Cutthroat flume

PRESENTATION

Open channel flow measurement includes all techniques, devices and methods used to measure flows involving a free surface. The devices used for measuring irrigation water through control of channel geometry include:

1. Weirs
2. Flumes, i.e., Parshall and Cutthroat flumes

These usually employ the concept of critical depth where flow passes through a point of minimum specific energy within a defined cross section. However, the flumes are also capable of measurement under conditions where flow does not go through critical depth, although in this case, the accuracy may not be as good.

Characteristics of Measuring Devices

Among the various flow measuring devices, the Cutthroat flume is the latest development having the following characteristics:

1. Water measurement is satisfactory under both free and submerged flow conditions.
2. Head loss through this flume is less compared to the Parshall flume.
3. It gives satisfactory accuracy of flow measurement in the flat gradient channels of Pakistan.
4. Its construction is easier as compared to the Parshall flume because of the flat bottom.
5. The device is self-cleaning and will not silt up as easily as a weir.

Flume Dimensions

The size of a cutthroat flume is usually denoted by the width of throat and total length. Sizes of 4", 8", and 12" x 3' are in common use. Figure 1 gives the general specifications for any throat size of a 3 ft. long Cutthroat flume. Because of the critical entrance characteristics of the 18 inch flume, the 3 ft. flume is best suited for use.

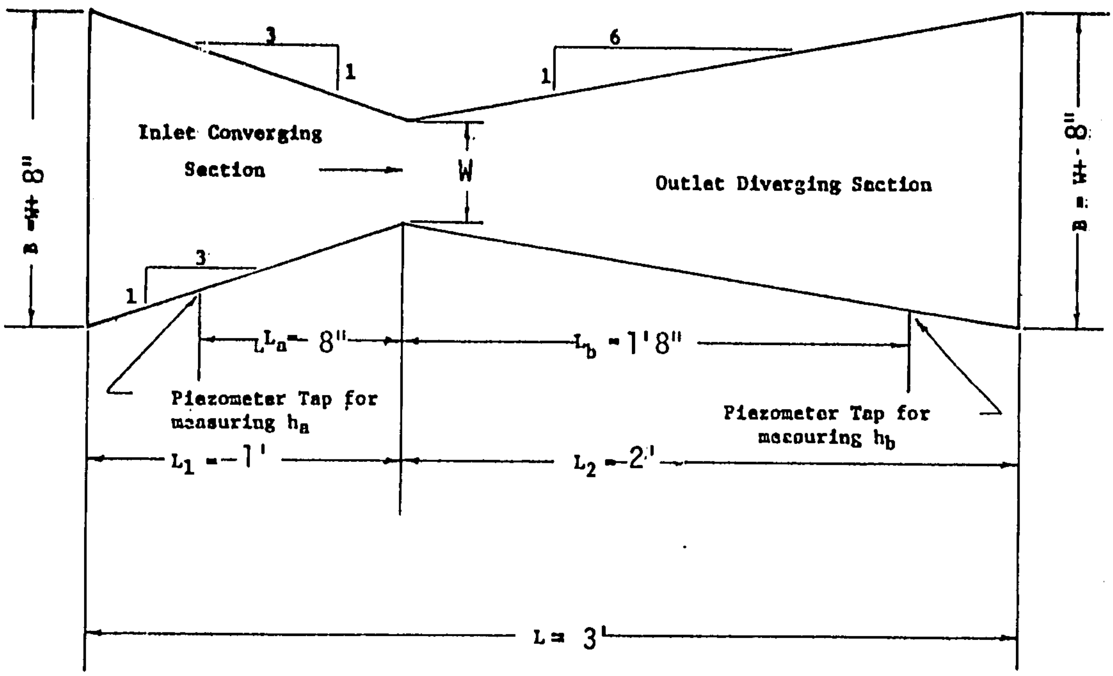


Figure 1. Dimensionless Design for Cutthroat Flume

Where,

W = width at the throat (ft.)

The flume dimensions at the throat should be within 1/16" whereas at converging and diverging ends the width should not vary more than 1/8". The walls should be vertical with respect to flat bottom. The upstream as well as downstream gauges may be installed with or without stilling wells. Vertical gauge placement as well as flume squareness can be tested by setting a leveled flume in shallow ponded water and comparing gauge readings with actual measured depths.

A. Installation of Flume:

1. Approach the farmer on whose field measurement is to be done in such a way that he understands the objectives and benefits of discharge measurement program.

2. Check the flume dimensions and squareness to ensure that they meet the standard specifications.

3. Mark the suitable positions on the walls of flume for its orientation for levelling.

4. Select a section of watercourse which is relatively straight and narrow.

5. Place the flume in the center of the channel such that the smaller converging section faces upstream.

6. In case the watercourse has curved bottom, it should be flattened by either scraping the sides or placing the soil in the center.

7. Place spirit level on predetermined positions to level the flume for its longitudinal as well as transverse direction.

8. Block the space of watercourse at the sides of the flume with soil keeping the flume in level position.

9. Check the flume bottoms and sides for any leakage.

10. The leak may be removed by placing the mud on upstream side.

11. Check the level of flume before taking readings.

12. Allow flume readings to become steady. This may require as much as 30-40 min. in long flat channels.

13. Recheck levelness and for leakage before each reading.

B. Conveyance Losses:

For determination of conveyance losses through a watercourse, the following steps may be taken:

1. Install the first flume near mogha such that is does not additionally submerge the mogha. If submergence is a problem, install the flume at least 200 feet below the mogha with minimal head loss.

2. Install the second flume at the downstream end of the watercourse under test.

3. Record the gauge readings (both h_a and h_b in case of submerged and only h_a in free flow) of both the flumes at regular intervals.

4. Determine the corresponding discharge readings using calibration charts and plot this discharge data of both the flumes on a graph paper.

5. The average discharge values, Q1 and Q2, may be determined through arithmetic average of steady state discharge value.

6. The data should be carefully recorded in the field book for use in the classroom to calculate conveyance percentage.

Recording Flow Data

After the flume is properly installed one should wait for sufficient time till the flow reaches a steady state before the gauge readings are started. This is because the section through which the water has to flow (flume throat) restricts the flow and therefore, causes an increase of the upstream depth and storage of water in the upstream section of the channel. This results in reduced flow (Actual Flow - Rate of Storage) for the initial period of flume installation. Sufficient time should be given to allow the ditch storage to stop so that the flow through the flume is the same as the normal flow through the channel. Several readings of identical values should be obtained to ensure steady state flow.

Flume Selection

For selection of suitable size of flume, the following should be considered:

1. Size of stream (discharge)
2. Depth of flow in the channel
3. Gradient of the channel
4. The free board in the channel
5. Allowable head loss in flume

Since most of the channels in Pakistan have flatter gradients with very little free board, in many cases, the flumes should be installed to operate under submerged flow conditions. For reliable discharge measurements, the submergence should not exceed 85%. The problem of overtopping can be minimized by careful installation and observation. Bank freeboards should be built up to stop any unavoidable overtopping. If the channel has a steep slope, the flume should be installed to operate under free flow condition. The discharge tables may help in selecting a proper flume size if the stream conditions are known.

FIELD WORK

The students will be taken to the field and practice installing a flume for ½ day. The students will then go to a watercourse and install Cutthroat flumes and measure the conveyance losses of a watercourse over the entire length of the main watercourse.

Subject: DATA REDUCTION OF FLUME MEASUREMENTS AND CONVEYANCE LOSSES

Trainer Agricultural Engineer

Class Room 4 hours

Field 0 Days

OBJECTIVES

To train the students in using the data from flume measurements for discharge estimation which may be further utilized for determination of the conveyance efficiency of existing watercourses and for designing new channels.

MATERIALS NEEDED

1 - Engineering field book

2 - Pencil

3 - Eraser

4 - Graph paper

TRAINING AIDS

None

INTRODUCTION

Installation of a flume in a watercourse causes some head loss which is produced by increasing the depth of water on the upstream side. This results in discharge values which are decreased initially and slowly approaches a steady state flow when the upstream head (h_a) becomes stable. Therefore, it is advisable to start taking flume readings only after suitable time period following installation of flume. Average discharge may, however, be calculated by taking arithmetic mean of steady state discharge values for given period of time. Discharge calibration charts for free as well as submerged flow condition, are included in Tables 1 and 2. Fluctuations maybe observed in discharge data from time to time which may be due to the one or some of the following reasons:

1. Fluctuations in head in the canal.
2. Obstructions in the canal outlet.
3. Overtopping in the watercourse on upstream side.
4. Leaks through broken bunds, nakkas or mole holes.
5. Sudden drops in discharge values due to washing of nakkas or stealing of water upstream.
6. Diversion of water to some other watercourse upstream.
7. Obstructions in the watercourse which may be due to human or animal entrance in the watercourse.
8. Farmer changing the field irrigated from a higher to a lower one or vice-versa, which changes the channel storage. Such a change will affect h_b readings and flow rates as the flume is submerged.

Sudden drops in h_a, and therefore, discharge, have been found to be mostly due to the reasons mentioned under item 4, 5, 6 and 8. However, other reasons may also contribute. Fluctuations in the canal head are usually gradual.

PRESENTATION

The data collected from flume consists of:

1. h_a (upstream head)
2. h_b (downstream head)

The flow condition may be determined through the ratio of h_b to h_a. The flow remains free as long as $\frac{h_b}{h_a}$ does not exceed 0.65 and discharge values may be obtained through using free flow calibration chart. In case $\frac{h_b}{h_a}$ exceeds 0.65 submerged flow table should be used which needs h_a and h_a - h_b values. Average discharge value may be computed for both the flumes upstream and downstream of a watercourse. These discharge data may be transferred to a graph in order to observe fluctuations in discharge as well as to determine upstream storage. Discharge may also be found from the graph. A sample graph is attached as Figure 1.

Conveyance losses consist of seepage from the watercourse to groundwater, evaporation, transpiration, loss through leaky nakkas, mole holes and cracked bunds and overtopping from the banks of watercourses, etc. Water loss may be expressed in terms of Delivery Efficiency or percent loss of discharge in the upstream section.

$$\text{Delivery efficiency, } E_d(\%) = \frac{\text{Discharge from downstream flume 2}}{\text{Discharge from upstream flume 1}} \times 100 = \frac{Q_2}{Q_1} \times 100$$

$$\text{Percent Loss} = \frac{Q_1 - Q_2}{Q_1} \times 100 = 1-E_d$$

Loss may also be expressed in terms of length of the channel or wetted surface area, which is the product of wetted perimeter and length of channel.

$$\text{Loss Rate (lps/100m)} = \frac{Q_1 - Q_2}{\text{Length of Channel (100 m)}}$$

$$\text{Percent Loss Rate (\%/100 m)} = \frac{Q_1 - Q_2}{Q_1 \times L}$$

APPLICATIONS

Flow data from a flume may be plotted to observe the fluctuations in discharge with respect to time or season. Moreover, discharge values may be utilized in determination of the amount of irrigation application, application efficiency, conveyance efficiency as well as losses by different means. Due to the critical entrance characteristics of the 1.5 ft. flume, it should not be used in the field. The 3 ft. flume is best suited for use in the field under ordinary conditions.

Table 1. Free Flow Discharge Tables for 3' Cutthroat Flumes

ha (ft)	Discharge (lps) Flume Dimensions		
	4"x3'	8"x3'	12"x3'
0.02	0.0	0.1	0.1
0.04	0.1	0.2	0.3
0.06	0.2	0.5	0.7
0.08	0.4	0.8	1.2
0.10	0.6	1.2	1.8
0.12	0.8	1.7	2.6
0.14	1.1	2.3	3.4
0.16	1.4	2.9	4.4
0.18	1.8	3.6	5.4
0.20	2.1	4.3	6.6
0.22	2.5	5.2	7.9
0.24	3.0	6.1	9.2
0.26	3.5	7.0	10.7
0.28	4.0	8.1	12.2
0.30	4.5	9.2	13.9
0.32	5.1	10.3	15.6
0.34	5.7	11.5	17.5
0.36	6.3	12.8	19.4
0.38	7.0	14.2	21.5
0.40	7.6	15.6	23.6
0.42	8.4	17.0	25.8
0.44	9.1	18.6	28.1
0.46	9.9	20.1	30.5
0.48	10.7	21.8	33.0
0.50	11.5	23.5	35.6
0.52	12.4	25.2	38.2
0.54	13.3	27.0	41.0
0.56	14.2	28.9	43.8
0.58	15.1	30.8	46.7
0.60	16.1	32.8	49.8
0.62	17.1	34.9	52.8
0.64	18.2	37.0	56.0
0.66	19.2	39.1	59.3
0.68	20.3	41.3	62.6
0.70	21.4	43.6	66.1
0.72	22.5	45.9	69.6
0.74	23.7	48.3	73.2
0.76	24.9	50.7	76.9
0.78	26.1	53.2	80.6
0.80	27.4	55.7	84.5
0.82	28.6	58.3	88.4
0.84	29.9	61.0	92.4
0.86	31.3	63.7	96.5
0.88	32.6	66.4	100.7
0.90	34.0	69.2	104.9
0.92	35.4	72.1	109.2
0.94	36.8	75.0	113.6
0.96	38.3	78.0	118.1
0.98	39.8	81.0	122.7
1.00	41.3	84.1	127.4
1.02	42.8	87.2	132.1
1.04	44.3	90.3	136.9
1.06	45.9	93.6	141.8
1.08	47.5	96.8	146.7
1.10	49.2	100.2	151.8
1.12	50.8	103.5	156.9
1.14	52.5	107.0	162.1
1.16	54.2	110.4	167.3
1.18	56.0	114.0	172.7
1.20	57.7	117.6	178.1
1.22	59.5	121.2	183.6
1.24	61.3	124.9	189.2
1.26	63.1	128.6	194.8
1.28	65.0	132.4	200.6
1.30	66.9	136.2	206.4
1.32	68.8	140.1	212.3
1.34	70.7	144.0	218.2
1.36	72.7	148.0	224.2
1.38	74.6	152.0	230.3
1.40	76.6	156.1	236.5

Table 2. Submerged Flow Discharge Tables for 4" x 3' Cutthroat Flumes (flow rate in lps).

ha (ft)	ha-hb (ft) .02	.04	.06	.08	.10	.12	.14	.16	.18	.20	.22	.24	.26	.28	.30	.32	.34	.36	.38	.40
0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.10	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.14	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.16	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	2	1	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
0.20	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0
0.22	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0
0.24	2	2	3	2	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0
0.26	3	3	3	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0
0.28	3	3	3	3	3	4	3	3	3	3	4	4	0	0	0	0	0	0	0	0
0.30	3	3	4	3	4	4	4	4	4	4	4	4	4	0	0	0	0	0	0	0
0.32	3	3	4	4	4	5	4	4	4	4	5	5	5	4	0	0	0	0	0	0
0.34	4	4	5	4	5	6	5	5	5	5	6	6	6	5	5	0	0	0	0	0
0.36	4	4	5	5	6	6	6	6	5	5	6	6	6	6	6	6	0	7	0	0
0.38	4	5	6	5	6	7	6	6	6	6	7	7	7	7	7	7	7	7	0	0
0.40	5	5	7	6	7	8	7	7	7	7	8	8	8	8	8	8	8	8	8	0
0.42	5	6	7	7	7	9	8	8	8	8	8	8	8	8	8	8	8	9	8	8
0.44	6	7	8	8	8	10	9	9	9	9	9	9	9	9	9	9	9	9	9	9
0.46	6	8	8	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
0.48	7	8	9	10	10	11	10	11	11	11	11	11	11	11	11	11	11	11	11	11
0.50	7	9	10	10	11	12	11	11	11	11	11	11	11	11	11	11	11	11	11	11
0.52	8	10	10	11	11	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12
0.54	8	10	11	11	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
0.56	9	11	11	12	13	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
0.58	9	11	12	13	14	15	14	15	15	15	15	15	15	15	15	15	15	15	15	15
0.60	9	12	13	13	14	15	15	16	16	16	16	16	16	16	16	16	16	16	16	16
0.62	9	12	13	14	15	16	16	17	17	17	17	17	17	17	17	17	17	17	17	17
0.64	10	13	14	14	16	17	17	17	18	18	18	18	18	18	18	18	18	18	18	18
0.66	10	13	15	15	17	17	18	18	19	19	19	19	19	19	19	19	19	19	19	19
0.68	11	14	15	16	18	18	19	19	20	20	20	20	20	20	20	20	20	20	20	20
0.70	11	15	16	17	18	19	20	20	21	21	21	21	21	21	21	21	21	21	21	21
0.72	12	15	17	17	19	20	21	21	22	22	22	22	22	22	22	22	22	22	22	22
0.74	12	16	17	18	20	21	22	22	23	23	23	23	23	23	23	23	[illegible]	23	[illegible]	[illegible]
0.76	13	17	18	19	21	22	23	23	24	24	24	24	25	25	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.78	13	17	19	20	22	23	24	24	25	25	25	26	26	26	26	26	26	26	26	26
0.80	14	18	20	21	23	24	25	25	26	26	27	27	27	27	27	27	27	27	27	27
0.82	14	19	20	22	24	25	26	26	27	27	28	28	28	28	28	28	28	28	28	28
0.84	15	19	21	23	25	26	27	28	28	29	29	29	29	29	29	29	29	29	29	29
0.86	15	20	22	24	26	27	28	29	29	30	30	30	31	31	31	31	31	31	31	31
0.88	16	21	23	25	26	28	29	30	30	31	31	32	32	32	32	32	32	32	32	32
0.90	16	21	24	26	27	29	30	31	32	32	33	33	33	33	33	33	33	33	33	33
0.92	17	22	24	27	28	30	31	32	33	33	34	34	35	35	35	35	35	35	35	35
0.94	17	23	25	28	29	31	32	33	34	35	35	36	36	36	36	36	36	36	36	36
0.96	18	24	26	28	30	32	33	34	35	36	36	37	37	37	38	38	38	38	38	38
0.98	19	24	27	29	31	33	34	35	36	37	38	38	39	39	39	39	39	39	39	39
1.00	19	25	28	30	32	34	35	37	37	38	39	39	40	40	40	41	41	41	41	41
1.02	20	25	29	31	33	35	37	38	39	40	40	41	41	42	42	42	42	42	42	42
1.04	20	26	29	32	34	36	38	39	40	41	42	42	43	43	43	44	44	44	44	44
1.06	21	27	30	33	35	37	39	40	41	42	43	44	44	44	45	45	45	45	45	45
1.08	21	28	31	34	36	38	40	41	42	43	44	45	45	46	46	47	47	47	47	47
1.10	22	29	32	35	38	39	41	43	44	45	46	46	47	47	48	48	48	48	48	48
1.12	23	30	33	36	39	41	42	44	45	46	47	48	48	49	49	50	50	50	50	50
1.14	23	30	34	37	40	42	43	45	46	47	48	49	50	50	51	51	51	52	52	52
1.16	24	31	35	38	41	43	45	46	48	49	50	51	51	52	52	53	53	53	53	53
1.18	24	31	36	39	42	44	46	48	49	50	51	52	53	53	54	54	55	55	55	55
1.20	25	32	37	40	43	45	47	49	50	52	53	54	54	55	55	56	56	57	57	57
1.22	26	33	37	41	44	46	48	50	52	53	54	55	56	57	57	58	58	58	58	59
1.24	26	34	38	42	45	48	50	52	53	54	56	57	57	58	59	59	60	60	60	60
1.26	27	34	39	43	46	49	51	53	54	56	57	58	59	60	60	61	61	62	62	62
1.28	28	35	40	44	47	50	52	54	56	57	58	60	60	61	62	62	63	63	64	64
1.30	28	36	41	45	49	51	54	55	57	59	60	61	62	63	64	64	65	65	65	66
1.32	29	37	42	46	50	52	55	57	59	60	61	63	64	64	65	66	66	67	67	67
1.34	30	38	43	47	51	54	56	58	60	62	63	64	65	66	67	68	68	69	69	69
1.36	30	38	44	48	52	55	57	60	61	63	64	66	67	68	69	69	70	70	71	71
1.38	31	39	45	50	53	56	59	61	63	65	66	67	68	69	70	71	72	72	73	73
1.40	32	40	46	51	54	57	60	62	64	66	68	69	70	71	72	73	73	74	74	75

Table 3. Submerged Flow Discharge Tables for 8" x 3' Cutthroat Flumes (flow rate in lps).

ha (ft)	ha-hb (ft) .02	.04	.06	.08	.10	.12	.14	.16	.18	.20	.22	.24	.26	.28	.30	.32	.34	.36	.38	.40
0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.04	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.06	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.08	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.10	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.14	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.16	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
0.20	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0
0.22	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0
0.24	2	2	3	3	3	3	3	2	3	3	3	0	0	0	0	0	0	0	0	0
0.26	3	3	3	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0
0.28	3	3	4	4	3	4	4	4	4	4	4	4	4	0	0	0	0	0	0	0
0.30	3	4	4	4	4	4	4	4	4	4	4	4	4	4	0	0	0	0	0	0
0.32	3	4	5	5	4	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0
0.34	4	5	5	5	5	5	6	6	6	5	6	6	6	6	6	6	0	0	0	0
0.36	4	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	0	0
0.38	4	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0	0
0.40	5	6	7	7	7	7	8	8	7	8	8	8	8	8	8	8	8	8	0	0
0.42	5	6	7	8	8	8	8	8	8	8	8	9	8	8	8	8	8	8	8	[illegible]
0.44	5	7	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
0.46	6	7	8	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
0.48	6	8	9	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11
0.50	7	8	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
0.52	7	9	10	11	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
0.54	8	10	11	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
0.56	8	10	11	12	13	13	13	14	14	14	14	14	14	14	14	14	14	14	14	14
0.58	9	11	12	13	14	14	14	15	15	15	15	15	15	15	15	15	15	15	15	15
0.60	9	11	13	14	15	15	15	16	16	16	16	16	16	16	16	16	16	16	16	[illegible]
0.62	9	12	13	14	15	16	16	17	17	17	17	17	17	17	17	17	17	17	17	17
0.64	10	12	14	15	16	17	17	17	18	18	18	18	18	18	18	18	18	18	18	19
0.66	10	13	15	16	17	17	18	18	19	19	19	19	19	19	19	19	19	19	19	19
0.68	11	14	15	17	18	18	19	19	20	20	20	[illegible]	20	20	20	20	20	20	20	20
0.70	11	14	16	[illegible]	19	19	[illegible]	20	21	[illegible]	[illegible]	21	21	21	21	21	21	21	21	21
0.72	12	15	17	[illegible]	[illegible]	20	[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]	22	22	22	22	22	22	22	22
0.74	12	15	17	19	20	21	22	[illegible]	23	[illegible]	[illegible]	23	23	23	23	23	23	23	23	23
0.76	13	16	18	20	21	22	23	[illegible]	24	24	[illegible]	[illegible]	[illegible]	25	25	25	25	25	25	[illegible]
0.78	13	17	19	21	22	23	24	[illegible]	25	[illegible]	[illegible]	[illegible]	[illegible]	26	26	26	26	26	26	25
0.80	14	17	20	21	23	24	25	[illegible]	26	26	27	27	27	27	27	27	27	27	27	[illegible]
0.82	14	18	20	22	24	25	26	[illegible]	27	27	28	[illegible]	[illegible]	28	28	28	28	28	28	28
0.84	15	19	21	23	25	26	27	28	28	[illegible]	29	29	29	29	29	29	29	29	29	29
0.86	15	19	22	24	[illegible]	27	[illegible]	[illegible]	29	30	30	30	31	31	31	31	31	31	31	31
0.88	16	20	23	25	[illegible]	28	[illegible]	30	30	[illegible]	31	32	32	32	32	32	32	32	32	32
0.90	16	21	23	26	[illegible]	29	30	31	32	32	33	33	33	33	33	33	33	33	33	33
0.92	17	21	24	26	28	30	31	32	33	33	34	34	35	35	35	35	35	35	35	35
0.94	17	22	25	27	29	31	32	33	34	35	35	36	36	36	36	36	36	36	36	36
0.96	18	23	26	28	30	32	33	34	35	36	36	37	37	37	38	38	38	38	38	38
0.98	19	24	27	29	31	33	34	35	36	37	38	38	39	39	39	39	39	39	39	39
1.00	19	24	28	30	32	34	35	37	37	38	39	39	40	40	40	41	41	41	41	41
1.02	20	25	28	31	33	35	37	38	39	40	40	41	41	42	42	42	42	42	42	42
1.04	20	26	29	32	34	36	38	39	40	41	42	42	43	43	43	44	44	44	44	44
1.06	21	27	30	33	35	37	39	40	41	42	43	44	44	44	45	45	45	45	45	45
1.08	21	28	31	34	36	38	40	41	42	43	44	45	45	46	46	47	47	47	47	47
1.10	22	28	32	35	38	39	41	43	44	45	46	46	47	47	48	48	48	48	48	48
1.12	22	29	33	36	39	41	42	44	45	46	47	48	48	49	49	50	50	50	50	50
1.14	23	30	34	37	40	42	44	45	46	47	48	49	50	50	51	51	51	52	52	52
1.16	24	30	35	38	41	43	45	46	48	49	50	51	51	52	52	53	53	53	53	53
1.18	24	31	36	39	42	44	46	48	49	50	51	52	53	53	54	54	55	55	55	55
1.20	25	32	37	40	43	45	47	49	50	52	53	54	54	55	55	56	56	57	57	57
1.22	26	33	37	41	44	46	48	50	52	53	54	55	56	57	57	58	58	58	58	59
1.24	26	34	38	42	45	48	50	52	53	54	56	57	57	58	59	59	60	60	60	60
1.26	27	34	39	43	46	49	51	53	54	56	57	58	59	60	60	61	61	62	62	62
1.28	28	35	40	44	47	50	52	54	56	57	58	60	60	61	62	62	63	63	64	64
1.30	28	36	41	45	49	51	54	55	57	59	60	61	62	63	64	64	65	65	65	66
1.32	29	37	42	46	50	52	55	57	59	60	61	63	64	64	65	66	66	67	67	67
1.34	30	38	43	47	51	54	56	58	60	62	63	64	65	66	67	68	68	69	69	69
1.36	30	38	44	48	52	55	57	60	61	63	64	66	67	68	69	69	70	70	71	71
1.38	31	39	45	50	53	56	59	61	63	65	66	67	68	69	70	71	72	72	73	73
1.40	32	40	46	51	54	57	60	62	64	66	68	69	70	71	72	73	73	74	74	75

Table 4. Submerged Flow Discharge Tables for 12" x 3' Cutthroat Flumes (flow rate in lps).

ha (ft)	ha-hb (ft) .02	.04	.06	.08	.10	.12	.14	.16	.18	.20	.22	.24	.26	.28	.30	.32	.34	.36	.38	.40
0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.08	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.10	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.14	2	2	2	2	2	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.16	3	3	3	3	3	[illegible]	3	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	3	3	4	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0
0.20	3	4	4	4	4	[illegible]	4	4	4	0	0	0	0	0	0	0	0	0	0	0
0.22	4	4	5	5	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0
0.24	4	5	5	6	6	[illegible]	6	6	6	6	6	0	0	0	0	0	0	0	0	0
0.26	5	5	6	7	7	7	7	7	7	7	7	7	0	0	0	0	0	0	0	0
0.28	5	6	7	8	8	8	8	8	8	8	8	8	8	0	0	0	0	0	0	0
0.30	6	7	8	9	9	9	9	9	9	9	9	9	9	9	0	0	0	0	0	0
0.32	6	8	9	10	10	10	10	10	10	10	10	10	10	10	10	0	0	0	0	0
0.34	[illegible]	9	10	11	11	11	11	11	11	11	11	11	11	11	11	11	0	[illegible]	0	0
0.36	[illegible]	10	11	[illegible]	12	[illegible]	13	13	13	[illegible]	13	13	13	13	13	13	13	[illegible]	0	0
0.38	9	11	[illegible]	[illegible]	14	14	14	14	14	[illegible]	14	14	14	14	14	14	14	14	0	0
0.40	[illegible]	12	[illegible]	[illegible]	15	15	15	15	15	15	15	15	[illegible]	15	15	15	15	15	0	0
0.42	[illegible]	13	[illegible]	[illegible]	16	[illegible]	17	17	17	17	17	17	17	17	17	17	[illegible]	[illegible]	[illegible]	[illegible]
0.44	11	14	[illegible]	[illegible]	18	[illegible]	18	18	[illegible]	[illegible]	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.48	[illegible]	[illegible]	18	[illegible]	[illegible]	[illegible]	21	21	[illegible]	[illegible]	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21
0.50	14	17	19	[illegible]	[illegible]	[illegible]	23	23	[illegible]	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.52	[illegible]	18	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25
0.54	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27
0.56	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28	[illegible]	28	[illegible]	28	28	28	28	28	28	[illegible]	28
0.58	17	22	24	26	[illegible]	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30
0.60	18	[illegible]	[illegible]	28	29	30	31	32	32	32	32	32	32	32	32	32	32	32	32	32
0.62	19	24	27	29	31	[illegible]	33	34	34	34	34	34	34	34	34	34	34	34	34	34
0.64	20	25	28	31	33	34	35	36	36	36	36	36	36	36	36	36	36	36	36	36
0.66	21	26	30	32	34	[illegible]	37	37	38	38	39	39	39	37	39	39	39	39	37	39
0.68	22	28	31	34	36	[illegible]	39	39	40	40	41	41	41	41	41	41	41	41	41	41
0.70	23	29	33	35	38	39	40	41	42	43	43	43	43	43	43	43	43	43	43	43
0.72	24	30	34	37	39	41	42	43	44	45	45	45	45	45	45	45	45	45	45	45
0.74	25	31	36	39	41	43	44	45	46	47	47	47	47	47	47	47	47	47	47	47
0.76	26	33	37	40	43	45	46	48	48	49	50	50	50	50	50	50	50	50	[illegible]	50
0.78	27	34	39	42	45	47	48	50	51	51	52	52	52	52	52	52	52	52	52	52
0.80	28	35	40	44	46	[illegible]	50	52	53	54	54	55	55	55	55	55	55	55	55	55
0.82	29	37	42	45	48	51	52	54	55	56	57	57	57	57	57	57	57	57	57	57
0.84	30	38	43	47	50	53	55	56	57	58	59	60	60	60	60	60	60	60	60	60
0.86	31	39	45	49	52	55	57	58	60	61	61	62	62	63	63	63	63	63	63	63
0.88	32	41	46	51	54	57	59	60	62	63	64	65	65	65	65	65	65	65	65	65
0.90	33	42	48	52	56	59	61	63	64	65	66	67	68	68	68	68	68	68	68	68
0.92	34	44	50	54	58	61	63	65	67	68	69	70	70	71	71	71	71	71	71	71
0.94	36	45	51	56	60	63	65	67	69	70	71	72	73	73	74	74	74	74	74	74
0.96	37	46	53	58	62	65	68	70	71	73	74	75	76	76	77	77	77	77	77	77
0.98	38	48	55	60	64	67	70	72	74	75	77	78	78	79	79	80	80	80	80	80
1.00	39	49	56	62	66	69	72	74	76	78	79	80	81	82	82	83	83	83	93	83
1.02	40	51	58	64	68	71	74	77	79	81	82	83	84	85	85	86	86	86	86	86
1.04	41	52	60	66	70	74	77	79	81	83	85	86	87	88	88	89	89	89	87	89
1.06	42	54	62	67	72	76	79	82	84	86	87	89	90	91	91	92	92	92	92	92
1.08	44	55	63	69	74	78	81	84	87	89	90	92	93	94	94	95	95	95	95	95
1.10	45	57	65	71	76	80	84	87	89	91	93	94	96	97	97	98	98	99	99	99
1.12	46	59	67	73	78	83	86	89	92	94	96	97	99	100	100	101	102	102	102	102
1.14	47	60	69	75	81	85	89	92	94	97	99	100	102	103	104	104	105	105	105	105
1.16	49	62	71	77	83	87	91	94	97	99	101	103	105	106	107	107	108	108	109	109
1.18	50	63	73	80	85	90	94	97	100	102	104	106	108	109	110	111	111	112	112	112
1.20	51	65	74	82	87	92	96	100	103	105	107	109	111	112	113	114	115	115	116	116
1.22	52	67	76	84	90	95	99	102	105	108	110	112	114	115	116	117	118	119	119	119
1.24	54	68	78	86	92	97	101	105	108	111	113	115	117	118	120	121	121	122	122	123
1.26	55	70	80	88	94	99	104	108	111	114	116	118	120	122	123	124	125	125	126	126
1.28	56	72	82	90	96	102	106	110	114	117	119	121	123	125	126	127	128	129	130	130
1.30	58	73	84	92	99	104	109	113	117	120	122	124	126	128	130	131	132	133	133	134
1.32	59	75	86	94	101	107	112	116	119	122	125	128	130	131	133	134	135	136	137	137
1.34	60	77	88	97	104	109	114	119	122	125	128	131	133	135	136	138	139	140	140	141
1.36	62	78	90	99	106	112	117	121	125	128	131	134	136	138	140	141	142	143	144	145
1.38	63	80	92	101	108	114	120	124	128	132	135	137	139	141	143	145	146	147	148	149
1.40	64	82	94	103	111	117	122	127	131	135	138	140	143	145	147	148	150	151	152	152

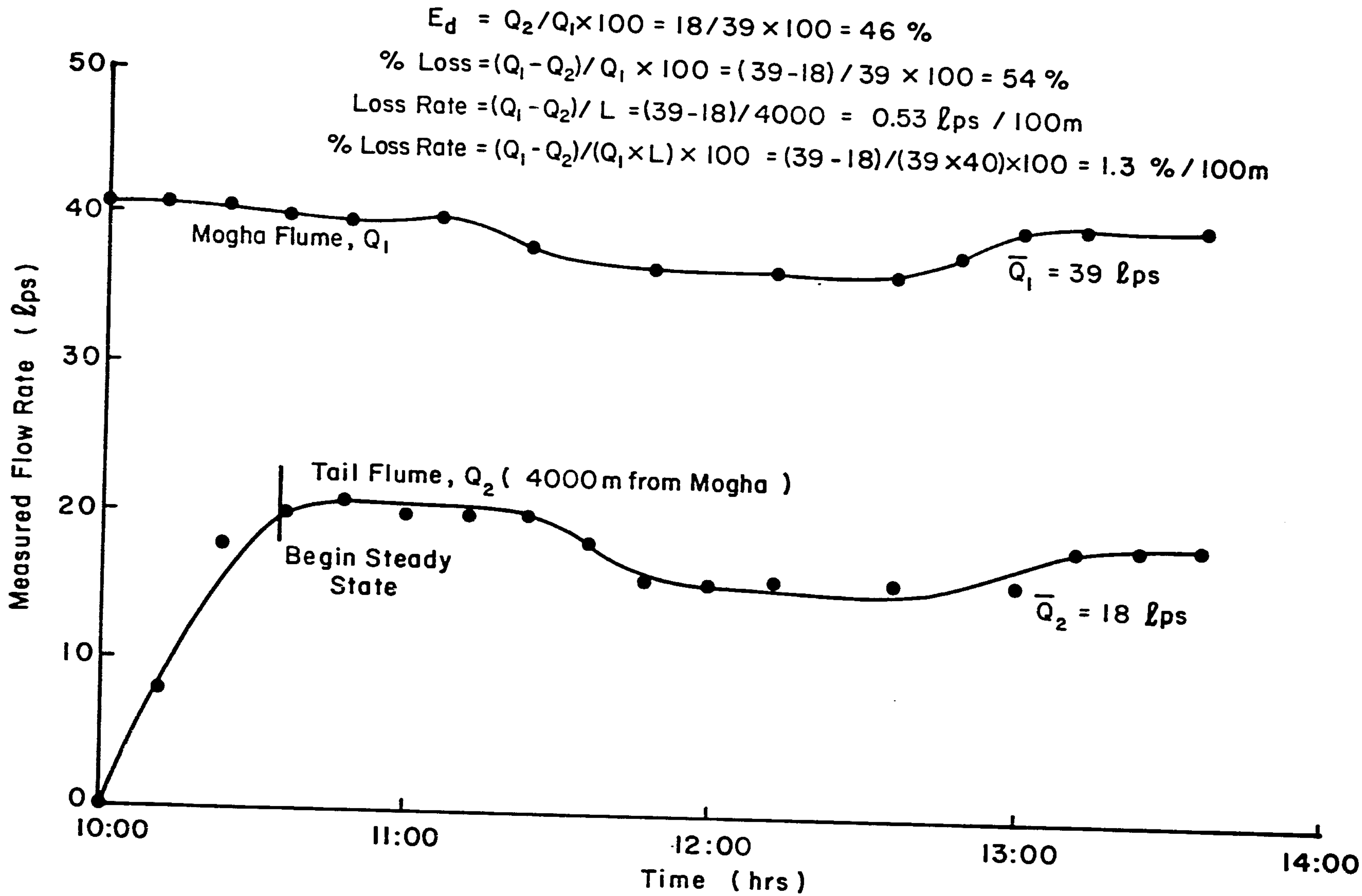


Figure 1. Illustration of Conveyance Loss Calculation.

Subject: FIELD TRIP TO IMPROVED WATERCOURSE IN THIKRIWALA

Trainer Agricultural Engineer & Agricultural Extension

Class Room 0 hours

Field 1 Days

OBJECTIVE

To demonstrate the impact of Watercourse Improvement Program on farm production.

MATERIALS NEEDED

1 - Transportation

2 - Field notebooks

3 - Questionnaire form

TRAINING AIDS

None

PRESENTATION

At Thikriwala, the Trainees will form groups, each group consisting of 3-4 persons. Each group will independently select nine farmers, three from head, three from middle and three from tail reaches of the watercourse. Out of three at each place, at least one should be a small farmer and own less than five acres.

Each farmer will be asked the following questions and his answers recorded.

a) How much time was taken to irrigate one acre before improvement?

b) How much time is taken to irrigate one acre after improvement?

c) If answer to (b) is less than (a), then ask how the farmer is using the additional supply of water. Possible answers are:

   1) Cropping more area.

   2) Changing to a higher water use crop like sugarcane or rice.

   3) Applying additional water to the same field and crops.

d) If answer to (c) is 3), then ask whether he is getting more yield due to increased irrigation or has the yield remained the same.

e) Farmers views about the program.

APPLICATION

Trainees will submit group reports along with their suggestions and conclusions regarding the effect of watercourse improvement on crop production.

Subject: FIELD TRIP TO IMPROVED WATERCOURSES AT THE MONA RECLAMATION PROJECT AREA

Trainer Agricultural Engineer
Class Room 0 hours
Field 1 Days

OBJECTIVES

1 - To show the trainees the success of the watercourse improvement program in this area and let the trainees observe the various experimental watercourse improvement techniques that have been tried.

2 - To let trainees visit with farmers to determine their feelings about watercourse improvement program.

MATERIALS NEEDED

1 - Transportation

2 - Field notebooks

TRAINING AIDS

To be handled by Mona Project Leader. He should be asked to show slides regarding the evaluation of the water management program at Mona. The film "Pakistan - A Land of Promise" should be shown.

PRESENTATION

The program will be under the direction of the Project Director. The trainees should visit several improved and unimproved watercourses. If possible, they should observe a watercourse improvement project in process.

APPLICATION

Trainees will write a brief report on the benefits of watercourse improvement.

Subject: FIELD TRIP TO IMPROVED WATERCOURSE AT CHINIOT

Trainer Agricultural Engineer
Class Room 0 hours
Field 1 Days

OBJECTIVE

To let the trainees observe an On-Farm Water Management Field Team in action in the field while supervising a watercourse improvement program.

MATERIALS NEEDED

1 - Transportation

2 - Field notebooks

TRAINING AIDS

None

PRESENTATION

Coordination will be made with the OFWM field team leader in Chiniot so the field trip can be accomplished while the team is in the process of improving a watercourse. The field team leader will take the trainees to the field and let them observe the improvement program and meet with the Farmer Watercourse Executive Committee. They will discuss the methods used to convince the farmers on the watercourse to undertake the improvement program.

APPLICATION

At the end of the day, the trainees and trainer will have a discussion regarding the improvement program and their meeting with the watercourse executive committee. The trainer will point out weaknesses or mistakes that were made by the Executive Committee or Watercourse Engineer and ways of correcting them.

Subject: WATERCOURSE DESIGN AIDS

Trainer Agricultural Engineer
Class Room 3 hours
Field 0 Days

OBJECTIVES

1 - To teach the trainees the basic information needed to design watercourses.

2 - To teach the trainees various equations used in calculating various parameters which facilitate watercourse design.

3 - To teach the simple technique of designing a watercourse.

MATERIALS NEEDED

Data from watercourse survey.

TRAINING AIDS

Topographic map, profile map, blank design sheets.

INTRODUCTION

Open Channel Design: Manning's Equation

The flow of water in channels is controlled primarily by two opposing forces: gravity, which pulls the water downhill; and friction, which resists the flow. Since the pull of gravity is essentially constant, the force exerted on the water depends upon the angle of the flow with respect to the downward gravity force or the slope of the channel. The friction which resists the flow is primarily a result of the "rubbing" of the flowing water against the bed and banks of the channel. The amount of resistance depends upon the degree of roughness (i.e., the length of vegetation, the size of clods or rocks in the bed, and the nonuniformity of the cross section), the area of contact (wetted perimeter length), and the velocity of the flowing water.

When the flow is steady and uniform, these two opposing forces--the driving and resisting forces--are equal and can be combined into the Chezy equation:

$$V = C\sqrt{RS} \tag{1}$$

where:

V = the flow velocity (m/sec),

C = a coefficient of roughness,

R = the hydraulic radius = A/WP (m),

S = the slope of the water surface (m/m),

A = the cross-sectional area (m^2), and

WP = the wetted perimeter length (m).

Manning derived an empirical equation adapting the Chezy equation for open channel flow in which the roughness coefficient, C, is equal to $R^{1/6}/n$:

$$V = (1/n)R^{2/3}\sqrt{S}, \tag{2}$$

where n is the Manning's roughness coefficient. Manning's equation is the most commonly used design equation for steady, uniform open channel flow, and is the equation which will be used to design watercourses.

Since the flow rate, Q (m^3/sec), is equal to the velocity times the cross-sectional area, Manning's equation can be written in terms of the flow rate:

$$Q = (1/n)AR^{2/3}\sqrt{S} \tag{3}$$

While designing channels, the problem usually is to design the shape and size of the channel for a desired flow rate, an available slope, and the design roughness coefficient. Manning's equation is most conveniently used if these two sets of factors are separated out:

$$AR^{2/3} = Qn/\sqrt{S} \tag{4}$$

The problem will be to determine the cross section which will give an $AR^{2/3}$, termed the hydraulic section, equal to the desired factors on the right-hand side of Equation 4.

The hydraulic section is a complex expression for most cross-sectional shapes. For example, for the trapezoidal shape:

$$A = BD + ZD^2, \text{ and} \tag{5}$$

$$WP = B + 2D\sqrt{Z^2 + 1}, \text{ so} \tag{6}$$

$$AR^{2/3} = A^{5/3}/WP^{2/3} = \frac{\{BD + ZD^2\}^{5/3}}{\{B + 2D\sqrt{Z^2+1}\}^{2/3}}, \tag{7}$$

where:

B = bottom width (m),

D = flow depth (m), and

Z = the side slope (horizontal/vertical).

These geometric parameters are shown in Fig. 1. Note that the side slope value is the opposite of a slope in the usual sense.

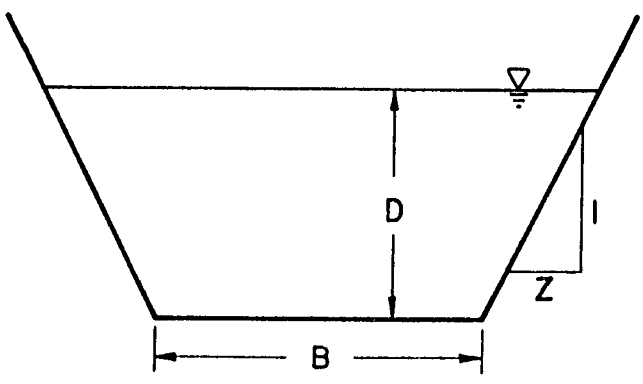


Figure 1. The trapezoidal channel cross section showing the geometric parameters used in Eqs. 5 - 7.

A solution for this equation for the three variables B, D, and Z, is possible only by trial and error, and is quite time-consuming. Consequently, graphs or nomographs are used to assist with the design process.

The trapezoidal shape shown in Fig. 1 is the most common shape for both lined and unlined small channels and so is the shape which will be used. The rectangular shape is simply a trapezoidal channel with vertical sides (Z = 0). The trapezoidal shape is fairly efficient (has a large capacity for a given wetted perimeter length), easy to design and build since a flat bottom and two straight sides are involved, and is adaptable to materials with various stabilities. The three design parameters required are defined in the figure.

Solution Graphs for Watercourse Design

Figures 2 to 4 show solutions for Mannings equation for 1:1 (Z = 1) side slopes and a roughness coefficient value of 0.04, the recommended design values for watercourses built in the most common clay or silt loam soils and kept moderately clean. Separate graphs for bed width values of 0.30, 0.45 and 0.60 m are given , which will cover most required watercourse sizes.

To use the design graphs, first choose a desired bottom width value. Generally, smaller channels will have smaller bottom widths. A couple of bottom widths can be tried and the one which results in the bottom width being about the same or slightly less than the depth should be chosen.

On the design graph for the chosen bottom width, find the design slope on the horizontal axis and the design flow rate value on the vertical axis. Move upward from the slope value and to the right from the flow rate value to where the two lines cross. At that point, the required depth can

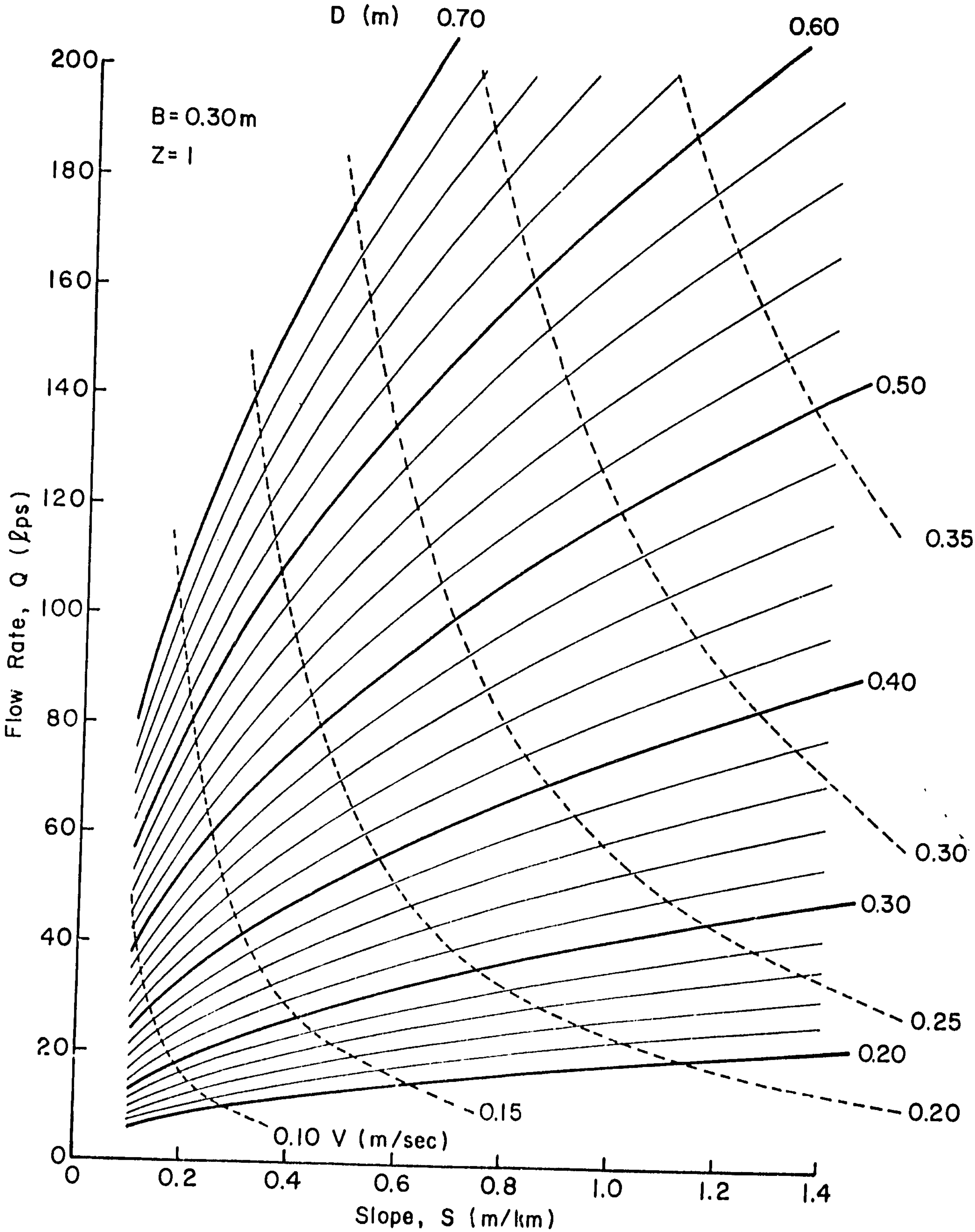


Figure 2. Design graph for earthen trapezoidal channels with bottom widths, B, of 0.30m and a roughness coefficient of 0.04.

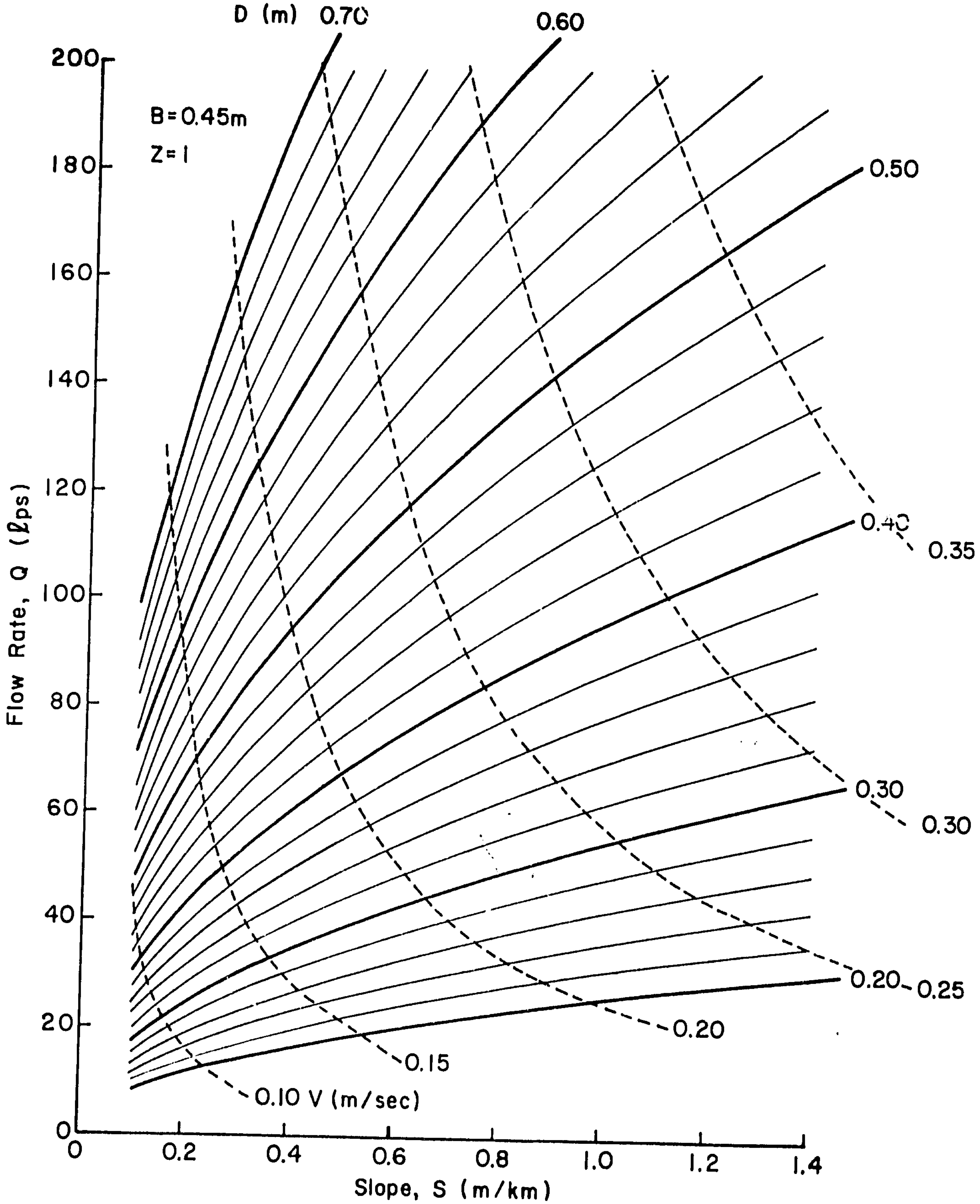


Figure 3. Design graph for earthen trapezoidal channels with bottom width, B, of 0.45m and a roughness coefficient of 0.04.

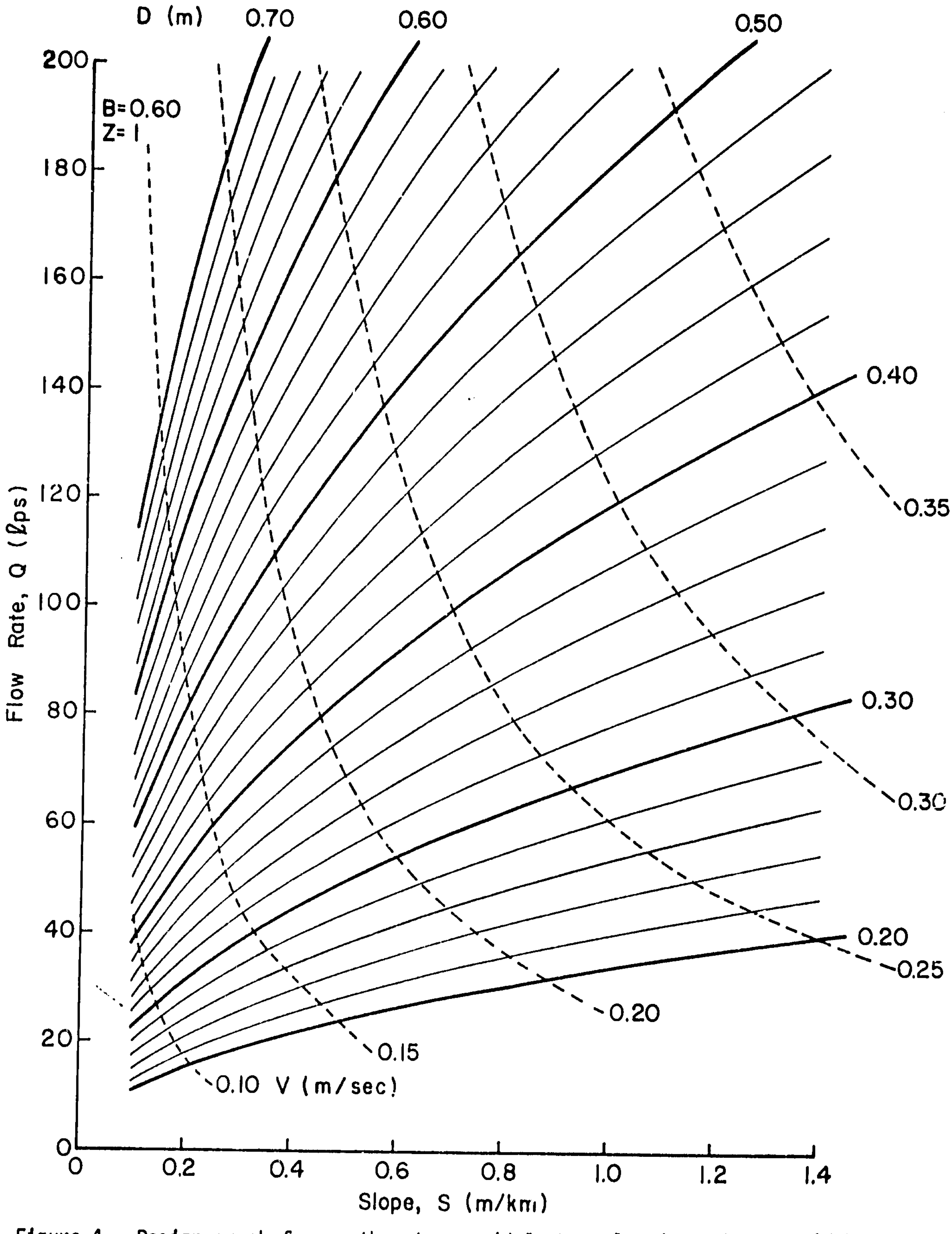


Figure 4. Design graph for earthen trapezoidal channels with a bottom width, B, of .60m and a roughness coefficient of 0.04.

be read from the depth curves. Follow the nearest curve to the right or top margin where the depth values are listed. Each depth curve represents an increase of 0.02 m. Flow velocity values can also be read from the graph at the point where the slope and flow rate lines cross. The dashed velocity lines are labelled at their bottom ends. You must interpolate values between those listed.

As an example of the use of these design graphs, suppose it is desired to design a watercourse for a slope of 0.7 m/km (0.0007 m/m) and a flow rate of 65 lps. Since this is a moderate flow rate and slope, first choose a bottom width value of 0.45 m. So on Fig. 3 (B = 0.45 m), find 0.7 on the horizontal axis and 65 (halfway between 60 and 70) on the vertical axis. Draw lines (real or imaginary) from these two values upward and to the right to where they cross. Then follow the nearest solid curve to its right end to determine to required depth, which is 0.36 m (third line above the 0.30 line - each curve represents 0.02 m). Also, the crossing point is about half way between the 0.20 and 0.25 m/sec dashed velocity curves, so the flow velocity for the channel will be about 0.22 m/sec. Since the depth is less than the bottom width, a bottom width value of 0.30 m should also be tried. From Fig. 3 (B=0.30m) a required depth of 0.41 m is read (interpolated between the D = 0.40 and D = 0.42 m lines) by the same methods just described. Either of these two designs would be OK, so the one which gives a depth closest to the design depths in the upstream and downstream sections should be chosen.

Figure 7 is a different type of design graph which can be used to design rectangular lined channels. To use this solution graph, the design hydraulic section ($Qn/\sqrt{S}$ (the right side of Eq. 4) must be calculated. The curve (or closest listed curve) for the desired hydaulic section can then be found at the top of the graph. Any combination of bottom width (horizontal

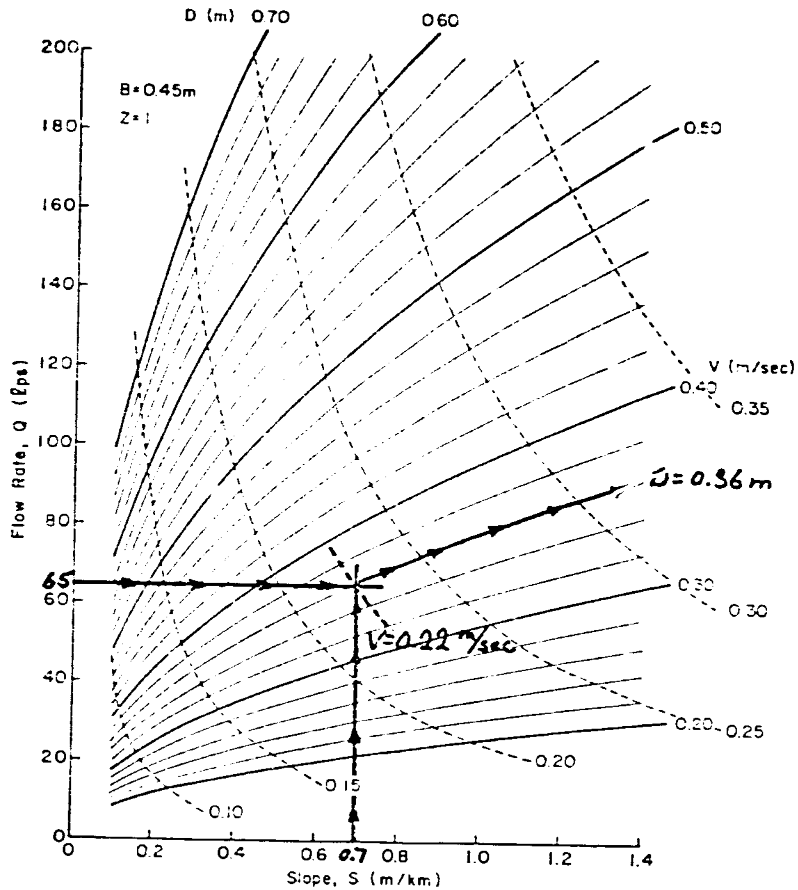


Figure 5. Solution to Example #1: design of an earthen trapezoidal channel with Z = 1 utilizing Figure 3.

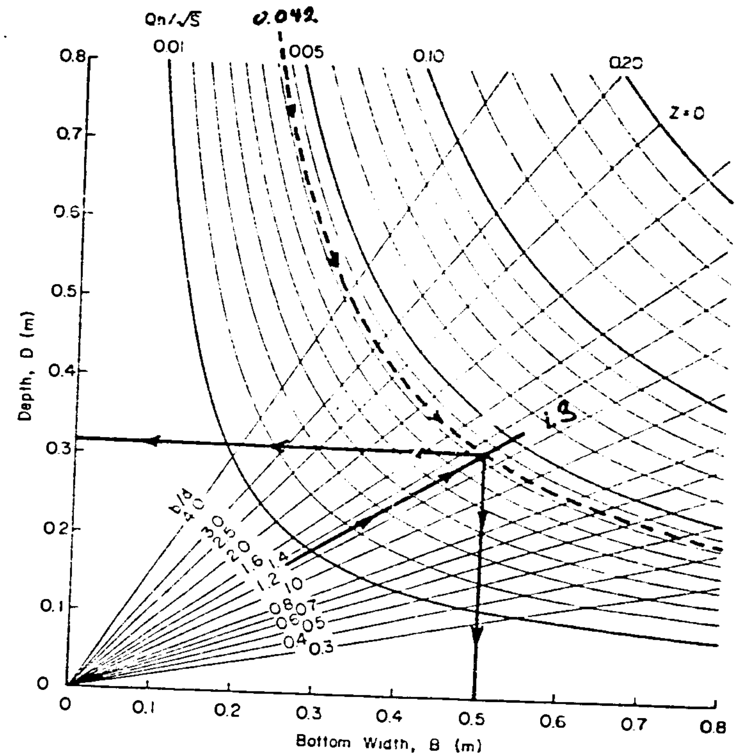


Figure 6. Solution to Example #2: design of a rectangular lined channel using Figure 7.

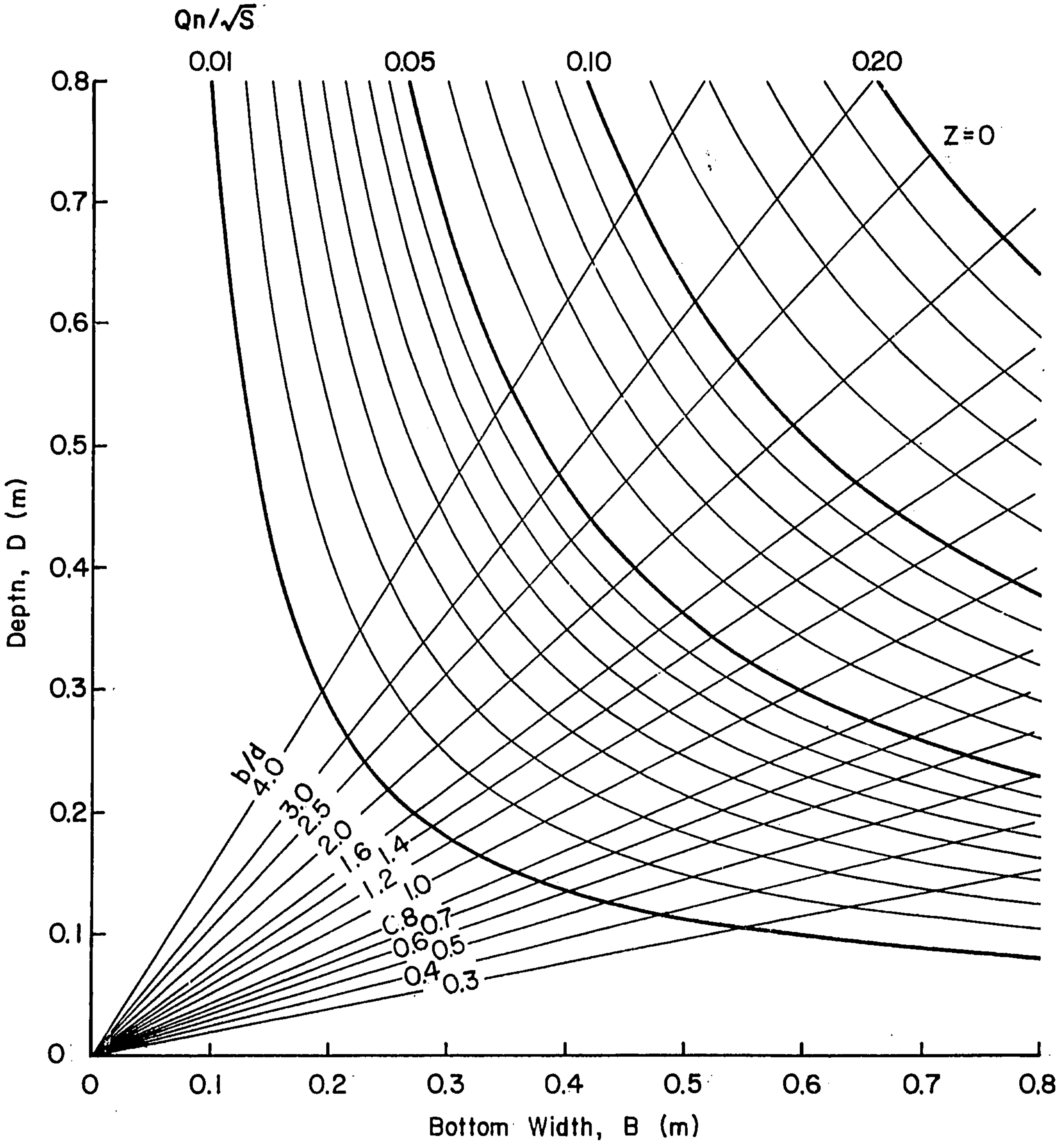


Figure 7. Design graph for lined rectangular channels including cost minimization lines.

axis) or depth (vertical axis) which falls on this curve will be proper designs. As you move down the hydraulic section curve, notice that depths decrease and bottom widths increase. The best design for a lined section would be that combinations of B and D which leads to the lowest lining costs. The lines radiating from the origin can be used to find the lowest cost combination. The b/d value is the ratio of the cost of the bottom material, per unit width, to the cost of the side materials, per unit height. The B and D values found where the proper hydraulic section line crosses this b/d cost ratio line give be the lowest cost design.

For example, as before, assume that Q = 65 lps and S = 0.7 m/km. For a lined channel, assume the roughness coefficient, n, is 0.017. So, the required hydraulic section is

$$Qn/\sqrt{S} = \frac{0.065 \text{ m}^3\text{/sec x } 0.017}{0.0007 \text{ m/m}} = 0.042.$$

(Note that Q must be in m^3/sec (or lps/1000) and S must be in m/m.) Since 0.42 lies between the lines for 0.04 and 0.045, either the closest line can be chosen, or an imaginary line can be drawn about 1/3 of the way between the 0.040 and 0.045 lines. Although any B and D values on this line, such as B = 0.30 and D = 0.58 m or B = 0.65 and D = 0.23m, will be large enough to carry the flows, certain combinations will be cheaper to build. Let's say that a channel with a 0.10 m thick concrete base and one brick thick wall is to be built. If the concrete cost is about Rs 450/m^3, the base would cost Rs 450 x 0.10 m or Rs 45 per meter width per meter length. If bricks and mortar cost Rs 300 m^3, the one brick thick wall (11.5 cm) would cost Rs 300 x 0.115 m = Rs 34.5 per meter height per meter length. Thus, the material cost ratio, b/d = 45/34.5 = 1.30. Following this interpolated b/d line until it crosses the hydraulic section line of 0.042 gives a lowest cost design of B = .50 m and D = 0.32 m. As a rule of thumb, if the side and bottom material costs are the same, B should be double D, if side costs are higher, B should be more than double D, and if bottom costs are high, the bottom width should be less than double the depth.

Calibrated Construction Guide Form Solution Method

The cross-sectional design process can be bypassed with the use of construction guide forms if channel shapes and sizes are standardized. Instead of utilizing the design graphs, solutions can be printed directly on the guide forms. These forms can then be used directly by technicians in the field.

Figure 8 shows an example of a trapezoidal form. Hydraulic section values ($Qn/\sqrt{S}$) are marked on the sides. The forms could be used either to establish the correct channel width and depths for construction or to check excavation work during or after construction. Once bank top or water surface elevations are established as will be explained later, the form will indicate the correct bottom elevation and bottom and top width for a given required hydraulic section. Since bottom widths could easily be made adjustable, one form can be used for several bottom widths as long as scales for each width are available. A new form should probably be used for each side slope value. Table 1 can be used to make such guide forms.

The scales on the side indicate the proper side length for a required flow rate, roughness coefficient, and slope, plus a freeboard allowance. If one standardized value of roughness coefficient is used, the scale could read in terms of only flow and slope ($Q/\sqrt{S}$). The scale can be developed analytically or from the design graphs.

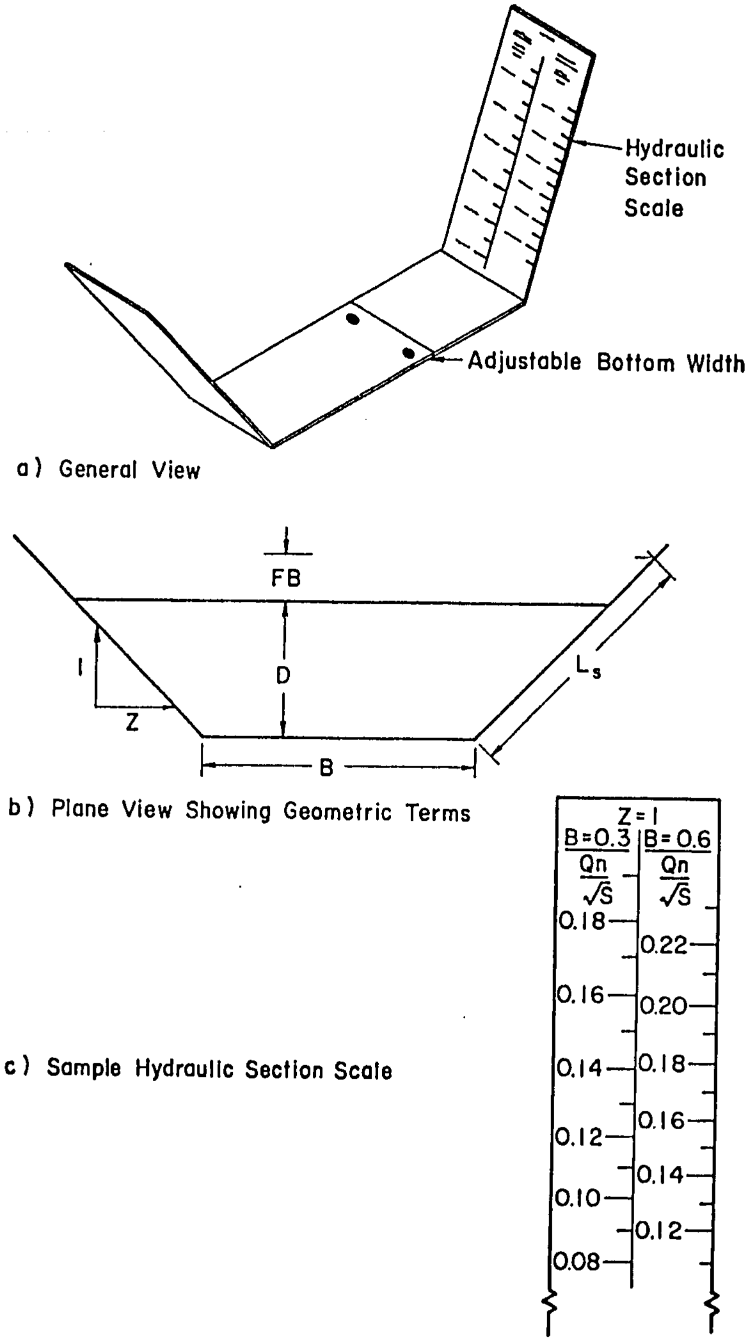


Figure 8. Trapezoidal construction guide form.

Table 1. Side length values, L_S(m), for side slope values, Z, of 1.0 and 1.5 and bottom width values, B(m), of 0.30, 0.45, and 0.60 for various hydraulic section values, $Qn/\sqrt{S}$.

$Qn/\sqrt{S}$	Z = 1			Z = 1.5		
	B=0.300 m	0.450	0.600	B=0.300 m	0.450	0.600
0.010	0.389 m	0.355 m	0.334 m	0.481 m	0.445 m	0.421 m
0.020	0.471	0.425	0.395	0.571	0.527	0.494
0.030	0.532	0.480	0.443	0.638	0.588	0.550
0.040	0.583	0.527	0.485	0.694	0.640	0.598
0.050	0.627	0.567	0.522	0.742	0.685	0.640
0.060	0.666	0.603	0.555	0.784	0.725	0.678
0.070	0.702	0.637	0.586	0.822	0.762	0.713
0.080	0.735	0.667	0.614	0.857	0.796	0.745
0.090	0.765	0.696	0.641	0.890	0.827	0.775
0.100	0.794	0.723	0.667	0.920	0.856	0.803
0.110	0.821	0.749	0.691	0.949	0.884	0.829
0.120	0.846	0.773	0.713	0.976	0.911	0.855
0.130	0.870	0.796	0.735	1.002	0.936	0.879
0.140	0.894	0.818	0.756	1.027	0.960	0.902
0.150	0.916	0.840	0.777	1.050	0.983	0.924
0.160	0.937	0.860	0.796	1.073	1.005	0.945
0.170	0.958	0.880	0.815	1.095	1.026	0.966
0.180	0.977	0.899	0.833	1.116	1.047	0.986
0.190	0.997	0.918	0.851	1.136	1.067	1.005
0.200	1.015	0.936	0.868	1.156	1.086	1.024
0.210	1.033	0.953	0.885	1.175	1.105	1.042
0.220	1.051	0.970	0.901	1.194	1.123	1.060
0.230	1.068	0.986	0.917	1.212	1.140	1.077
0.240	1.084	1.003	0.932	1.229	1.158	1.094
0.250	1.101	1.018	0.948	1.247	1.175	1.110

Choosing Irrigation Channel Design Parameters

Three parameters or values are required to design irrigation channels by the solution graphs given earlier: the roughness coefficient, n; the flow rate, Q; and, the slope, S.

Determining the Proper Roughness Coefficient

Manning's roughness coefficient for open channels varies from 0.01 in extremely smooth and uniform channels to over 0.10 in weedy irregular channels. Measurements of Manning's n were made in Pakistan earthen watercourses. Table 2 lists roughness values measured in watercourses. Figure 9 shows examples of watercourse channels with different n values.

The coefficient chosen for design depends not upon the desirable, or even intended condition of the channels, but upon the realistically expected condition. Although clean uniform channels can have n values as low as 0.02, to design for such a condition would be unrealistic. If it is truly expected that the maintenance will be good and vegetation will be regularly cleaned from the channels, a roughness value of 0.03 could be used. A value of 0.04 is more realistic for conditions in earthen watercourses and is the recommended value. Lined channels kept clean from vegetation will have a more constant n value and can be designed closer to the value in a new channel of 0.015 to 0.020.

There are both advantages and disadvantages of using a conservative roughness estimate. A conservative estimate leads to larger and more costly channels, and also gives the cultivators more leeway to allow their channels to get in bad condition. A low estimate can, if the channels are properly designed, force the users to maintain their conveyance system in good condition, but will also allow less safety factor if unusual circumstances should

Table 2. Manning's n values measured in Pakistan watercourses for various channel conditions.

Channel Condition	Measured Roughness Coefficients
lined with brick masonry	0.018
earthen, newly built, uniform, clean	0.17 - 0.032
earthen, winding, with no vegetation	0.030 - 0.035
earthen, uniform, with short grasses	0.026
earthen, winding, with grass and some weeds	0.035 - 0.055
earthen with dense weeds	0.05 - 0.20

(a) n = 0.025

(b) n = 0.035

(c) n = 0.045

Figure 9. Pakistan watercourse channels with various roughness coefficients (n).

(d) n = 0.08

(e) n>0.10

Figure 9. Pakistan watercourse channels with various roughness coefficients (n). (Cont'd.)

cause a high roughness. The freeboard allowance should, however, be sufficient to allow for most such circumstances.

Determining the Design Flow Rate

The design flow rate should be the maximum value which is expected in the watercourse. A first estimate of the value would be the measured flow rate, but several adjustments to measured values might be required.

An inquiry of the users will indicate whether the flow during the measurement is the usual rate, or if it is sometimes higher. An estimate of how much higher should be made from their estimates. If the mogha is submerged, the flow will increase after improvement, so measurements should be made during free flow conditions. It must be determined if water from other sources, such as wells, is also conveyed with or separately from the primary source.

Irrigation department officials should also be able to indicate how much the flow rate fluctuates and its relative value during the measurement. They also know the design flow rate for the mogha, as well as whether any changes in the design rate are anticipated. Mogha flow rates should always be checked with measurements in the field.

Flow measurements in different sections of the existing conveyance system will indicate how much flow is reaching each branch at the present loss rates. These loss rates will decrease after improvement with the amount of decrease depending on the type of improvement. Watercourse earthen renovation should reduce loss rates by about one-half. Lining should reduce loss rates to nearly zero. Once an after improvement loss rate is assumed, the design flow rate at the mogha can be adjusted downward for sections at some distance from the mogha by subtracting this loss rate times the conveyance distance from the mogha design rate.

$$Q_D = Q_{DM} - Q_L \times L \quad (8)$$

where

Q_D = the design flow rate in any watercourse section (lps),

Q_{DM} = the design mogha flow rate (lps),

Q_L = the assumed loss rate after improvement (lps/100 m), and

L = the distance from the mogha to the section (100 m).

For example, if measurement plus Irrigation Department records indicate that the maximum inflow rate to a watercourse is 55 lps, and experience has shown that an earthen renovation program reduces losses to about 0.5 lps/100 m, the design flow rate into a branch located 1600 m from the inflow point would be 47 lps.

Determining the Design Slope

The most difficult of the values required for channel design to determine is the slope, S. Slope is more complicated and time-consuming to measure in the field. It is also the most flexible design parameter, and is thus the one which is usually adjusted if the channel design is not satisfactory (i.e., flow velocities are too fast or slow).

The slope of an open channel really refers to the change in energy of the water in the channel over some distance. In a steady and uniformly flowing channel, this is equivalent to the change in elevation of the water surface over a given length of channel. Consequently, the slope of a channel refers to the slope of the water surface and not necessarily of the channel bottom. Designing for the water surface is also convenient since the water surface elevation determines whether fields can be adequately served or whether banks will be overtopped. Channel bottom elevations are calculated later by subtracting the design depth, D, from the water surface elevation;

and bank top elevations will be the water surface elevation plus a freeboard allowance.

The most thorough and accurate procedure to determine watercourse design slopes will involve determining the water surface elevation required at each point in the system to adequately irrigate the commanded land. Watercourse elevation and slope calculations will consequently begin at the fields at the tail of the system and move up-channel including progressively more of the commanded fields in the design. The channels will follow the natural land surface as close as possible so that construction costs are minimized. This design process will continue until the mogha is reached, at which point a check must be made that the system can be served by the mogha.

Design slopes for channels are dependent upon seven factors:

1. the channel layout,
2. the water surface elevation required to adequately irrigate each field,
3. the elevation of the water supply source, i.e., mogha or well outflow,
4. the topography of the land around the channels,
5. any head losses in the system,
6. limiting velocities of the water in the channels, and
7. the elevations of permanent structures.

The first information needed to design watercourse slopes is a base map of the commanded area, from which the locations and lengths of all the channels can be determined. The method of obtaining a base map will vary. A prepared base map should be available from the canal patwari or irrigation department SDO. The accuracy of the maps should be checked in the field because most are out-of-date. Aerial photographs, if available in a large enough scale, can also be used to construct or verify base maps.

If no maps or photos are available, a base map must be made from field measurements. If the command area and fields are relatively rectangular in shape, and the channels are relatively straight, such a map can be made by drawing a sketch and taping or pacing the distances. If the field shapes are irregular and channels meander (Kishtiwar), a plane table and peep-sight alidade can be used to construct a base map. The equipment required for plane tabling is simple and inexpensive, but the procedure requires a large amount of time. The alternative to the plane table method is the use of a transit and regular surveying techniques, which requires expensive equipment in addition to a large amount of time. The accuracy obtainable with a transit is not required.

Once the base map is available indicating watercourse locations and lengths, field locations and naccas, a topographic survey must be conducted to determine the elevations of the commanded fields. The objective of the measurement is to determine the required elevation of the water in the watercourse to adequately irrigate the fields. For level basins, the desired elevation will be of the average land surface in each field. If the basins are relatively flat and small, one elevation determination per bunded unit should be sufficient. If they are larger and uneven, several measurements might be necessary to determine an average value. If the fields are irrigated down slopes using either borders or furrows, the elevation at the top of the field near the nacca is required since that establishes the required water supply elevation. The precision required of the topographic survey will depend upon the general slope of the area. Small topographic fluctuations will be important in a relatively flat area, while only a few shots are required to determine the slope of an area with more relief. The first step in a topographic survey is to survey bench marks scattered around the command area from which field surveys can be run. Other lectures will discuss bench mark and topographic surveys.

During the topographic surveying, all permanent structures (those which will not be removed or rebuilt during channel improvement) should be noted, and their elevations measured. For example, the top and bottom elevations and size of road culverts, inverted siphon entrances and exists, and junction box elevations should be measured. Also, the elevation of the mogha should be determined. The water surface elevation below the mogha should be measured as well as the elevation of the bottom of the mogha, the type of mogha, and whether it is flowing freely and the elevation of the water surface in the canal. If the source is a well, the outflow pipe or box elevation should be measured. Field and structure elevations should be added to the base map.

Topographic lines can be sketched on the base map to indicate general land patterns and slopes and to act as a check for erroneous elevation measurements. Figure 10 shows a base map with field elevations and topographic lines of the small level basins commanded by a sarkari khal branch channel. The topographic map shows all existing farmers branches and naccas, proposed check locations and the location, elevation, and cross-sectional area of an existing culvert.

The information from the topographic map should next be transferred to a channel profile sheet to determine the design slope. Figure 11 shows a channel profile sheet for the sarkari khal branch shown in the topographic map. The horizontal axis follows the channel along its length. Location identifiers such as naccas, bends, and structures should be marked on the horizontal axis. The vertical axis of the profile sheet is elevation relative to the bench mark used in the topographic map.

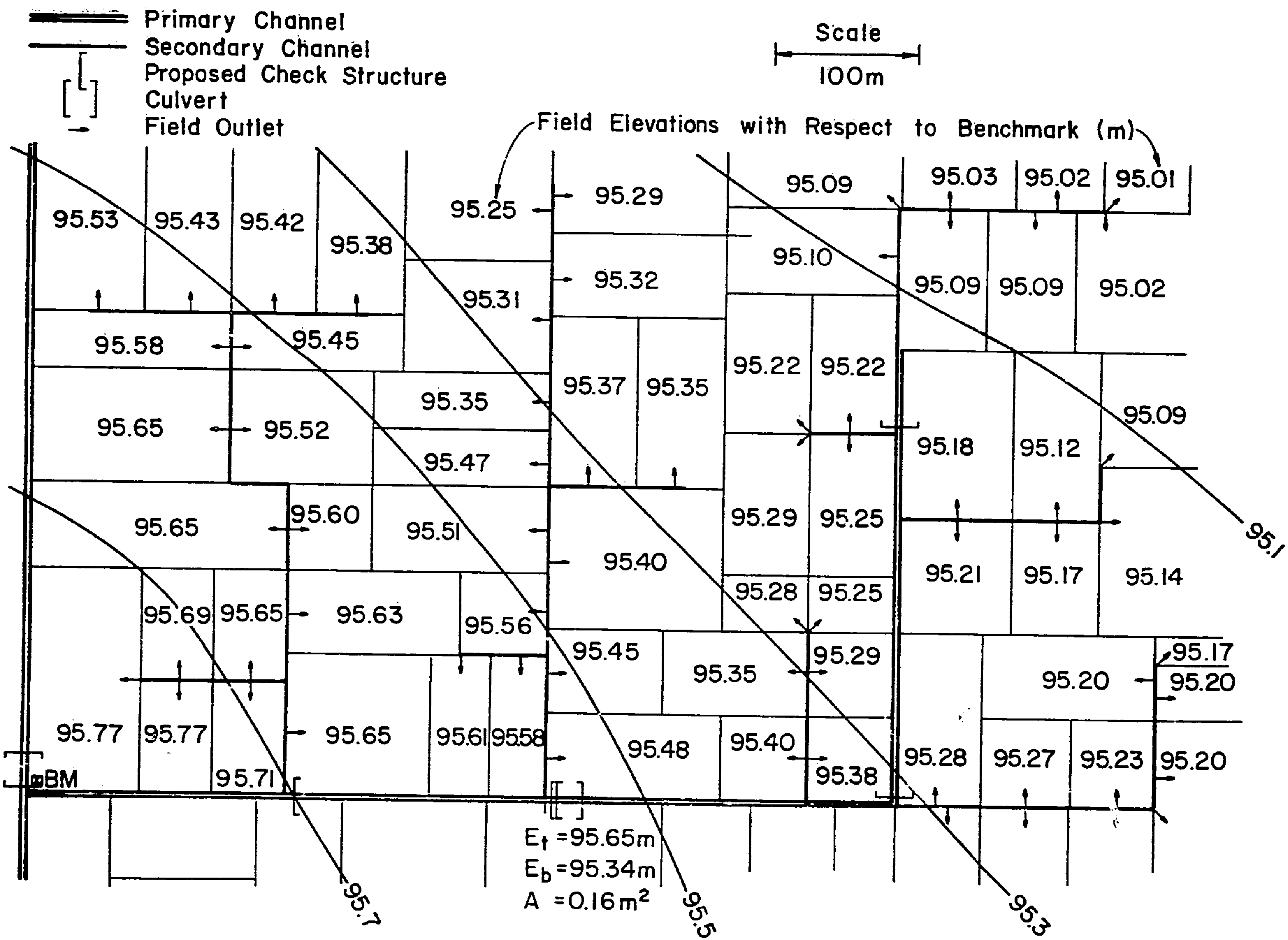


Figure 10. Topographic Map of Rectangular Basins Served by a Primary Branch Showing Channel Layout and Topographic

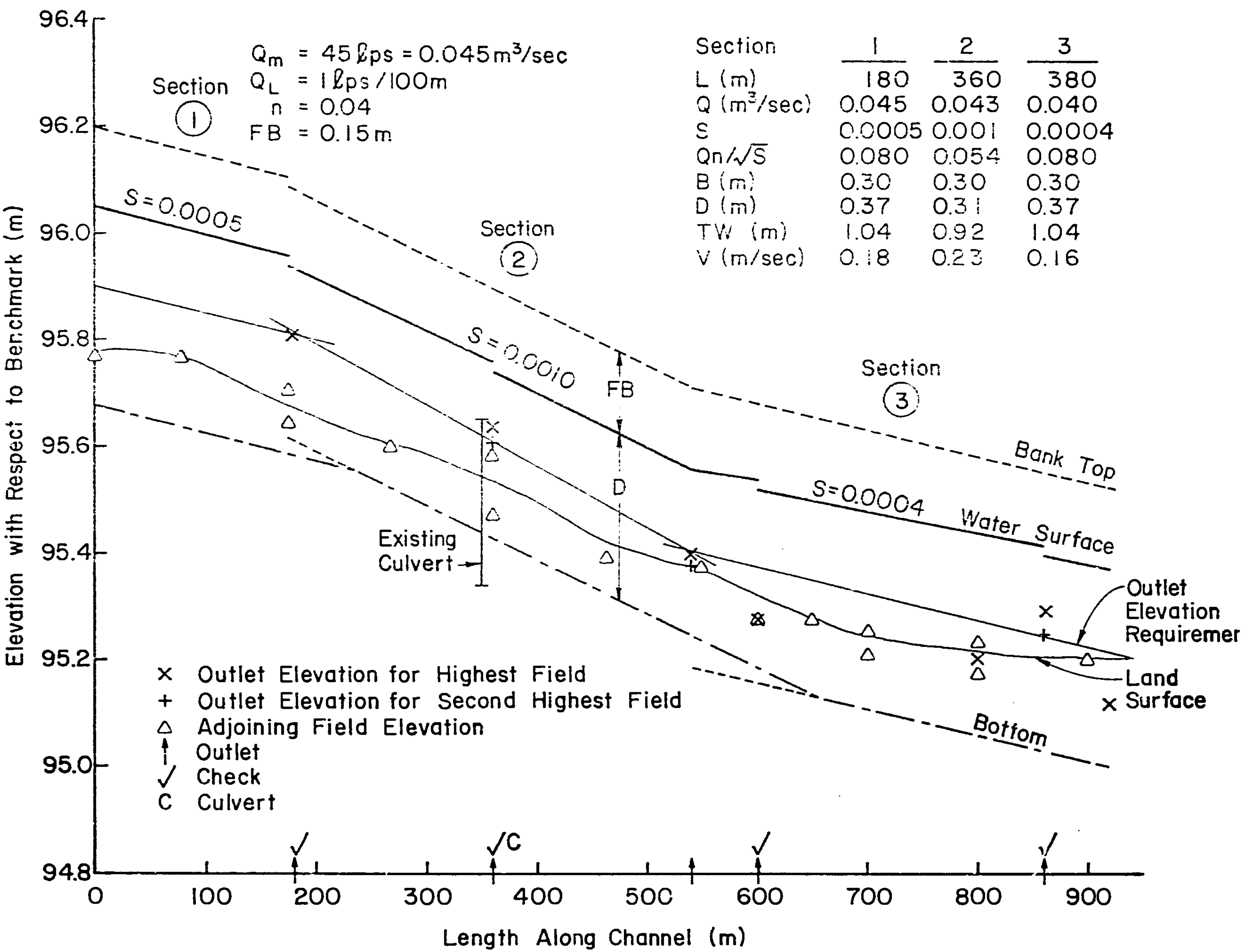


Figure 11. Sample channel profile sheet.

The next information needed on the profile sheet is the elevation required at each nacca to serve the fields. The nacca elevations can be determined from the highest fields on each farmer's branch, the field nacca's distance from the sarkari khal nucca, and an assumed slope of the branch. Since farmer's branches are usually no more than a few hundred meters in length, proper slopes aren't so critical if the freeboard is sufficient. In the example, since the area is relatively flat, a field channel slope of 0.0002 was assumed. Steeper slopes can be used in steeper areas. For every 100 m distance from the sarkari khal nacca to the field, 0.02 m was added to the field elevation to derive a required sarkari khal nacca elevation. For example, on the second branch, a field at the end of the branch is at an elevation of 95.29 m. It lies 430 m from the sarkari khal nacca, so the required nacca elevation for the field is 95.29 m + .02 m/100 m x 4.3 = 95.38 m. Because of this slope requirement, the highest field will not always require the highest nacca if fields farther from the nacca are only slightly lower. If the nacca elevation for one field is significantly higher than for the remaining fields, the elevation for the second highest field should also be marked on the profile sheet.

Top and bottom elevations of permanent structures should also be noted on the profile. Once nacca elevations are marked on the profile, the channel should be divided into sections where several naccas can be roughly connected with a straight line. These lines should pass through or above the nacca elevation marks. The number of sections should be kept as small as possible to simplify the design, yet large enough that the line doesn't pass too far above several consecutive nacca elevations.

It is desirable to build the channel as low as possible both to reduce construction costs and to reduce losses. Consequently, if one or two fields representing a small proportion of the total commanded area are higher than the others, the slope can be designed for the second or even third highest fields, as was done at the second and fifth naccas in the sample profile. Since a working head and freeboard allowance will be added to these water surface elevations, the high fields can still be served although not as easily. Plotting the elevations of fields adjacent to the channel on the profile will indicate whether the channel is high or low relative to the surrounding land.

Very flat slopes should be avoided as much as possible. Flat slopes require large channel cross sections, increasing construction costs and losses, and result in low velocities which can lead to siltation if the water is carrying sediment. Slopes less than 0.0002 are discouraged and greater than 0.0004 are preferred.

Steep slopes cause high flow velocities which can be erosive in earthen channels and can be difficult to control at bends and outlets. Maximum permissable velocities in earthen channels will depend upon the soil type, construction techniques, and vegetation cover. Velocities should generally be kept below 0.40 m/sec. If erosion in newly built channels is a problem, bank compaction, gradual initial wetting up of the channels, and establishment of vegetation can reduce potential erosion problems. Flow velocity, V (m/sec), can be taken directly from the solution graphs. If steep slopes are unavoidable, the excess velocity can be dissipated through the use of drop structures. Drop structures effectively stairstep water down a steep slope. The watercourse profile design will indicate where drops are required.

Once tentative design sections and slopes are chosen, the water surface profile can be plotted taking into consideration the mogha elevation requirement, permanent structure elevations, the working head allowance, and head losses in structures. The working head is the elevation required to push the water through the outlets and into the fields. If the working head is small, water will flow slowly from the channel into the field until the water level builds up in the channel. If channel freeboard isn't sufficient, the banks may eventually overtop unless additional field outlets are cut. Higher fields will also tend to receive less water than low fields due to this in-channel storage change. If the working head allowance is large, the channel must be built higher which increases construction costs. The recommended working head for watercourse channels is 0.15 m. This should be sufficient to easily push the water from the channels onto the fields, provide equitable distribution to most fields, and provide a safety factor for surveying or calculation errors or unexpected head losses in the system; without causing the channels to be too high and increasing construction costs and water losses. The tentative water surface profile, previously drawn at the required nacca elevations, should be redrawn to reflect the working head requirement. In the example the profile lines were raised 0.15 m.

A check must be made to insure that the proposed channel elevations are compatible with the structures which will be retained. If the water levels is too low, it must be raised or the structure must be lowered. If the water level is higher than the structures, the structures can be raised or entrance and exit structures built to siphon the flow through the structure.

Once the proposed water surface elevation at the head of the channel is determined, it must be checked whether this level is attainable from the water supply source. If the source is flexible, such as a well outflow, the source can be adapted to the channel. If a preexisting or otherwise fixed source is higher than the design surface elevation, the chosen level is OK. However, if the source outflow is below the proposed surface level, slopes must be reduced, working head reduced and/or some higher fields cannot be irrigated. In the example given, the channel is one branch of a system and the main channel will be designed to the required branch inlet elevation.

If permanent check structures, culverts, drop structures, or other structures which will impede the water flow are to be built across the watercourse, the head loss (water surface elevation drop) they will create should be taken into account. The head loss through a structure will depend primarily on two factors:

1. The amount of flow constriction, or the difference between the structure flow area and the channel cross-sectional flow area; and
2. The abruptness of the constriction--gradual converging and diverging sections will reduce head loss.

In practice, the first to these two factors is the most important. Head loss is generally proportional to the change in the velocity of the water as it passes through the constriction, squared; and since velocity is inversely related to flow area, head loss is also proportional to the difference between the square of the flow area of the channel and of the structure. Figure 12 shows the head loss through submerged orifice check structures based on the equation:

$$\Delta h = 1/C^2 \; V_s^2/2g, \qquad (9)$$

where

Δh = head loss (m),

C = an empirical coefficient ($C = 0.8$ in Fig. 12),

V_s = velocity in the structure (m/sec) = Q/A_s,

A_s = the structure flow area, and

g = acceleration of gravity (9.81 m/sec^2).

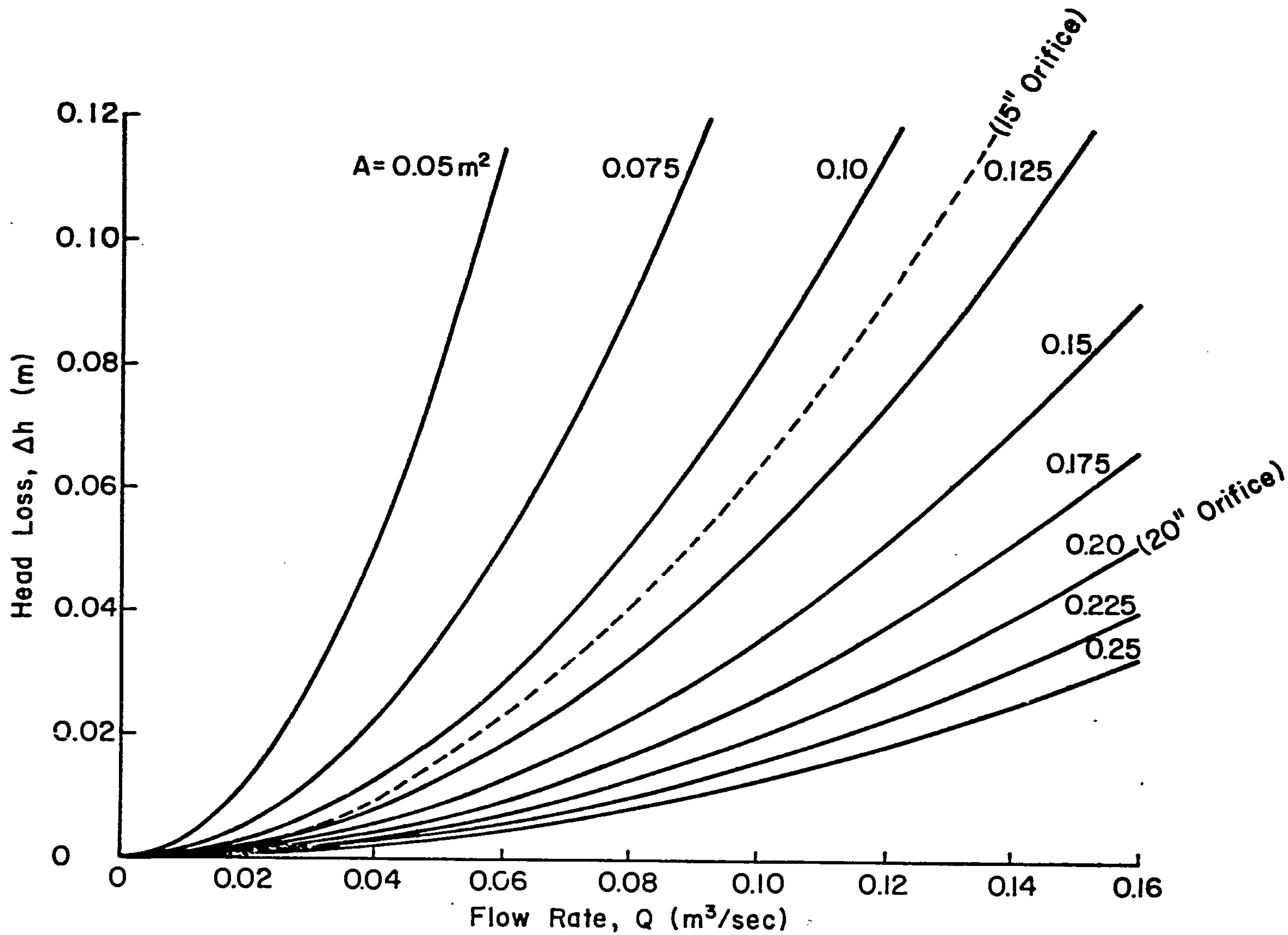


Figure 12. Head loss through submerged orifices of various flow areas versus flow rate assuming a coefficient C (Eq. 9) of 0.80 and low approach velocities.

The figure assumes the area of the orifice is significantly less than the channel cross-sectional flow area, and that the flow is constricted on all sides. The head loss predicted by Eq. 9 and in the figure can be corrected for the "approach" velocity by subtracting out the velocity head in the channel, h_v(m):

$$h_v = V^2/2g, \tag{10}$$

where:

V = the flow velocity in the channel = Q/A.

This velocity head correction will generally be less than 10 percent if the orifice area is less than 1/3 of the channel flow area. If a portion of the orifice is suppressed or does not constrict the flow due to the bottom or sides being even with the bottom or sides of the channel, the head loss will also be decreased somewhat making the value calculated in Eq. 9 a conservative estimate (too large). If the orifice is not flowing full or the structure is open at the top, again the head loss will be less than that predicted by Eq. 9. It should be noted that the area, A_s, used to calculate V_s in Eq. 9 is the flow area and not the orifice area if the orifice is not full. For the purpose of design, it can be assumed that culverts have the same head loss as orifices of the same flow area. In the sample profile, it was assumed that 0.38 m (15") diameter circular orifice checks were being used, which have a flow area of 0.11 m^2, and at a flow rate of 45 lps (0.045 m^3/sec) a head loss of 0.02 m.

The location of each proposed structure should be noted on the profile. The slope of each section can now be calculated by determining the elevation drop for each section, subtracting the structure head losses, and dividing by the section length.

$$S = \frac{EL_1 - EL_2 - \Sigma\Delta h}{L} \qquad (11)$$

where,

EL_1 = the water surface elevation at the beginning of each channel section (m),

EL_2 = the water surface elevation at the end of each channel section (m),

$\Sigma\Delta h$ = the sum of all the structure head losses in the section (m), and

L = the section length (m).

If the slopes are faily steep (> 0.0008) and the structure losses are not large (< 0.04 m), structure losses do not need to be considered because the final channel design is not sensitive to the relatively small slope decrease.

The method of determining the required nacca elevations by completing a topographic survey of the fields is, as stated, the most accurate. However, the method is very time-consuming and requires fairly expensive equipment and trained surveyors. If area slopes are steep enough that accurate slopes are not critical to the final design, fields are more easily served, and field surface elevation fluctuations are not as important, other less accurate methods can be used.

An alternative method is to determine the slope of the present watercourse and construct the new channel on the same slope and at the same elevation. Several techniques are available to measure the profiles of existing channels. One is to run a channel profile survey along the channel with a surveyor's level. The surface can be of the channel bottom but preferably should be of the water surface when the water is flowing to the tail. A plot of the present channel profile can be used on the profile design sheet in place of the nacca elevations.

A second method which can be used to determine the slope of an existing channel is to pond water in several adjoining channel sections and measure the elevation drop of the ponded water between sections and the length of the sections. The ponds should be as long as possible such that standing water will still be ponded at the upper end. The technique is most easily applied by building consecutive bunds across a channel beginning at the downstream end. As the ponded section nears being filled, the upstream bund can be built or installed which in turn serves as the lower end of the next section. A series of completed ponds is illustrated in Fig. 13. After waves in the ponded sections have ceased, the elevation drop across the checks can be measured with clear plastic tubing filled with water, submerged in the higher pond, and turned up at the lower pond water surface. Such a device is shown in Fig. 14. The elevation of the water in the tubing above the water surface in the lower pond is equal to the water elevation difference across the check.

A third measurement technique utilizes a long plastic tube manometer such as that shown in Fig. 15. Both ends of the clear flexible tubing should be attached to a rule which can be set on or inserted into the channel bed. The tubing should be as long as is practical. Thirty to fifty meters is recommended. The tubing should be filled with water to about midscale on the rule so that it acts as a manometer. Both rules should be fixed upright in the channel with the tubing stretched out between. The difference in the readings on the two manometers is equal to the elevation differences between the bases of the two rules. The rules can be fixed relative to the channel bottom or, more preferably, relative to the flowing water surface. An alternative method would be to always leap-frog the upstream end while

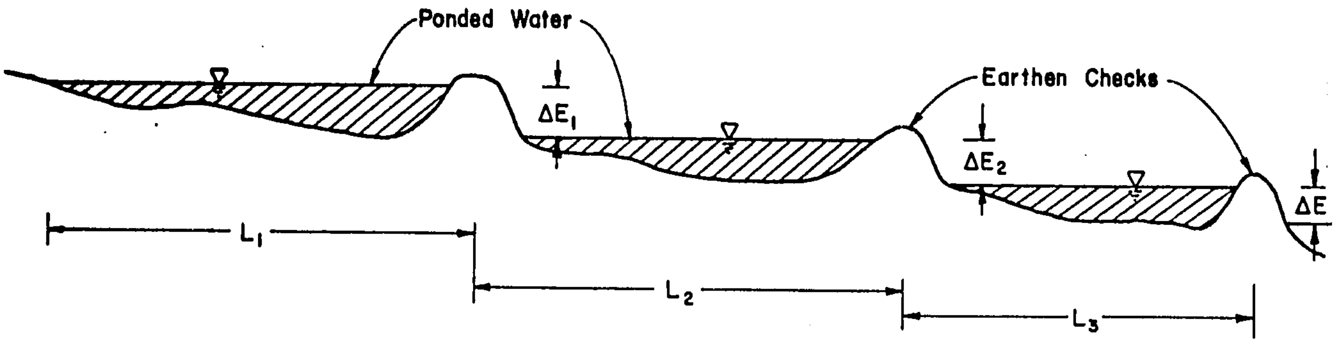


Figure 13. An illustration of the ponded water technique to determine the slope of a channel.

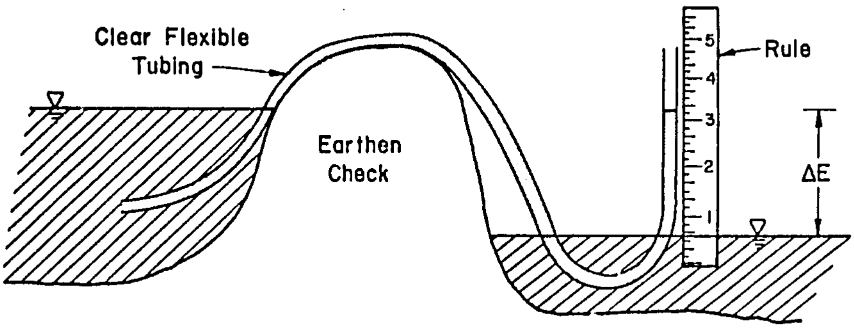


Figure 14. Measurement technique to determine the water elevation difference, ΔE, of two ponds using clear flexible tubing and a rule.

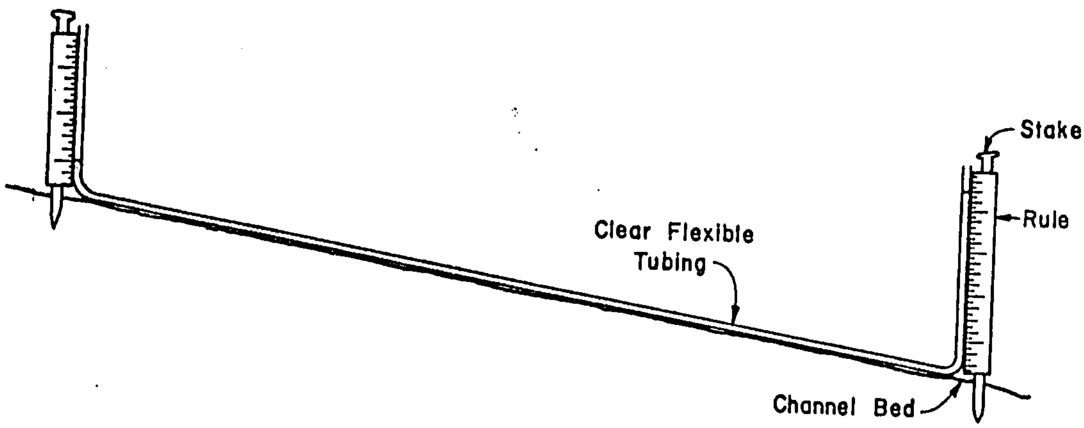


Figure 15. A long clear tubing manometer used for determining channel slopes.

leaving the downstream rule fixed and insuring that no water is lost from the tube. Then the elevation drop in the section is equal to the reading change in each fixed end when the other end is moved. Manometer readings should not be made until the fluctuations of the water surfaces in the tube have stopped.

Either of the second two methods can be used to plot a channel profile, such as that shown in Fig. 16, from which slopes of present watercourse channels can be determined. If the present channels are effectively serving all commanded area, the same slopes should be adequate for renovated channels. The inclusion of some additional working head in the new design will add a safety factor. The measured slopes can be adjusted for head losses in proposed structures by Eq. 11.

A problem with these alternative techniques is that no bench marks are established from which the rebuilt channel can be positioned after the old channels are destroyed. One alternative is to establish bench marks (wooden stakes are sufficient) relative to the present water surface which can remain fixed during reconstruction. The bench marks can be fixed either in the channel bed using a rule or outside the channel using the flexible tubing. The tubing manometer can then be used to establish intermediate design elevations between bench marks during construction by reversing the slope measuring process.

Completing the Design

Once the slope, flow rate, and roughness coefficient are determined, the channel cross section can be designed using the solution graphs. The final design information and parameters should be noted directly on the channel profile sheet. The flow velocity for each section should be calculated and design adjustments made if velocities are too high or low.

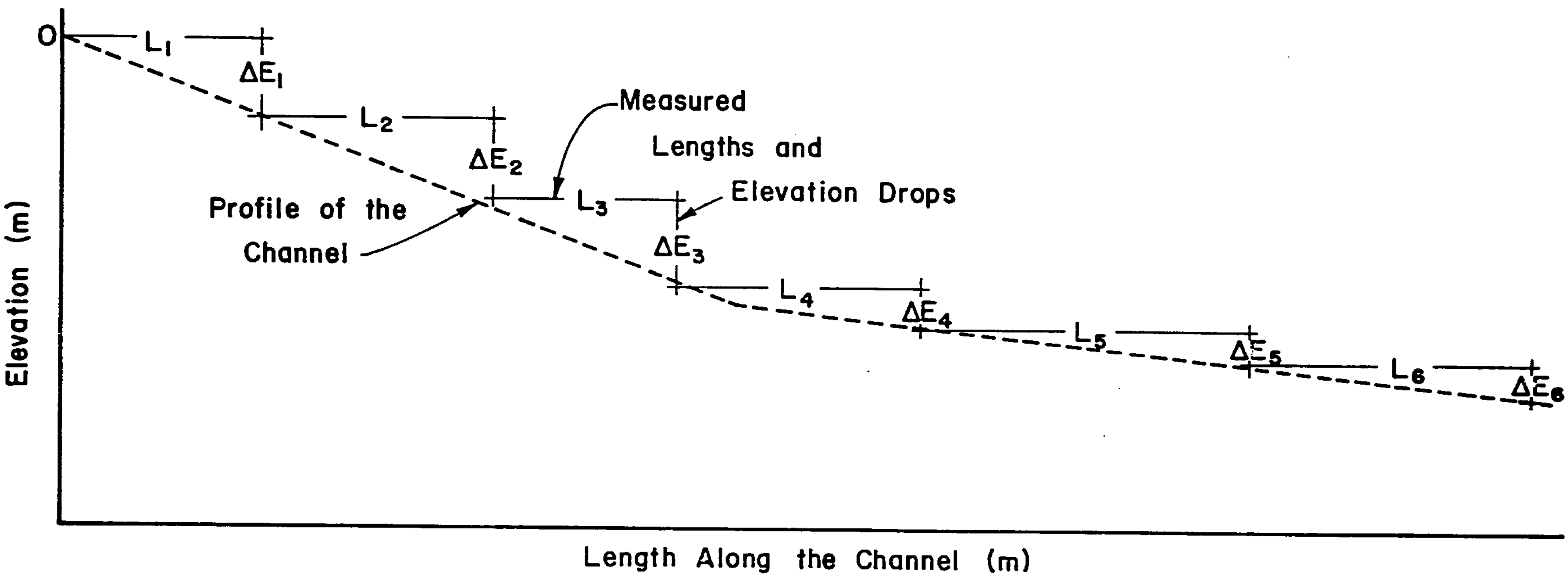


Figure 16. Plotting ponded water or manometer measurements to determine a channel profile or slope.

Bank top elevations will be the water surface elevations plus a freeboard allowance. The freeboard allows for increased roughness coefficients, inflow rates above the design level, temporary obstructions in the channels, and errors in the survey, design, or construction work. A freeboard of 0.15 m is recommended.

Channel bottom elevation will be the water surface elevation minus the design flow depth. A jump or drop in the bottom elevation will occur between sections when slopes change. Instead of an abrupt change which can lead to dead storage losses or silt deposition, a smooth transition should be designed from one section to the next. The bank top and channel bottom elevation profiles should be drawn on the design sheet, as was done in Fig. 11.

The design profile sheet now should contain all the information required in the field to construct the channel. Channel bottom elevations, widths, and alignments, and bank top elevations and widths can be staked with a surveyor's level using the same bench marks as in the original topographic survey. If the cross section construction forms described in the previous chapter are used, only bottom elevations and alignments are required.

Experience may show that after final construction, the earthen bank top elevations are below the design. This is due to settling of the bank soils. A settling allowance must be added to the freeboard allowance to compensate for this. It was found in Pakistan that an additional 5 cm must be added to the designed bank elevations during construction to allow for settling of the uncompacted bank soils.

APPLICATION

The main watercourse shown in Figure 7 will be designed. The first step is to design each branch channel which is to be rebuilt. Figure 10

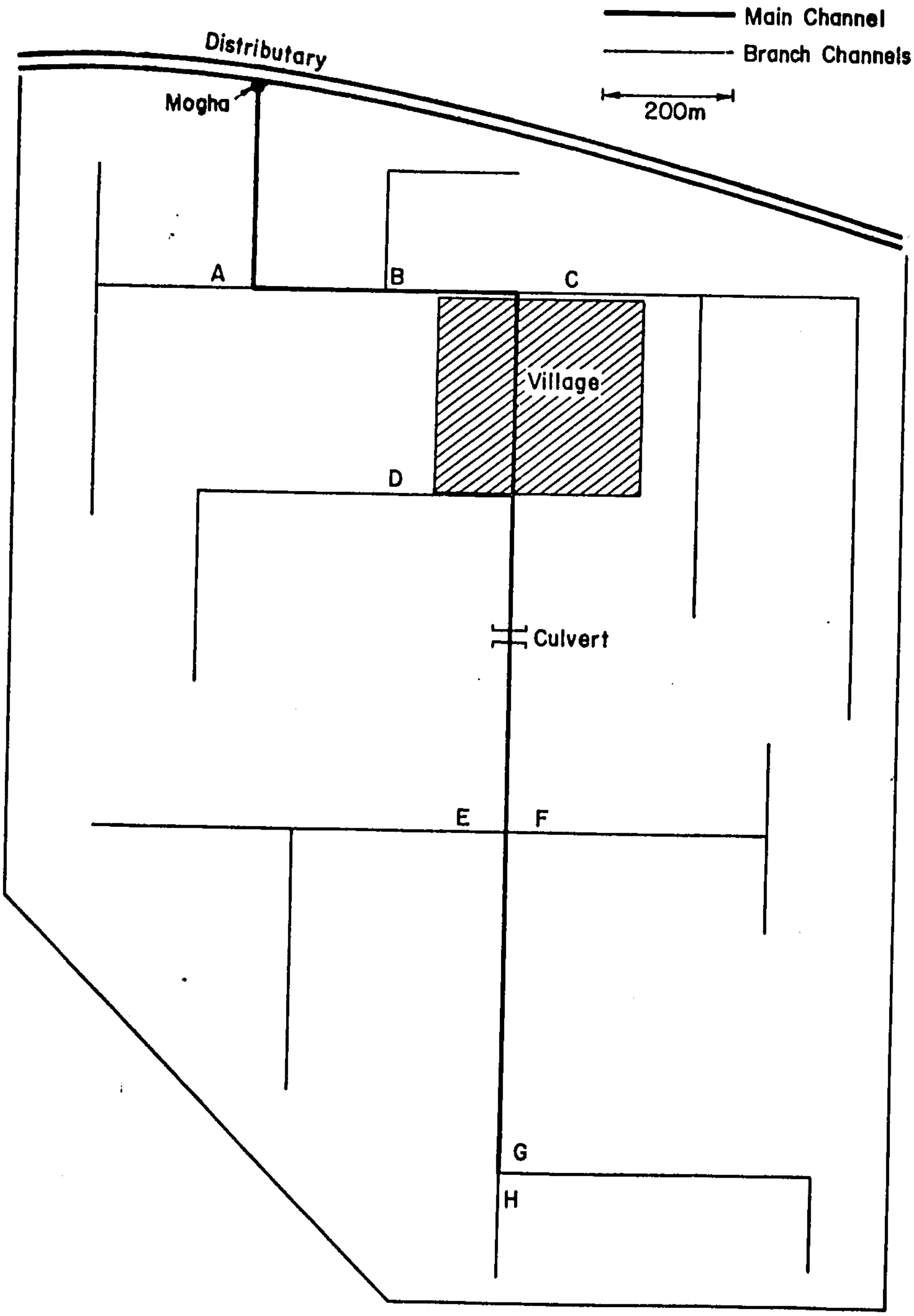


Figure 17. Layout of the sample main sartiar; khal and command area.

shows the layout and Fig. 11 the design profile of branch D based on field surface elevations and a 0.15 m working head. Each branch should be designed by the same method.

Branch design profiles will determine the required water surface elevation at the branch naccas. Branch D profile shows a required elevation at the inlet nucca of 96.05 m. This elevation along will nacca elevation for each branch is put on a main channel profile design sheet, shown in Figure 18. The horizontal axis on this profile follows the main from the mogha to the tail. The location of each branch is marked on the axis as well as a proposed culvert.

The vertical axis represents the elevation with respect to the bench marks. The axis should be scaled such that the highest and lowest naccas plus allowances for freeboard (+15 m) and bottom elevations (-.60 m) will fall within the elevation range.

The design elevation of the water surface below the mogha should also be added to the vertical axis. In the example, the mogha begins flowing freely at an elevation of 96.80 m, so the elevation must be maintained below this level to insure free flow. As an added safety factor, the design elevation is decreased an additional 0.10 m to allow for flow depth increases due to sedimentation or vegetation growth without submerging the mogha. Thus, 96.70 m is chosen as the design maximum water surface elevation at the mogha. The elevation at the head should not be higher than this value.

As with the branch profile, nacca elevations should be plotted on the graph. The water must be delivered to each nacca at this elevation or higher, or else the branch channel must be redesigned to lower the elevation.

The proposed water surface profile can now be plotted connecting or exceeding each nacca elevation. For this purpose, the main is divided into

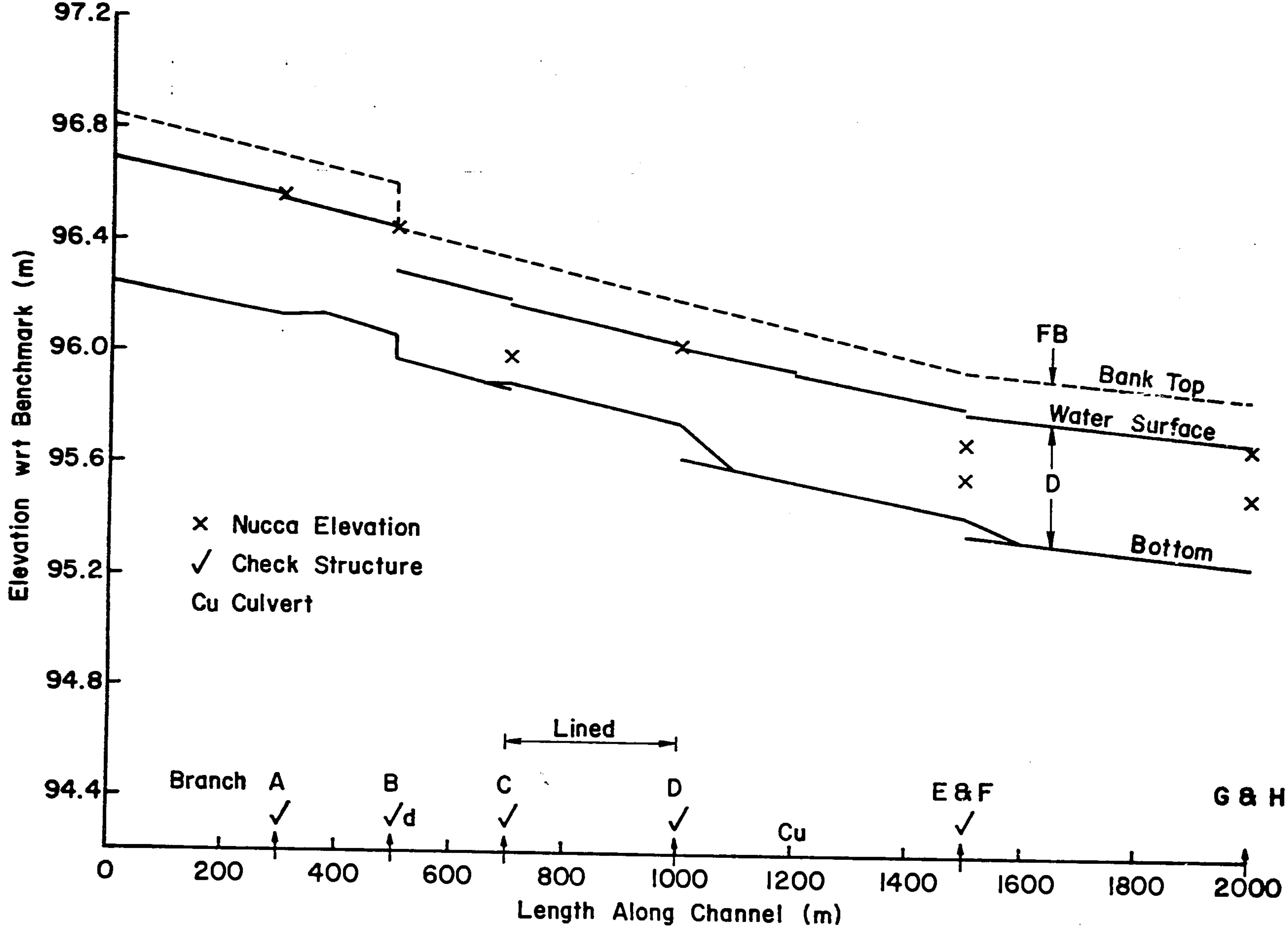


Figure 18. Main channel profile.

4 sections in which the nacca elevations fall roughly in a straight line. The slopes of this preliminary profile should be measured to see if they are reasonable. The initial section slope is limited by the maximum mogha elevation. The tail section slope is very flat, and is limited by the chosen minimum of 0.2 m/km. A drop is designed between the second and third section so that the channel can be built as low as possible.

Between branch C and D (700-1000 m) the main passes through the village. Because an earthen channel would deteriorate quickly in the village and the wider top width would make passage difficult, a rectangular lined section will be built. Thus, because of the lined section, the main is divided into a total of 6 subsections for design purposes.

The location of proposed checks and other structures is also added to the design profile. Each nacca is given a check in the example, and a requested culvert is located 1200 m from the mogha.

The information from the profile sheet should be recorded on a design sheet, shown in Fig. 19. Each subsection's length, preliminary slope, and structures should be noted. Structures located between subsections are listed between subsections. The design inflow rate at the mogha and assumed loss rate should also be noted on the sheet. Design flow rates in each subsection are then calculated by Eq. 8 and listed on the sheet. Utilizing the flow rate and a graph such as Fig. 12, the head losses through the structures are calculated and listed. In the example, 0.38 (15") orifice checks are used as well as a 0.38 m culvert. The head loss varies between 0.02 and 0.01 m for the decreasing flow rates.

Between sections 2 and 3, either a steep slope or a drop must be used. A drop of the water surface will allow the channel to be built lower, and thus is chosen. The amount of drop is determined by the elevation difference

MAIN CHANNEL DESIGN SHEET

Inflow Rate, Q (lps) 52 lps
Assumed Loss Rate, Q_2 (lps/100m) 1 lps/100m in earthen, 0 in lined section
Maximum inlet elevation (m) 96.80m
Design Inlet Elevation (m) 96.70m

Section	Length (m)	Preliminary Slope m/km	Structure Head Loss (m)	FSL Elevation Head m	FSL Elevation Tail m	Final Slope m/km	Design Flow Rate (lps)	Z	Design B m	Design D m	TW m
1	300	0.4	.40m check: .02	96.70	96.58	0.4	51	1	.3	.42	1.12
2	200	0.6	check/ drop .16	96.56	96.46	0.5	49	1	.3	.39	1.04
3	200	0.5	.40m check: .02	96.30	96.20	0.5	46	1	.45	.32	1.09
4	300	.05	lined section .40m check: .01	96.18	96.04	0.47	45	0	.49*	.28	.49
5	500	.05	.40m culvert: .01 .40m check: .01	96.03	95.81	0.42	43	1	.3	.38	1.06
6	500	.02	.40m check: .01	95.80	95.70	0.2	38	1	.3	.43	1.16

Freeboard Allowance (m) 0.15m
Bank Top Width (m) 0.60m

*assume n = .018, so $Qn/\sqrt{s}$ = .038; and b/d = 1.2

Figure 19. Sample Main Channel Design Sheet.

between the upstream and downstream water surfaces. In the example, this drop is 0.16 m. Such a drop can be accomplished by use of a raised, small-sized check structure with an extended downstream section.

Final slopes are now calculated using Eq. 11 and the elevations at each subsection head and tail taken from the profile. For example, in section 5, the elevation below the upstream check is 96.03 m, the elevation above the downstream check is 95.81 m, and a culvert in the section causes a 0.01 m head loss. The calculated slope by Eq. 11 is

$$\frac{96.03 - 95.81 - 0.01}{500 \text{ m}} = .00042 = 0.42 \text{ m/km}$$

With design flow rates and slopes established, the cross sections can be determined from the design graphs (Figs. 2, 3, 4, and 7) by the method previously explained. Bottom widths of 0.30 m are chosen initially in the earthen sections because they result in depths only somewhat larger than the bottom widths. In the lined section, a wide shallow cross section is chosen to reduce costs.

In Section 3, just upstream of the lined section, the flow depth with a 0.30 m bottom width was 0.38 m. This would have caused an upward step in the bottom at the lined section of 0.08 m which would have caused some dead storage. Consequently, a wider bottom width (B = 0.45 m) and shallower depth (0.32 m) design was chosen to eliminate most of this dead storage.

The watercourse bottom and bank top elevations are now added to the design profile. The bank top elevation is drawn 0.15 m above the designed water surface profile, to reflect the freeboard allowance. The bottom elevations are equal to the water surface elevations minus the design depths. For example, at the start of section 5, the bed elevation is 96.03 m - 0.38 m = 95.65 m and the bank top elevation is 96.03 m + 0.15 m = 96.18m. Where subsections join, there are abrupt steps in the bottom profile. These steps are smoothed out on the profile by extending straight lines from one section to the other. This smoothing out process if not considered in the design, will in fact occur naturally in earthen channels as a result of erosion and sedimentation.

With the profile and design sheet, all the required information is available for construction in the field. The watercourse bottom and bank top elevation at any location is read from the profile, and can be staked in the proper alignment using a surveyors level and the bench marks. Watercourse bottom and top widths, read for each section from the design sheet, can be taped and staked.

Nacca and check structures are also installed according to the design profile. The structures should be installed such that the top of the orifice is 2 or 3 cm (0.02-0.03 m) above the upstream water surface elevation at that location. Structures should always be surveyed in.

QUESTIONS

1. What basic information is required to design a watercourse?
2. What are the reasons for head loss through culverts and naccas and how do you calculate their magnitudes?
3. What is the relationship between the bed slope of a watercourse and the average velocity of flow?
4. What precautions do you observe while designing a watercourse to maintain free flow in the mogha?

Subject: USE OF LEVELS

Trainer Agricultural Engineer
Class Room 2 hours
Field 1 Days

OBJECTIVES

To obtain the basic information regarding surveying terminology, care and use of levels and other equipment needed for surveying.

MATERIALS NEEDED

Engineers level/transit, staff rod, flag, field notebook, measuring tape, etc.

TRAINING AIDS

Engineers level.

INTRODUCTION

Terminology Used in Levelling

Datum surfaces:

A datum surface or line is any arbitrarily assumed level surface or line from which vertical distances are measured.

The elevation:

The elevation of a point is its vertical distance above or below the datum. It is also known as the reduced level (R.L.). The elevation of a point is plus or minus according as the point is above or below the datum.

The difference in elevation:

The difference in elevation (H) between two points is the vertical distance between the level surfaces passing through the two points.

Bench marks:

A bench mark (B.M.) is a fixed reference point of known elevation.

The line of Collimation:

The line of collimation is the line joining the intersection of the cross-hairs to the optical center of the object glass and its continuation. It is also called the line of sight.

Axis of the telescope:

An axis of the telescope is a line joining the optical center of the object glass to the center of the eye-piece.

Axis of the level tube or bubble tube:

An axis of the level tube or bubble tube is an imaginary line tangential to the longitudinal curve of the tube at its middle point. It is also known as the bubble line. It is horizontal when the bubble is centered.

The vertical axis is the center line of the axis of rotation.

Backsight (B.S.):

A backsight (B.S.), also termed as a backsight reading, is a staff (or rod) reading taken on a point of known elevation, on a bench mark or a change point. It is also called a plus sight. It is the first staff reading taken after the level is set up and levelled.

Foresight:

A foresight (F.S.), also called a foresight reading, is a staff (or rod) reading on a point whose elevation is to be determined as on a change point. It is also termed as a minus sight. It is the last staff reading denoting the shifting of the instrument. It must be remembered here that the work sight does not imply any direction, but it denotes the reading.

Intermediate sight:

An intermediate sight (I.S.) is any other staff reading taken on a point of unknown elevation from the same set-up of the level. All sights taken between the backsight and the foresight are intermediate sights.

Change point:

A change point (C.P.) is a point denoting the shifting of the level. It is a point on which the fore and back sights are taken. Any stable and well defined subject, such as a boundary stone, curb stone, rail, rock, etc., is used as a change point. A bench mark may also be taken as a change point. It is also called a turning point (T.P.).

Station:

A station is a point whose elevation is to be determined or a point which is to be established at a given elevation. It may be noted that it is a point where the staff is held and not the point where the level is set up.

The height of instrument (H.I.):

The height of instrument (H.I.) is the elevation (or the R.L.) of the plane of collimation (or plane of sight) when the instrument is correctly levelled. It is also called the "height of plane of collimation" or the collimation.

Range poles:

The range pole is a one-piece pole from 100 cm to 200 cm in length, painted red and white. It is used generally to establish a "line of sight".

Level rods:

The levelling rod is for the purpose of measuring vertical distances.

Engineer's transit:

This instrument is used primarily for measuring horizontal and vertical angles, prolonging or setting points in line, measuring approximate distances by the stadia principle, and for levelling operations. It can also be used as a compass when equipped with a compass needle. Horizontal and vertical plates graduated in degrees and fractions are provided for measurement of angles. They are mounted at right angles to the horizontal and vertical axis. Spirit levels are provided for leveling the horizontal plates. A telescope, equipped with a spirit level, is mounted at right angles on a horizontal axis supported by two up rights (standards) attached to the upper horizontal plate. In use, the instrument is mounted on a tripod and is equipped with a small chain and hook to which a plumb bob can be attached. This provides a means of centering the instrument over a point.

Field books:

Engineering field books are used for the recording of survey notes and layout and construction data. They are valuable documents because of the time and expense involved in obtaining such data. It should not be used for scratch computations or notes which have no permanent value pertaining to engineering surveys.

PRESENTATION

Care and Handling of Level/Transit

Transporting level or transit and rod:

Survey instruments should be carried in the instrument case, preferably in a well padded compartment. Level rods should be in cases and carried where they will be protected from weather and from material being piled on top of or against them. Tripods should be similarly protected from damage and the weather.

Mounting of level on tripod:

The first step in mounting the level is to set up the tripod. First, extend each leg full length to stop and tighten. The wing nuts on the tripod base should be tightened just enough so that when a tripod leg is elevated, it will drop, gradually of its own weight. Legs of the tripod should be spread evenly and pressed firmly in the ground, keeping the top of the tripod near level.

The instrument should be carefully removed from the case. It is best to grasp firmly by the telescope and cradle in the crook of your arm immediately. Then hold telescope in left hand while attaching level to the tripod with the screw located and attached to the bottom of the tripod head.

The lens cap should be removed and placed in the instrument case for safe-keeping, and the sunshade attached to the telescope. The sunshade should be used regardless of the weather.

Carrying the instrument:

Usually the instrument is carried to the field on the shoulder, but in passing through doors, woods or brush, the field worker should hold the instrument head close to the front of his body. Little damage will be done to tripod legs if they strike the side of a door or tree as compared to the damage to the instrument head if similarly hit.

Cleaning and storage of equipment:

Always return the instrument to the case when returning from the field. Before placing the instrument in the case loosen the lower clamp screw (transit) and replace the lens cap on the telescope. Return the sunshade to the case. After placing the instrument into the case, tighten the transit telescope clamp screw. The lid should close freely and easily. If it does not, the instrument is not properly placed on the pads. Never force the lid; look for the cause of the obstruction.

Checking Instruments for Adjustment

Adjustment for instrument line of sight:

To make the line of sight parallel to the axis of the level, preform the direct or two peg test. Set two pegs or stakes (A&B) about 120 meters apart. Set up and level the instrument midway between the two stakes at point C. See Figure 1. Take a rod reading on each. (Be sure rod is plumb while taking reading and read rod to nearest .005 m.) The difference in reading will be the true difference of elevation between them.

Next, move the instrument and set up so that when the rod is at A, the eye piece will not be over three meters on opposite side of rod from point B. This will be point D. Read and record readings at A. Then to the reading at A add or subtract (depending upon whether B is lower or higher than A) the true difference of elevation. Sight on the rod at B. If the reading is the same as obtained above, the instrument is in perfect adjustment. If it is out of adjustment, move the horizontal crosshair until the line of sight intercepts the true reading on the rod at B.

Adjustment of bubble (circular vial):

To check bubble, set up tripod and instrument as previously described and final level the instrument. Rotate the instrument 180 degrees; bubble should remain in circle. If any part of the bubble is out of circle, unscrew circular bubble reflector. Correct half the error with three bubble adjusting screws and remainder with three levelling screws. Rotate the instrument 180 degrees. If the bubble is off center, repeat the above operations until bubble remains in center in any position.

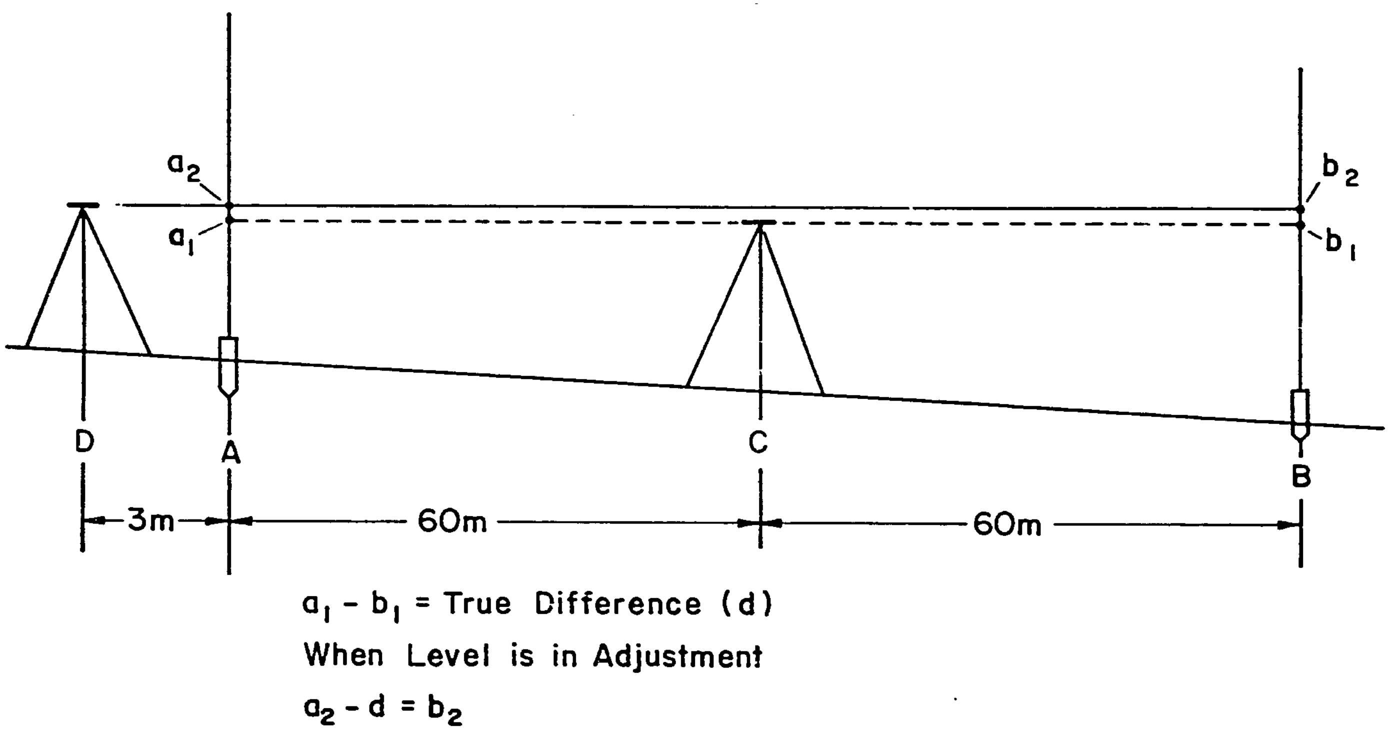


Figure 1. Checking a level by the two peg method.

Rules For Keeping Good Notes

The following are suggestions for keeping good field notes.

1. The first few pages of the field book should be reserved for an index, which should be kept up-to-date as the work is completed.

2. The double sheet is considered as one page. Pages should be numbered in the extreme upper right-hand corner of the right-hand side of the page.

3. A descriptive title should be printed at the top left of the right-hand side at the page. It should show the type of survey, description of location, and the name of the farm.

4. At the top right of the right-hand side of the page, the names of the survey party should be recorded along with the job assigned to each. The date and weather conditions at the time the data were taken should also be recorded.

5. A 3H or 4H hard lead pencil, well-pointed, should be used in recording data. Ink should never be used as it will smear as will soft leaded pencils.

6. Titles, descriptions, and works should be lettered in the best form possible, usually capital letters for headings and titles, and lower case letters for other information.

7. Numbers recorded should be neat and plain and one figure should never be written over another. In general, numerical data should not be erased; if a number is in error, a line should be drawn through it and the correction value written above. Portions of sketches and explanatory notes may be erased if there is a good reason for doing so.

8. In tabulating numbers, all figures in the tens columns, for example, should be in the same vertical line. Where decimals are required, the decimal point should never be omitted. The number should always show to what degree of accuracy the measurement was taken, thus, a rod reading to the nearest 0.01 meters should show 2.40 rather than 2.4 without the zero.

9. Sketches should be neat and large enough to show details without crowding the figures together. Rod readings, distances, and other numerical data are generally not shown on the sketch provided that they are recorded on the left-hand sides of the page; however, reference points, a north arrow, names of streams, roads, landowners, and property lines are shown. The sketch is drawn on the right-hand side and should correspond to the data recorded on the left-hand sides or on a succeeding page.

10. Explanatory notes, such as the approximate location of reference points, should be shown on the same horizontal line but on the right-hand side. They are needed to make clear what the numerical data and sketches fail to bring out.

11. If a page of notes become illegible or erroneous, the data should be retained and usable notes reentered in the book before writing the work "void" in large letters diagonally across the page. The page number of the continuation of the notes should be indicated. Making portions of a page void may be handled in the same manner as voiding a full page.

12. Scribbling should not be done in the field book. A piece of scratch paper held in the field book with a rubber band is convenient for making calculations. If this is not available, the back pages of the field book will suffice. Particular attention should be paid to neatness and arrangement of the data.

Subject: BENCH MARK SURVEY

Trainer Agricultural Engineer
Class Room 2 hours
Field 5 Days

OBJECTIVES

1 - To discuss the need for bench mark surveys.

2 - To learn the technique for conducting Bench-Mark Surveys.

3 - To carry out a Bench-Mark Survey.

MATERIALS NEEDED

Engineer's level with tripod, staff rod, field book, materials for constructing Bench Marks (Bricks, Sand, and Cement).

TRAINING AIDS

None

INTRODUCTION

A bench mark is a permanent established point, the elevation of which is known so it can be used as a reference point in obtaining the elevations of subsequent stations. The permanent structures like the crest of a mogha, culverts, or pakka nakkas along the watercourse may be used as bench marks. If nothing is available, bench marks may be constructed, using bricks, cement and sand. Bench marks are usually established in each square along the watercourse to facilitate watercourse profile survey and topography survey of the watercourse command area. Bench marks should be marked, perhaps with paint, and numbered.

A Bench Mark Survey is the process of determining the elevation of all the bench marks established along the watercourse. The crest of the mogha is always the first bench mark whose elevation may be either obtained from the irrigation department or assumed.

PRESENTATION

A level is set up at a location approximately half way between a bench mark (B.M.) and a turning point (T.P.). A turning point is a temporary bench mark for the purpose of continuing a line of levels. If the elevation of the initial bench mark (B.M.1) is assumed 100.00 meters, the elevation of the turning point (T.P.1) can be determined. After levelling the instrument, a rod reading is taken on B.M.1, say it is 0.34. This rod reading is termed as back sight (B.S.). A back sight is a rod reading taken on a bench mark or turning point of known elevation. This reading is recorded in the B.S. column of the notes. Now the height of the instrument (H.I.) is determined by adding the B.S. to the elevation of B.M.1, 100.00 + 0.34 = 100.34 and is entered in the notes in the H.I. column.

After the back sight has been obtained, the rod man moves towards BM2 a distance roughly equal to the horizontal distance for the back sight, and selects a point for the turning point. A definite, solid object is selected for a turning point. This may be a stake driven in the ground or a solid rock that has a definite mark. It should not be taken on the ground. The level man takes a rod reading, say 1.63, on T.P.1 and the notekeeper enters this value in the notes in the foresight column. A foresight (F.S.) is a rod reading taken on a point for which the elevation is to be determined. The elevation of T.P.1 is then determined by substracting the rod reading, 1.63, from the height of instrument, 100.34, to give 98.71. This is entered in the notes as shown in Figure 1. The instrument man then picks up the level and moves away from the rod in the general direction of B.M.2. He levels the instrument and

Figure 1. Sample Bench Mark Survey Chak 279/J.B. Hyderabad Showing Fieldbook Entries.

Station	B.S.	H.I.	F.S.	Elevation	Remarks
BM_1	0.34	10.34	-	10.00	Elevation assumed.
TP_1	2.45	11.16	1.63	8.71	
TP_2	0.81	11.91	0.06	11.10	
BM_2	3.98	11.91	3.98	7.93	
TP_3	0.09	11.19	0.81	11.10	
TP_4	1.98	10.71	2.46	8.75	
BM_1			0.69	10.02	
	B.S. = 9.65		F.S. = 9.63	.02	

Sunny, Calm.

August 20, 1978.

BM_1 = Crest of Mogha No. 88230/L

BM_2 = Pipe culvert on the main water-course in sq. No. 24

Surveyers:
Mr. x.y.z.

Error of Closure = 9.65 - 9.63 = 0.02 Check takes a B.S. on T.P. 1, since the elevation has just been previously determined. This valve is entered in the notes as shown in Figure 1, and the previous procedure is repeated until a reading on B.M. 2 can be obtained.

Closed Survey

To verify the accuracy of the levelling, a return check must be made. That is, the line of levels must be continued from B.M. 2 back over a slightly different route to B.M. 1, the initial starting point. To make the return check independent of the first line of levels, after the F.S. is taken on B.M. 2, the level should be lifted and relevelled so that the H.I. is a slightly different elevation. This results in a B.S. on B.M. 2 different from the F.S. and should result in a better check of the lines of the levels. When the trainee has returned to B.M. 1, he has completed a closed survey. All levelling exercises should be closed surveys so that a check of the accuracy of the survey can be made.

Error of Closure

If there have been no errors made in a closed survey or if the errors have compensated, then the elevation determined for B.M. 1 by the return check will be the same as the original elevation of B.M. 1. Generally, these elevations are not the same because of errors in rod readings or instrumental errors.

The amount by which the original B.M. elevation and the B.M. elevation observed upon the return check fail to agree is called the error of closure.

Allowable errors of closure for a survey is a function of the accuracy of the instrument and the length of the survey or the number of times the instrument is set up. For a level, the allowable error of closure equals 0.01 meters per two instrument setups (.005 per setup). For the notes shown in Figure 1, there were four instrument setups so the allowable error of closure was 0.02. The actual error of closure was 0.02, so it is within the limits of error for the survey.

Checking the Level Notes

The computations of the level notes should always be checked by comparing the difference between the sum of the backsights (B.S.) and the sum of the foresights (F.S.) with the differences between the initial and final elevation of the B.M. used to close the survey. This computation checks the notes for arithmetical accuracy. The two differences must agree or an arithmetic error has been made. No set of leveling notes is complete without an error of closure computation and a check of the arithmetic accuracy of the notes.

APPLICATION

The trainees will conduct the bench mark survey in the watercourse command area and record the notes in the engineer's field book in the proper form.

QUESTIONS

1. How does a bench mark survey facilitate one to conduct a profile survey and a topographic survey?
2. How would you check the level notes and error of closure?
3. What precautions should be observed while locating and constructing a bench mark.

Subject: PROFILE SURVEY OF A WATERCOURSE, DATA REDUCTION, COMPUTATIONS, AND PLOTTING

Trainer Agricultural Engineer
Class Room 2 hours
Field 6 Days

OBJECTIVES

1 - To learn the definition and purpose of a profile survey.

2 - To understand the complete procedure of conducting profile survey of a watercourse.

3 - To learn the technique of data reduction, computation, and plotting.

MATERIALS NEEDED

1 - Engineer's level with stand

2 - Staff rod

3 - Engineer's field book and pencil

4 - Measuring tape

TRAINING AIDS

Charts showing a typical profile survey.

INTRODUCTION

A profile survey is the process of determining the elevation of a watercourse at a series of points at measured intervals along its length. The purpose of this survey is to determine the true slope of the water surface and watercourse bed. The stakes are usually set along the watercourse at 30, 50, or 100 meter intervals depending upon the detail required for the survey. In addition, the stakes are set at points where the watercourse changes direction. The distances along the watercourse are designated, for example, 0+00, 1+00, 2+00, etc. Remember that 0+00 designates the beginning of the watercourse. The digits to the left of the plus sign designate the distance in multiples of 100 meters and digits to the right of the plus sign designate the distance less than 100 meters. Thus, the distance 150 meters along the watercourse will be written as 1+50 meters.

PRESENTATION

The first step in conducting the profile survey is to measure the watercourse accurately setting stakes at all points where rod readings are to be taken.

Set the engineer's level near the watercourse at such a position from which a maximum number of rod readings can be taken. A rod reading is obtained on the Bench mark (which is usually the crest of the mogha) and the height of the instrument is determined. The first two rod readings are taken upstream of the mogha in order to determine the bed elevation and the full supply level of canal. After these rod readings are obtained, readings are taken on the bed of the watercourse, starting from the downstream side of the mogha which becomes the beginning of the profile survey. At each station, besides the watercourse bed, one reading of the top of the water, and one of the adjacent field on each side is also taken to compare the profile of the watercourse bed with that of supply level and fields along the length of the watercourse. Rod readings are recorded at each stake in the same manner up to the tail end of the watercourse. Turning points are selected and notes are recorded as shown in Figure 1. Since the points plotted on the paper from the profile notes represent average elevation, it is usually the practice to draw smooth lines (not straight lines) from point to point.

FIGURE 1. Sample Profile Data Sheet

Station	B.S.	H.I.	F.S.	Water Surface IS	Water Surface Elev.	Watercourse Bed IS	Watercourse Bed Elev.	Left Field Surface IS	Left Field Surface Elev.	Right Field Surface IS	Right Field Surface Elev.
BM_1	1.62	11.62			(10.00)						
0+00				1.74	9.88	2.15	9.47	1.91	9.71	1.96	9.66
0+50				1.76	9.86	2.17	9.45	1.95	9.67	1.99	9.63
1+00				1.78	9.84	2.17	9.45	1.94	9.68	2.00	9.62
1+50				1.81	9.81	2.17	9.45	1.94	9.68	2.01	9.61
2+00				1.83	9.79	2.17	9.45	1.96	9.66	2.01	9.61
2+50				1.85	9.77	2.21	9.41	2.00	9.62	2.01	9.61
3+00				1.87	9.75	2.25	9.37	2.02	9.60	2.00	9.62
$T.P._1$	1.71	11.41	1.92		(9.70)						
3+50				1.68	9.73	2.04	9.37	1.82	9.59	1.80	9.61
4+00				1.71	9.70	2.08	9.33	1.84	9.57	1.80	9.61
4+50				1.72	9.69	2.08	9.33	1.85	9.56	1.80	9.61
5+00				1.75	9.66	2.09	9.32	1.85	9.56	1.80	9.61
5+50				1.79	9.62	2.13	9.28	1.86	9.55	1.83	9.58
6+00				1.84	9.57	2.21	9.20	1.87	9.54	1.88	9.53
6+50				1.88	9.53	2.23	9.18	1.87	9.54	1.90	9.51
$T.P._2$	1.75	11.28	1.88		(9.53)						
7+00				1.79	9.49	2.14	9.14	1.78	9.50	1.81	9.47
7+50				1.84	9.44	2.17	9.11	1.84	9.44	1.84	9.44
8+00				1.88	9.40	2.22	9.06	1.98	9.30	1.87	9.41
8+50				1.93	9.35	2.29	8.99	2.05	9.23	1.98	9.30
9+00				1.96	9.32	2.31	8.97	2.07	9.21	2.07	9.21
9+50				2.01	9.27	2.34	8.94	2.13	9.15	2.13	9.15
10+00				2.07	9.21	2.38	8.90	2.21	9.07	2.15	9.13
$T.P._3$	1.90	11.50	1.68		(9.60)						
BM_1			1.48		(10.02)						
Σ	6.98		6.96								
	BS-FS=.02				.02						

Closed Surveys

In the profile survey, like the bench mark survey, a closed circuit of levels is always made to check the accuracy of the survey. This is done by running a line of differential levels back to the Bench Mark from which the survey was started or to the nearest bench mark.

For computing the error of closure, the fore sights and back sights used are only those which are taken on the bench marks and turning points. The intermediate rod readings are not used in the computation for error of closure.

Plotting of Profile

Profiles are usually plotted on graph paper as shown in Figure 2. The vertical scale of profile which shows the elevations are exaggerated.

APPLICATION

1. Trainees will conduct a profile survey of a watercourse command area.
2. The trainees will determine the grade of the watercourse from the plotted profile.
3. They will design a watercourse for improvement and determine the depth of cut or fill required.

QUESTIONS

1. What ways do a profile survey help in properly designing a watercourse?
2. How would you check the error of closure of a profile survey?
3. What is the general procedure for numbering the stakes?
4. What is the general slope of the channel shown in Figure 2?

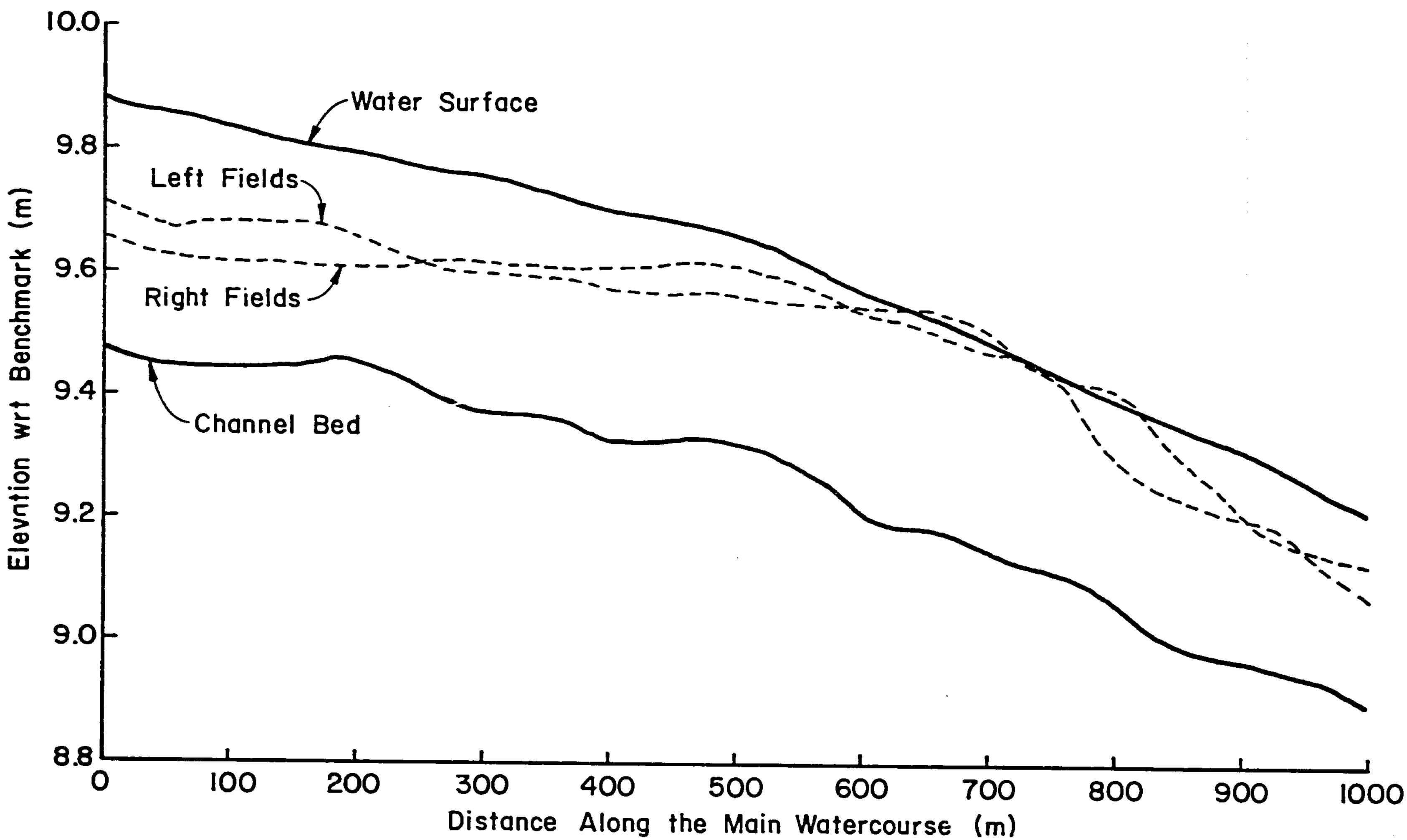


Figure 2. Graph of Watercourse Profile Data Listed in Figure 1.

Subject: TOPOGRAPHIC SURVEY OF A WATERCOURSE COMMAND AREA

Trainer Agricultural Engineer
Class Room 2 hours
Field 14 Days

OBJECTIVES

1 - To teach the trainees the procedure for conducting a topographic survey of a watercourse command area.

2 - To make the trainees confident in the techniques of data reduction, computation, and preparation of topographic maps.

MATERIALS NEEDED

1 - Engineer's level with stand and staff rod

2 - Engineer's field book

3 - Measuring tape

4 - A map of the watercourse command area obtained from the Patwari

5 - A map showing the position of the Bench Marks and their elevations.

TRAINING AIDS

1 - Completed topographic survey of watercourse

2 - Examples of data used to make the survey

INTRODUCTION

A topographic survey is the process of collecting the data required for preparing a topographic map. In this survey, the arrangement of bunded units in each acre with their elevations and the location of nakkas, culverts, roads, and other important features of the watercourse command are is determined and recorded. A map obtained from the local Patwari serves as a guide for locating the squares and acres at the time of survey.

PRESENTATION

A topographic survey is conducted on each square of ground. A map of each square (Figure 1) showing the arrangement of bunded units and the numbering of the acres is prepared. Each bunded unit is identified by its square and acre number, plus its individual number in the acre recorded on the map.

The topographic survey is started from the nearest bench mark and the notes are recorded as shown in Figure 2. The elevation of each bunded unit should be measured and recorded as shown in Figure 2. The survey is closed and error of closure is computed as discussed in the Benchmark survey lecture. The bunded unit elevations are recorded on the map.

Topographic lines should be drawn on the map to indicate general slopes and as a rough check of the measurements and calculations. Topographic lines represent locations of equal elevations of the ground surface. Each line should represent an equal increment of elevation change, such as 8.20, 8.30, 8.40 m, etc. Topographic lines are shown on Figure 3.

APPLICATION

The trainees will conduct the topographic survey for a watercourse command area and prepare a topographic map.

QUESTIONS

1. What is a topographic survey and why is it needed in the watercourse improvement program?
2. How do you locate different squares and acres in a watercourse command area?
3. How do you check the error of closure in a topographic survey?

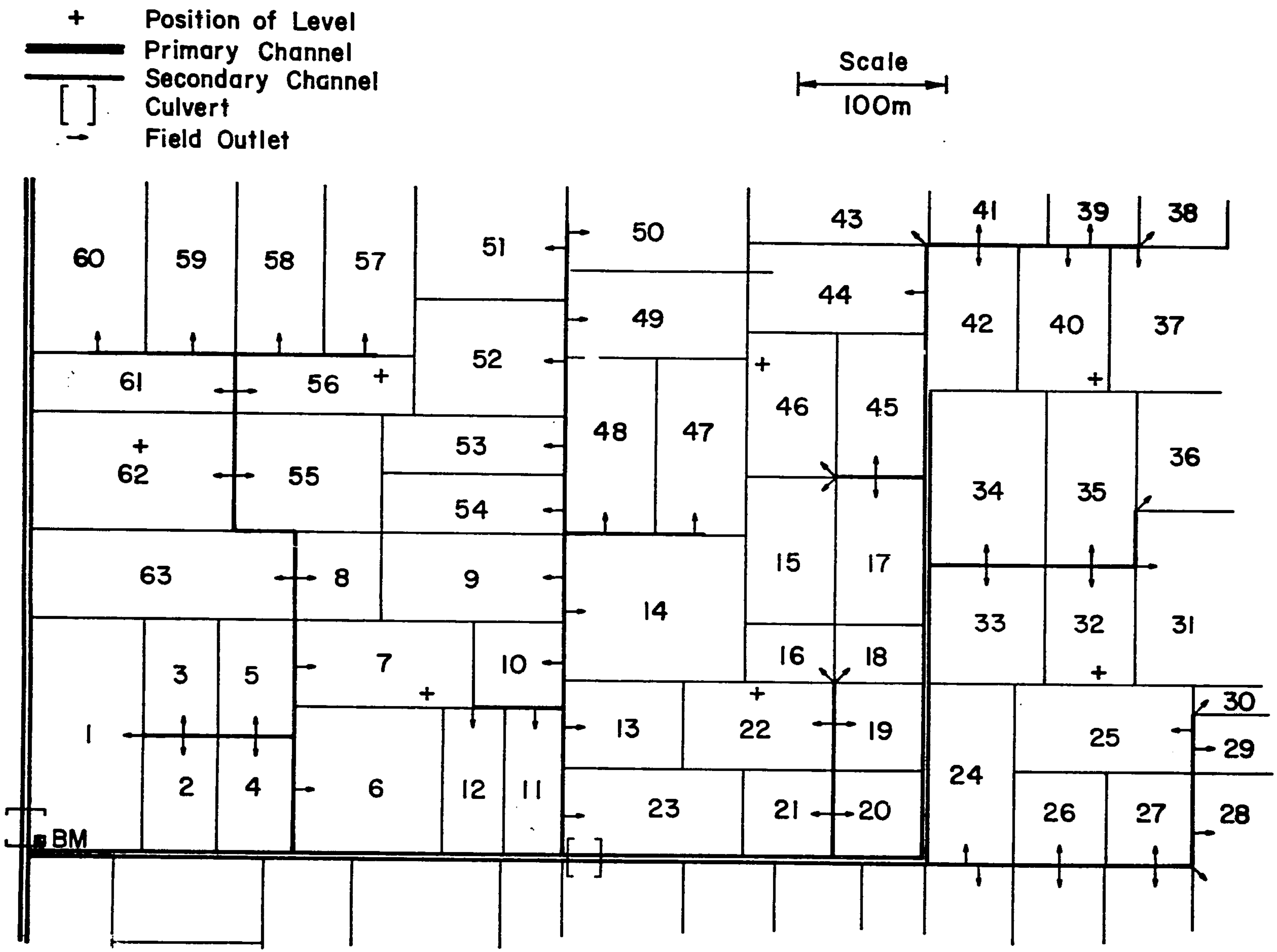


Figure 1. Command area to be surveyed showing field numbers for referencing in the field book.

Topographic Leveling of the Command
Area of Branch D of Turnout #347R
August 23, 1980; Zahid Saeed and Abdul Khaliq
Weather Cloudy and Windy

Field	BS	HI	FS	I.S.	Elev.
BM_1	1.16	97.44			96.28
1				1.67	95.77
2				1.67	95.77
3				1.75	95.69
4				1.73	95.71
5				1.79	95.65
TP_1	1.30	97.12	1.62		95.82
6				1.47	95.65
7				1.49	95.63
8				1.52	95.60
9				1.61	95.51
10				1.56	95.56
11				1.54	95.58
12				1.51	95.61
TP_2	1.23	96.88	1.47		95.65
13				1.43	95.45
14				1.48	95.40
15				1.59	95.29
16				1.60	95.28
17				1.63	95.25
18				1.63	95.25
19				1.59	95.29
20				1.50	95.38
21				1.48	95.40
22				1.53	95.35
23				1.40	95.48
TP_3	1.55	96.80	1.63		95.25
24				1.52	95.28
25				1.60	95.20
26				1.53	95.27
27				1.57	95.23
28				1.60	95.20
29				1.60	95.20
30				1.63	95.17
31				1.66	95.14
32				1.63	95.17
33				1.59	95.21
TP_4	1.52	96.77	1.55		95.25
34				1.59	95.18
35				1.65	95.12
36				1.68	95.09
37				1.75	95.02
38				1.76	95.01
39				1.75	95.02
40				1.74	95.03
41				1.68	95.09
42				1.68	95.09

Figure 2. Field notes for topographic survey of the fields shown in Figure 1.

Field	BS	HI	FS	I.S.	Elev.
TP_5	1.56	96.63	1.70		95.07
43				1.54	95.09
44				1.53	95.10
45				1.41	95.22
46				1.41	95.22
47				1.28	95.35
48				1.26	95.37
49				1.31	05.32
50				1.34	95.29
TP_6	1.69	97.02	1.30		95.33
51				1.77	95.25
52				1.71	95.31
53				1.67	95.35
54				1.55	95.47
55				1.50	95.52
56				1.57	95.45
57				1.64	95.38
58				1.60	95.42
TP_7	1.40	96.93	1.49		95.53
59				1.50	95.43
60				1.40	95.53
61				1.35	95.58
62				1.28	95.65
63				1.28	95.65
TP_8	1.56	97.38	1.11		95.82
BM			1.07		96.31
	12.97		12.94		

BS - FS = .03

$BM_2 - BM_1$ = .03 <u>check</u>

Figure 2. (continued)

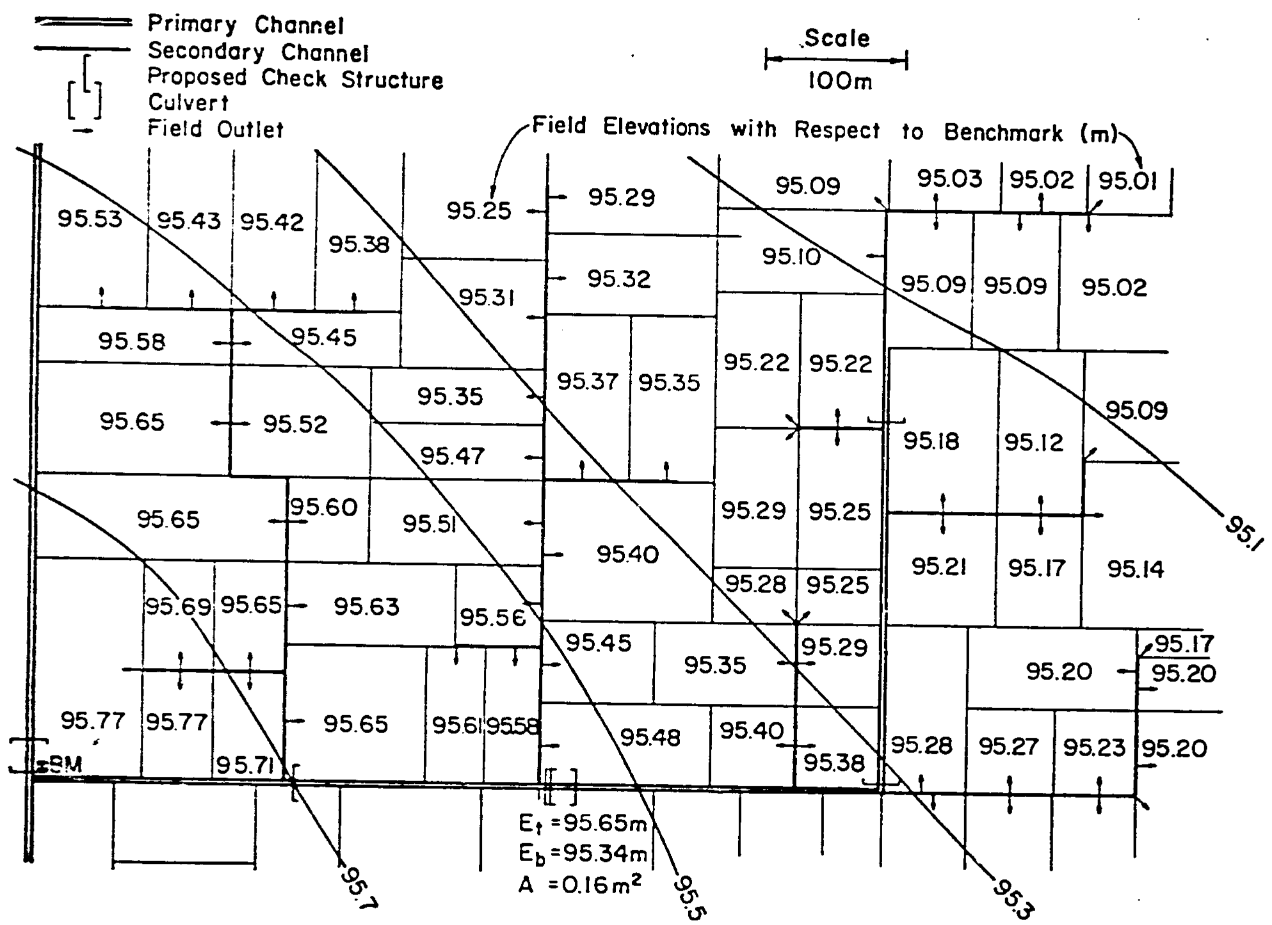


Figure 3. Topographic map of the rectangular basins served by a primary branch showing channel layout and topographic lines.

Subject: WATERCOURSE STRUCTURES

Trainer Agricultural Engineer
Class Room 4 hours
Field 0 Days

OBJECTIVES

1. To classify different types of watercourse structures.
2. To learn the technique of installing and constructing these structures.
3. To be able to prepare estimates of cost of materials used for constructing watercourse structures.

MATERIALS NEEDED

Panel Nakkas of different types, concrete pipe, bricks, Engineer's level and staff rod.

TRAINING AIDS

Slides and drawing of watercourse structure.

INTRODUCTION

The provision of pucca watercourse structures helps reduce water losses at the watercourse junctions and also prevent bank deterioration near the village. They can also act as guide to farmers in maintenance work and save irrigation time. Watercourse structures can be classified as follows:

1. Water control structures.
   a. Nakkas
   b. Checks

2. Community use structures.

   a. Culverts
   b. Buffalo baths
   c. Washing pads for ladies

The component parts of Nakkas and check structures are:

1. Lid
2. Panel
3. Support or Frame

Nakkas and check structures can be installed easily by local skilled and unskilled labour. The objectives of proper Nakkas and check installations are:

1. To support Nakka panel.
2. To prevent leakage around Nakka panel.
3. To prevent erosion above and below Nakka.

PRESENTATION

There are different types of panel Nakkas available on the market. Each type has its relative merit and demerits which are given below.

I. Round Orifice (Figure 1)

Advantages

1. Structurally strong and simple to use.

2. Relatively easy to manufacture from precision metal molds.

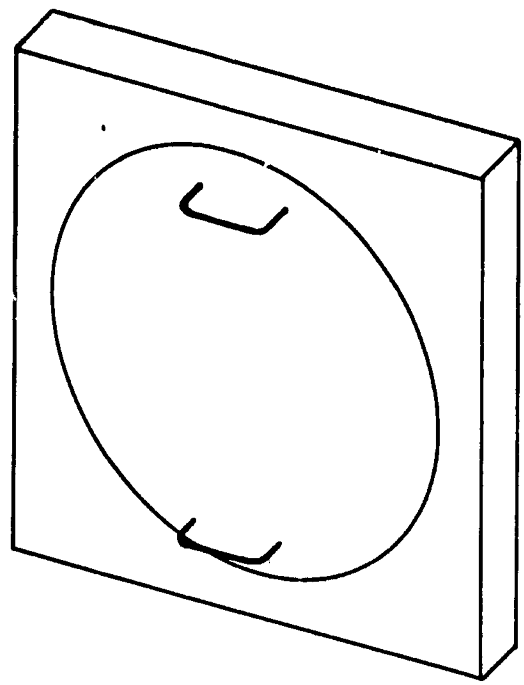
3. Round shape gives maximum cross-sectional flow area for given lid weight.

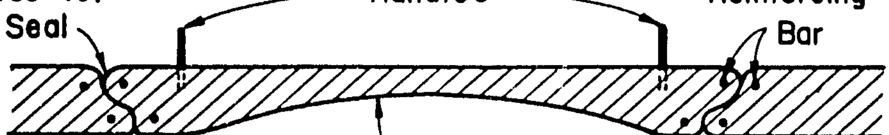
4. Potential low leakage and mud seal possibilities.

5. Available at low-cost which ranges from Rs. 50-70 per Nakka.

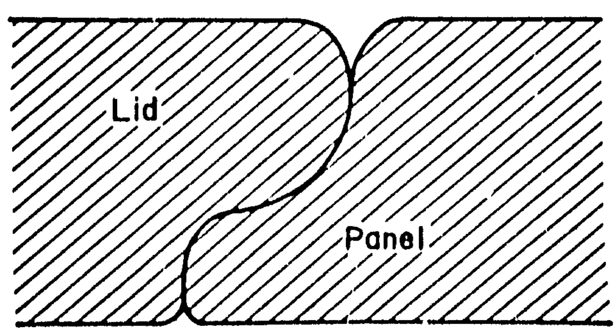
Disadvantages

1. Not convenient to use, the farmer must enter the watercourse and overcome weight and hydraulic pressure to open it (hydraulic pressure alone is 20 kg on 58 cm lid).





Cross Section



Enlarged Cross Section of the Sealing Surface

Figure 1. Circular Concrete Orifice Panel Nakka.

2. When closing, with added hydraulic pressure, breakage and chipping may occur which causes leakage.

3. Since it is not always a free surface opening, head loss is higher.

Method of Installation

1. If top of the opening is about 5 cm above full supply level there will be least head loss and it will be easiest to open.

2. Set at about 60-65 degree angle.

3. For check structures, bottom of opening should be near watercourse bottom to eliminate dead storage.

4. Always survey in Nakka elevation from design profiles.

5. Extra protection must be provided on the downstream side to stop erosion.

II. Trapezoidal Concrete Panel (Figure 2)

Advantages

1. Since removal is from above, the farmer need not enter the watercourse and pull against hydraulic pressure.

2. Chipping and breakage is less.

3. Since it is shaped more similar to channel cross-section, head loss is less for same flow area and flow constriction and erosion is also low.

4. One mold can make all sizes.

5. About same cost as that of orifice.

Disadvantages

1. Difficult to manufacture precision molds.

2. Because of free surface, difficult to check up flow depth.

3. Free board requirement adds weight to lid.

Method of Installation

1. Set at 60-70 degree angle.

2. Set nakka bottom at channel designed bottom elevation.

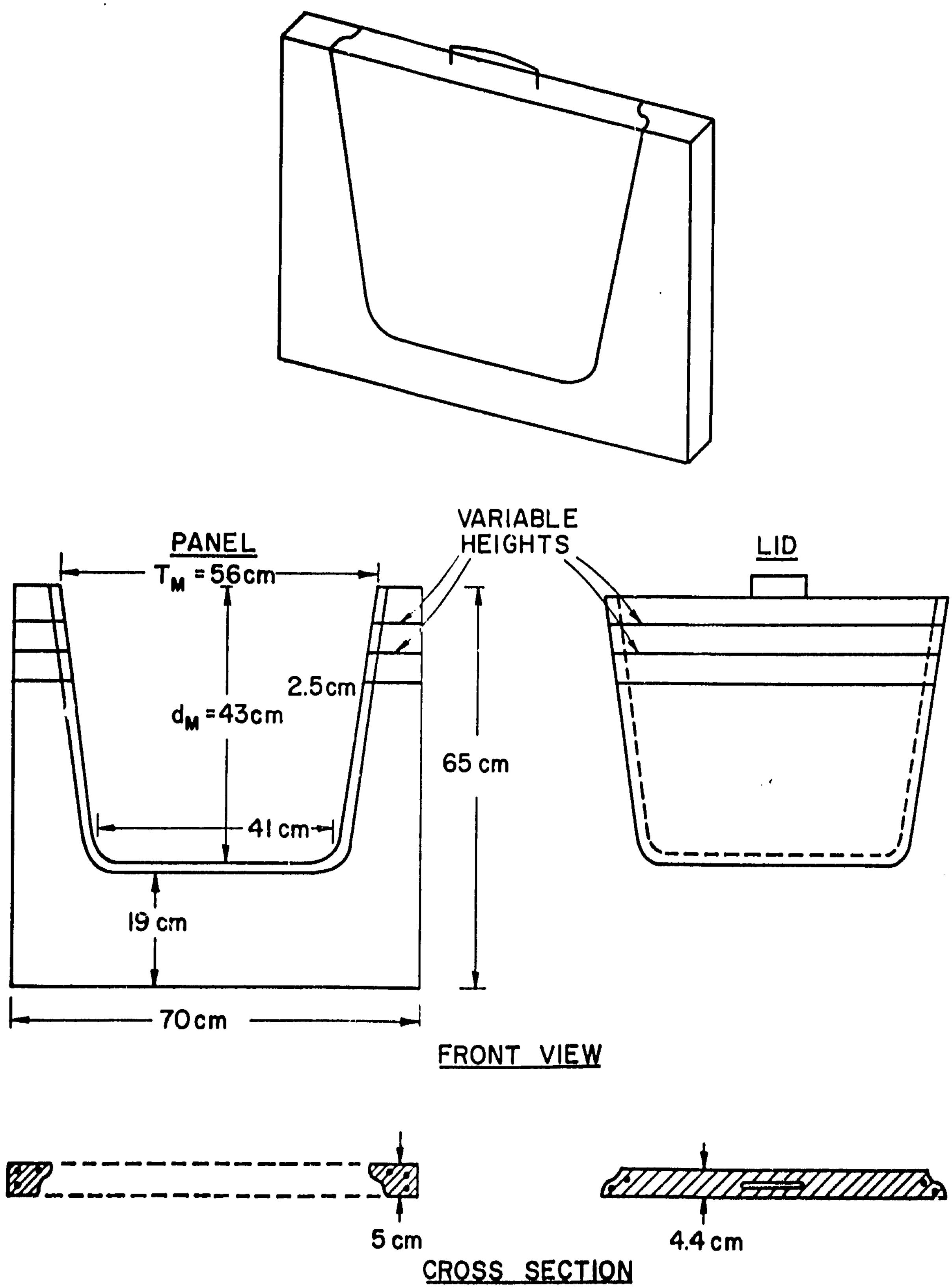


Figure 2. Trapezoidal Panel Nakka.

III. Trapezoidal Post Nakka (Figure 3)

Advantages

1. Large size, therefore, low head loss.
2. Shaped like channel, so little erosion.
3. Can be used to check up water.
4. Can make many sizes from the same mold.
5. Removed from the top, therefore, convenient to use.

Disadvantages

1. Difficult to manufacture molds and cast Nakkas.
2. Large size very heavy lids (50 kg).
3. Higher leakage possible.

Method of Installation

1. Excavate to about 10 cm below channel bottom.
2. Compact the soil, add a cushion (2 cm) of loose, moist soil.
3. Set frame in place, vertically.
4. Pack moist soil around base and then compact.

IV. Rectangular Sliding Nakka (Figure 4)

Advantages

1. Mold construction and casting is relatively easy.
2. Very easy to use.
3. Low price, Rs. 50-55.
4. Applicable to many flow depths. Can check up water.
5. Can regulate and divide flows.

Disadvantages

1. Greater leakage.

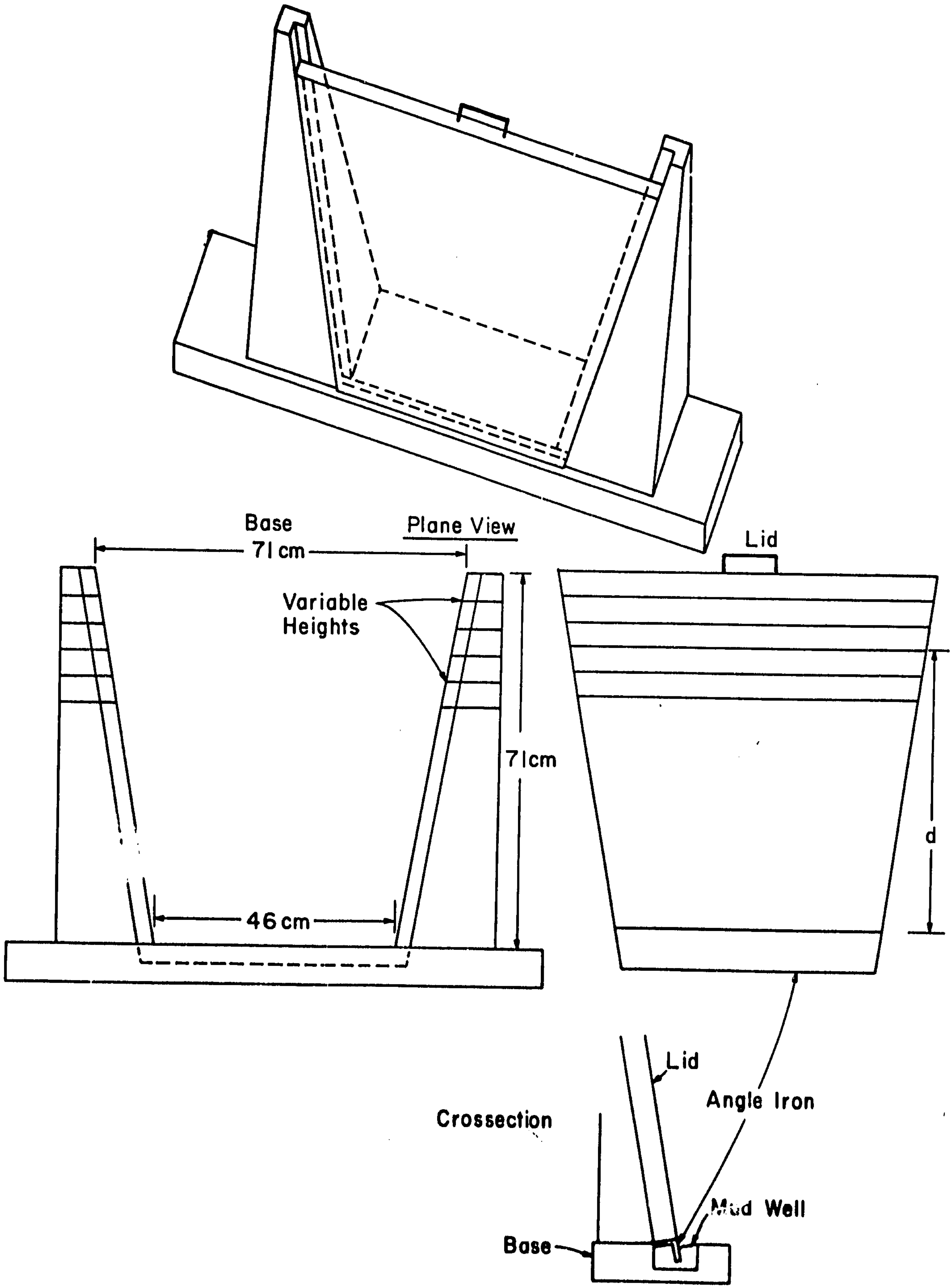


Figure 3. Trapezoidal Post Nakka.

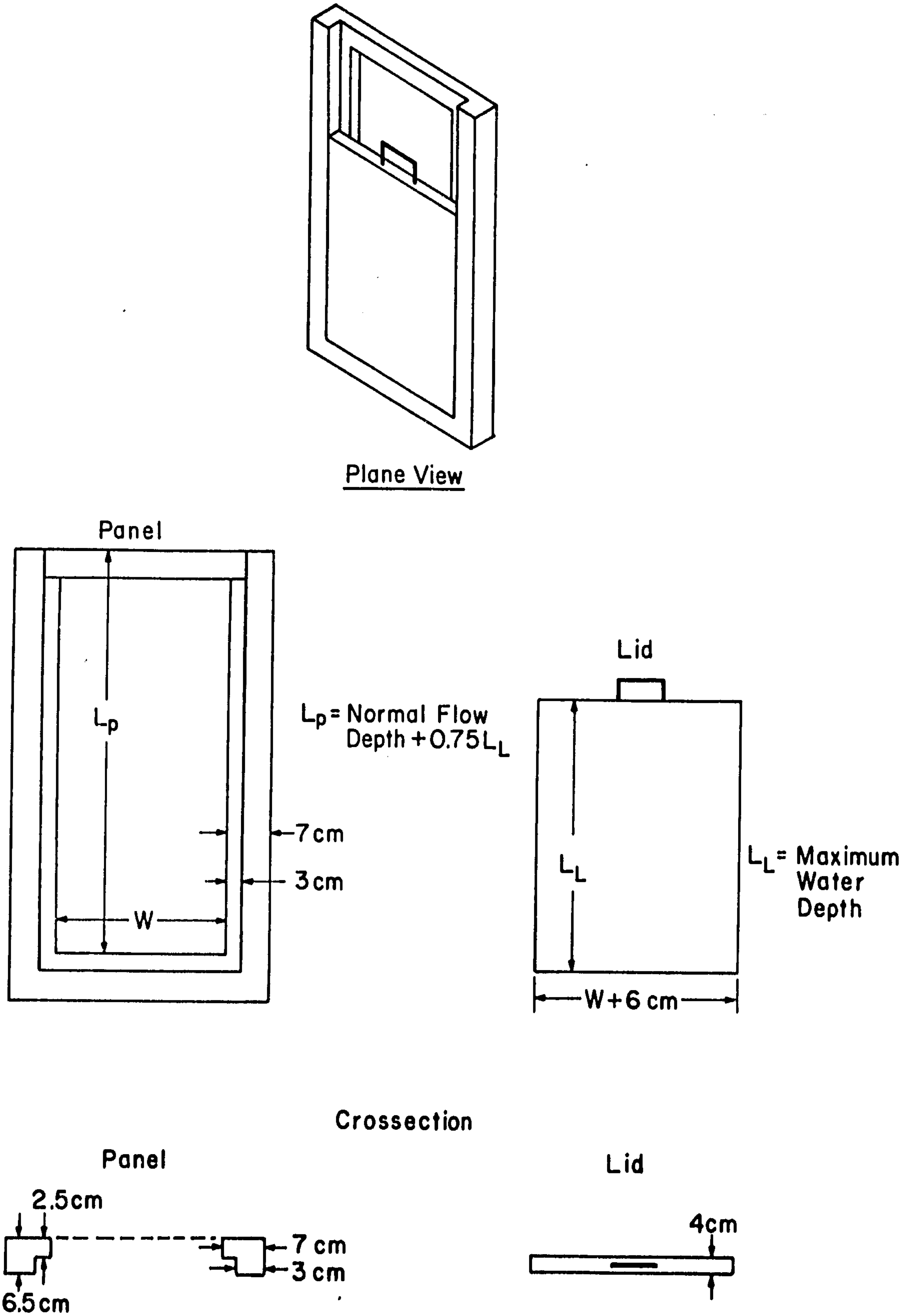


Figure 4. Rectangular Sliding Nakka.

Method of Installation

1. Set base at bottom of channel (designated elevation).

2. Set at 45-55 degree angle, depending on lid weight.

3. Design lid length (L_L) at 1.3 x design fsl or check up depth plus 12 cm freeboard.

4. Design panel length (L_P) at 1.3 x design flow depth + .75 times L_L.

5. Design width (w) according to allowable head loss.

6. Extend installation side walls up to within 15 cm of top of panel.

V. General Instructions Regarding Brick Masonary Installation (Figure 5)

1. Always survey in from the nearest benchmark according to design elevations.

2. Excavate for base and cut off walls.

3. Compact base.

4. Lay floor and base cut off walls.

5. Suspend panel in proper position, elevation, and angle with bricks.

6. Build wall around panel.

7. Build length according to erosion problem.

8. Complete cut-off walls.

9. Replace moist soil around installation.

10. Cure masonary work for three days by presoaking bricks, surrounding structure with moist soil, and sprinkling regularly with water.

11. Multiple installations (combined check and Nakkas) can be made by moving cut-off wall to front of structure and connecting at the corners.

12. Base can optionally be of poured concrete.

Precast Concrete Slab Installation (Figure 6)

1. Advantages: quick and easy to install, no masons required, saves engineer's time, uniform quality.

2. Disadvantages: difficult to transport to the site.

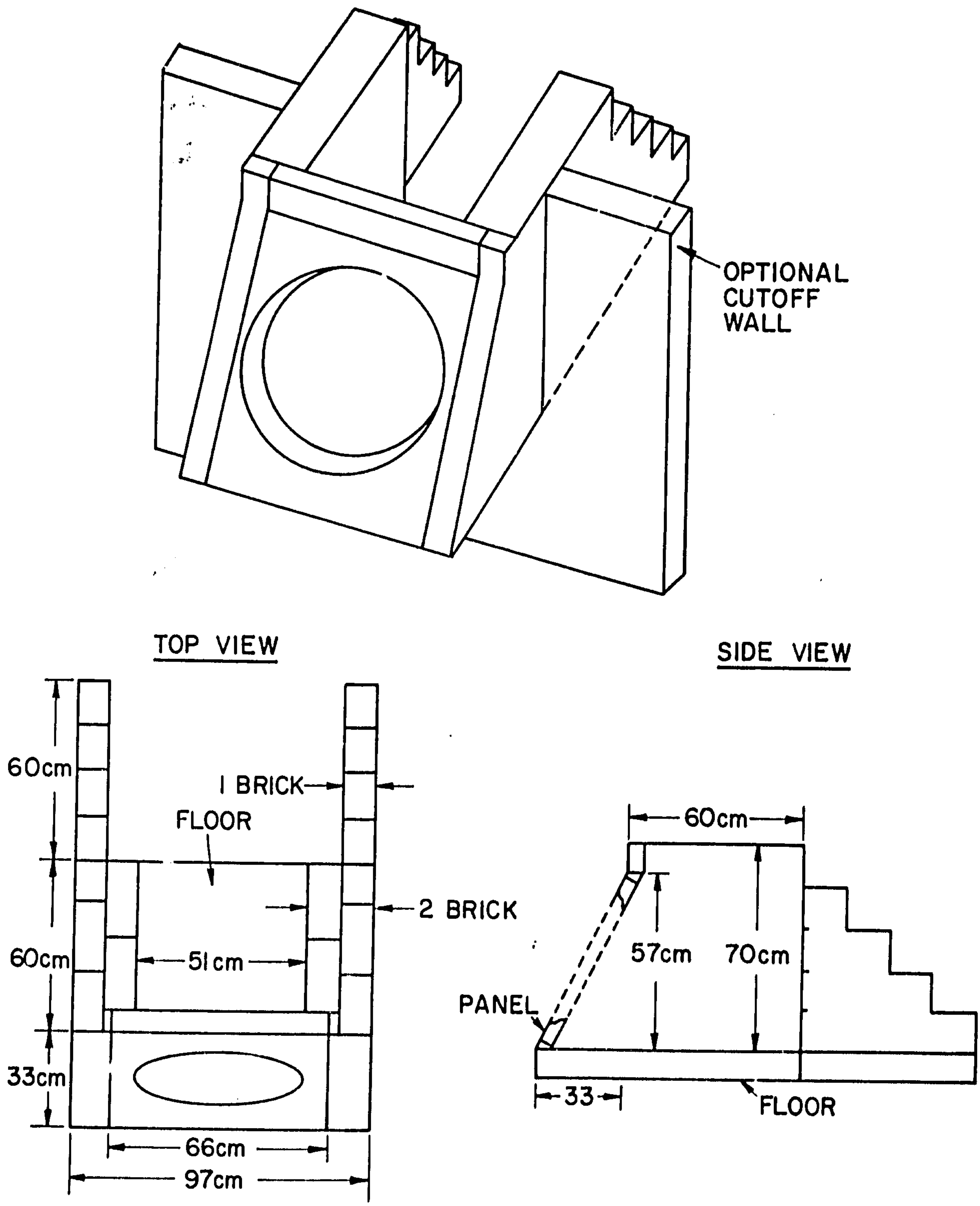


Figure 5. Brick Masonry Installation for Panel Nakkas.

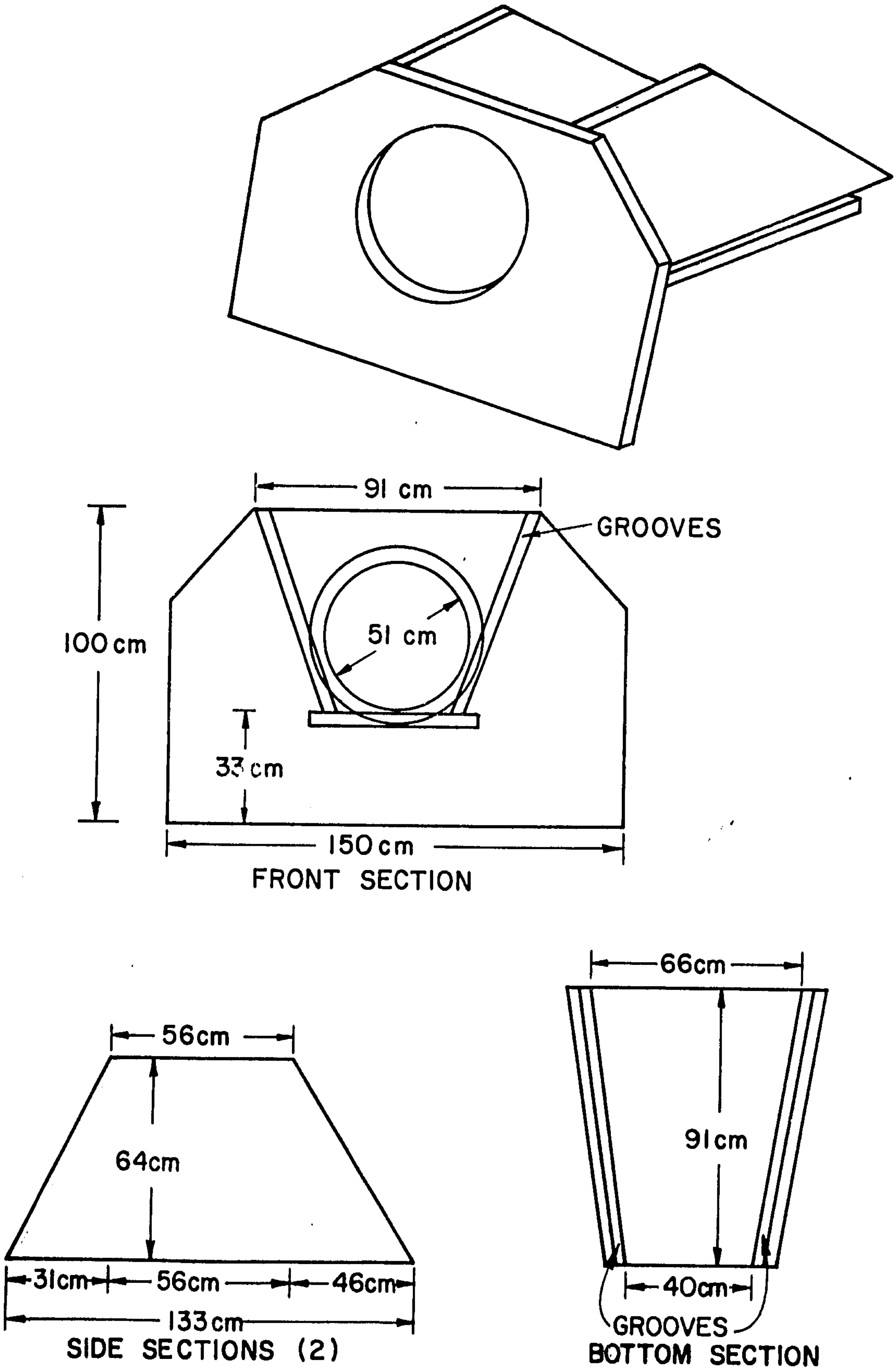


Figure 6. Precast Concrete Slab Installation for Panel Nakkas.

VI. <u>Other Watercourse Structures</u>

A. Culverts (Figure 7)

1. <u>Pipe Culvert</u>

a. Cheapest alternative.

b. Available in 2.4 meter maximum lengths.

c. Is not wide enough or strong enough at the edges for large traffic.

d. For large, heavy traffic, wing walls are required.

e. Pipe culvert head loss can be estimated from Figure 9.

2. <u>Installation</u>

a. Choose pipe size depending on allowed head loss.

b. Install so that top inside of pipe is about 5 cm above fsl.

c. Compact and shape soil underneath.

d. Compact soil very well around the sides of pipe.

3. <u>Half Pipe Culvert</u>

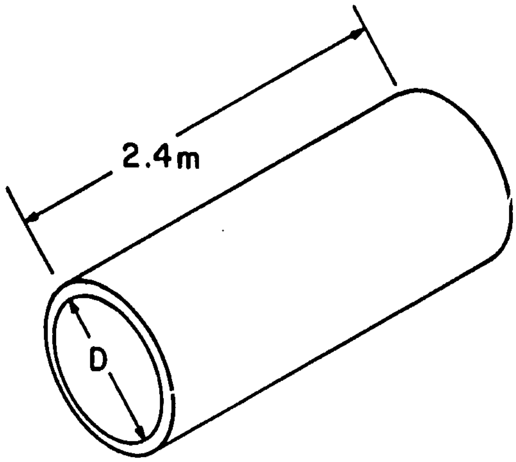
a. Use half pipes inverted.

b. Same cross-sectional area for less cost.

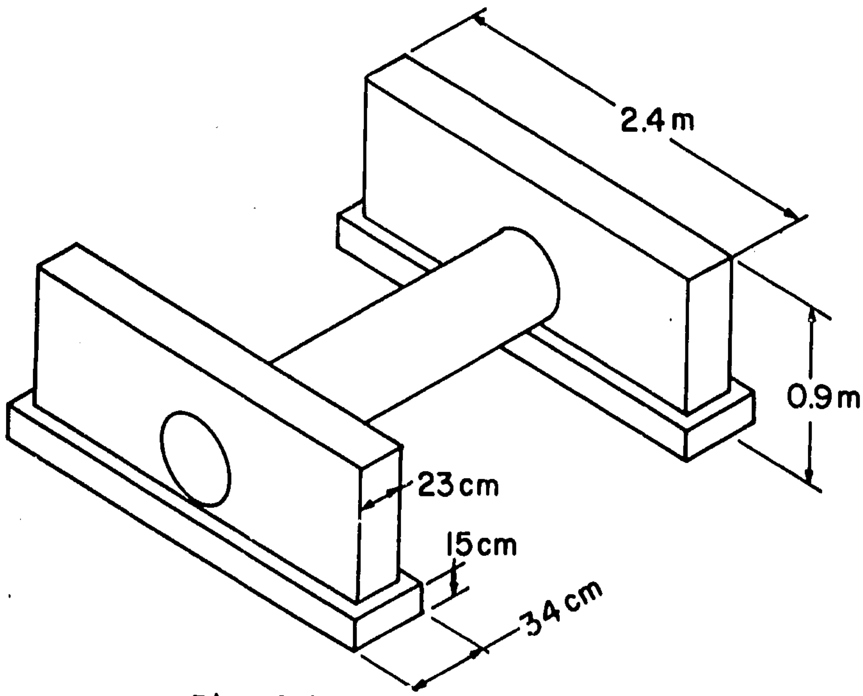
c. Especially for where traffic is light, such as walking culverts.

d. Additional support can be created with a brick foundation under edges (23 cm wide).

B. <u>Buffalo Baths</u> (Figure 8)



Pipe Culverts



Pipe Culvert with Wing Walls

Figure 7. Pipe Culverts.

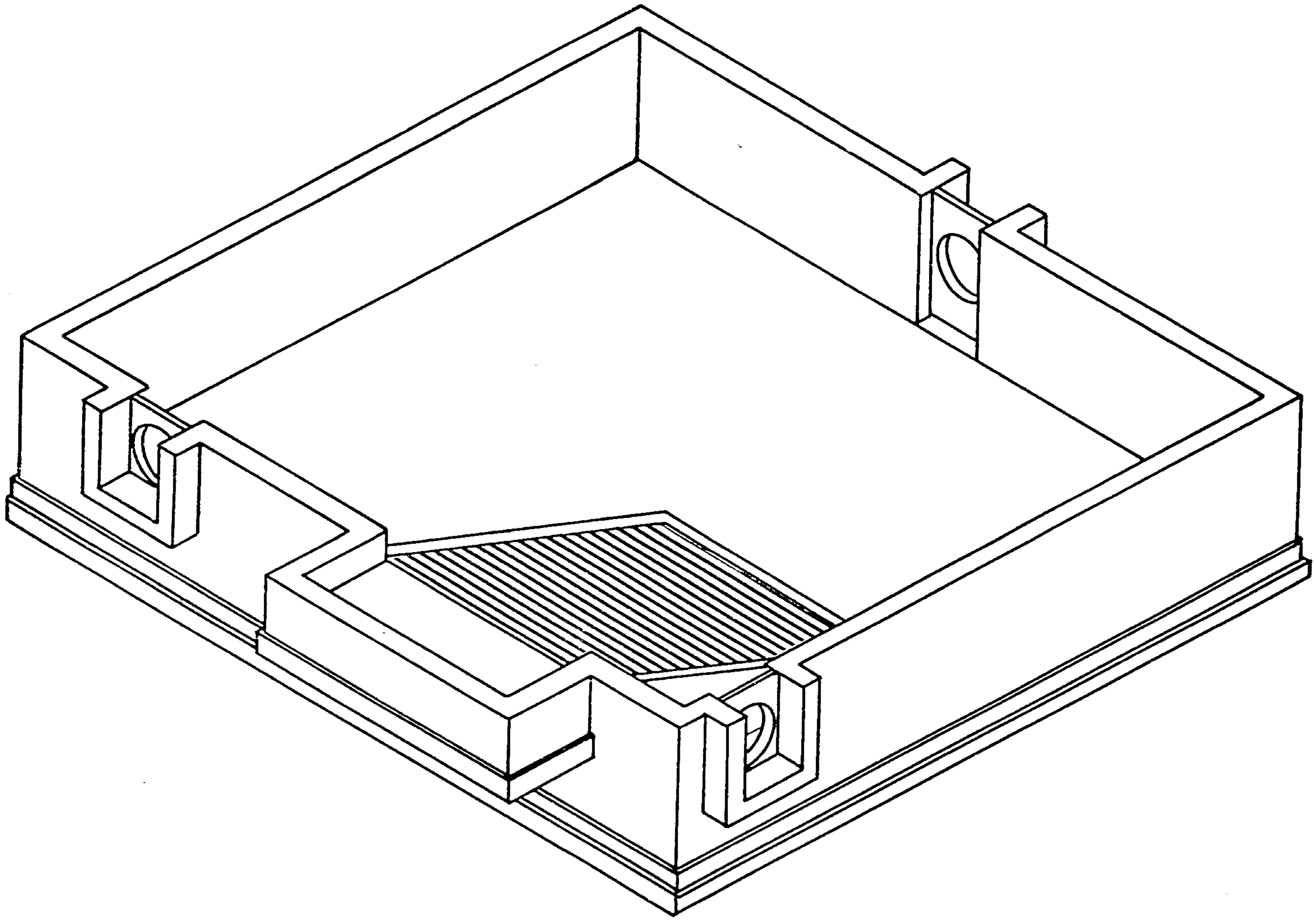


Figure 8. Sketch View of Rectangular Buffalo Bath.

Location

a. Where buffalo wallows were previously located.

b. Near villages.

c. Near areas where buffalo are located.

i) Regular Buffalo Bath

Exact configuration depends upon watercourse configuration and area available.

Installation (Figure 8)

Compact soil around foundation. For entrance ramp construction,

1. Soil foundation must be compacted very well.

2. At least 23 cm brick masonry required.

3. Poured concrete base is a stronger alternative.

If erosion of the base soil is a problem, pour in a sand or fine gravel base.

ii) Low Cost Buffalo Bath

a. Build two walls of slanting brick masonry 10 cm thick as the lining.

b. Leave other two walls as kucha entrances and exits.

c. Make pucca watercourse entrance and exit.

C. Washing Stations

1. Short pucca sections (perhaps 4 meters long) with a wide top width (30 cm) upon which village women can wash clothes.

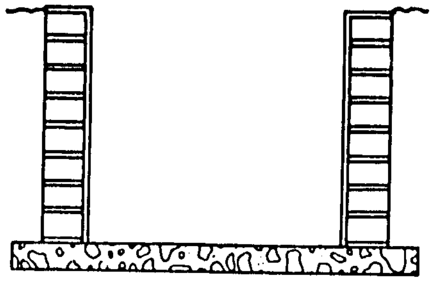
2. Provided near villages and present washing areas and where water flows most of the week.

3. Freeboard from design full supply level to platform should be reduced to 8 cm to allow easy access to water.

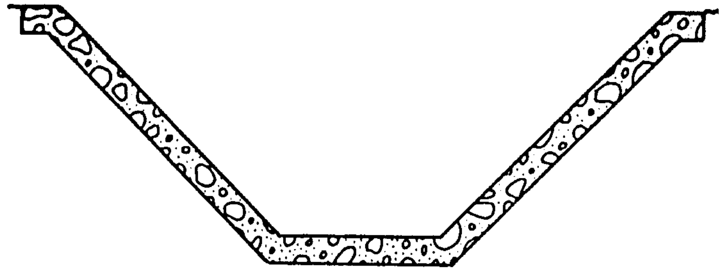
VII. Channel Linings (Figure 9)

A. Cross-sectional Shape

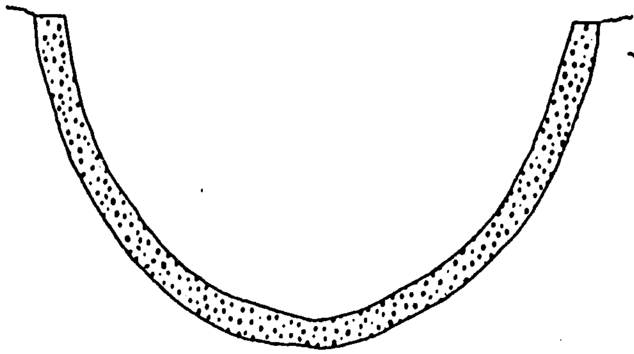
1. Will depend primarily on material chosen



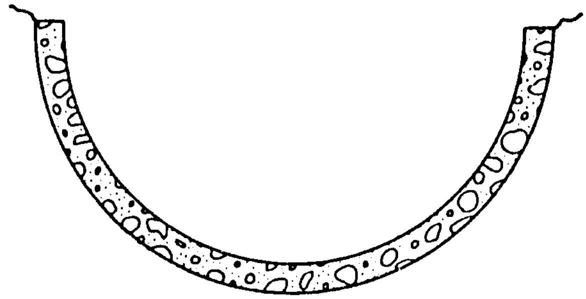
a) Rectangular Brick Masonry on a Poured Concrete Pad



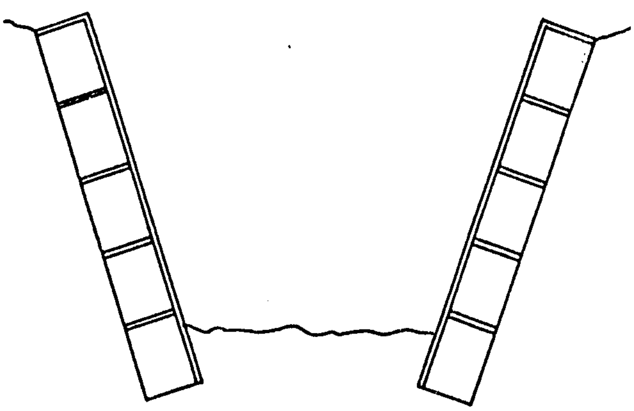
b) Poured Concrete Trapezoidal



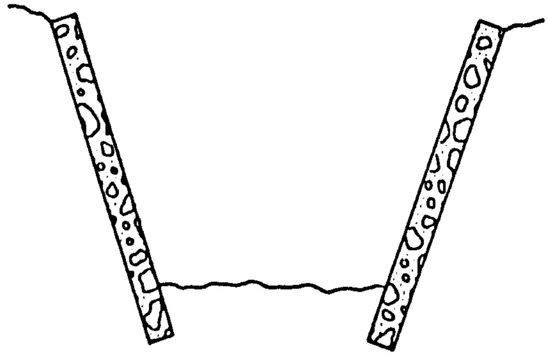
c) Sprayed or Hand Placed Cement Mortar, Soil Cement, or Asphaltic Parabolic



d) Precast Concrete Semicircular



e) Concrete or Soil Cement Block Side Lining



f) Precast Concrete Slab Side Lining

Figure 9. Various Types of Linings for Watercourses.

2. Sloping walls will resist back pressure better, but require good soil foundation.

3. Vertical walls are easier to build in masonry.

4. Cross-sectional dimensions should be chosen to minimize costs-rectangular channels should be wide and shallow.

5. Partial (side) linings can reduce costs without greatly increasing leakage.

B. Materials

1. Most popular materials in Pakistan are brick masonry and concrete.

2. Choice will depend primarily on the local costs of bricks and aggregate.

3. Brick masonry walls can be built only one brick thick to reduce costs when work is of good quality (Figure 10).

4. Plastering is not required if masonry work and bricks are of good quality.

5. Concrete can be poured in place or installed as precast slabs, and should generally be in trapezoidal cross sections.

VIII. Estimate of Cost of Materials

A. Masonary Work

1. Calculate the volume of masonary work in cu. meter. Assume masonary work is 200 cu. meters.

2. Number of bricks required @500 bricks/m^3: 200 x 500 = 100,000.

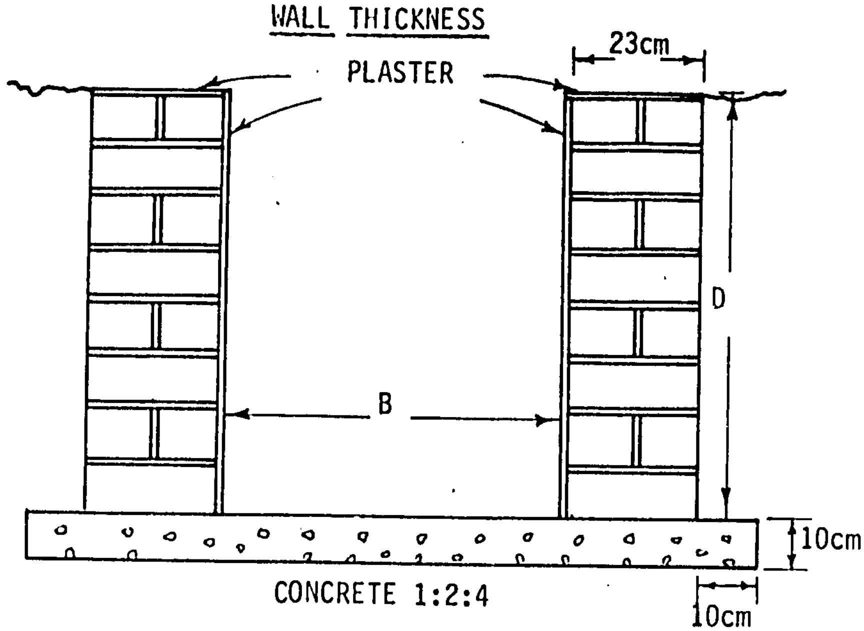
3. Volume of mortar required for 200 cu. meter masonary work (@.35 m^3/m^3): 200 x .35 = 70 cu. meter.

4. The standard cement sand ratio used in mortar is 1:3. The volume of cement (@9 bag/m^3): 70 x 9 = 630 bags

The volume of sand (@.8m^3/m^3): .8 x 70 = 56m^3

Find out the cost of cement and sand according to the market rates.

WALL THICKNESS



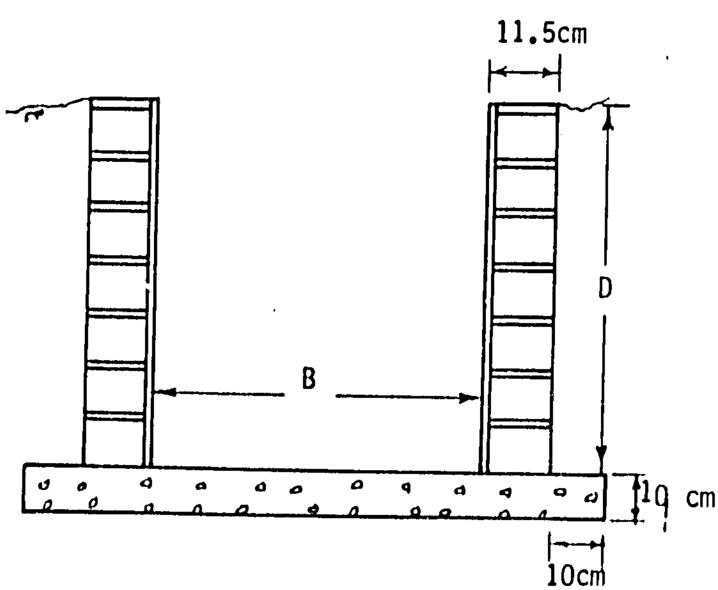
MATERIAL REQUIREMENTS
PER LINEAR METER

BRICKS	230 D
MORTAR	0.16 D m^3
CEMENT	0.48 D bags
SAND	0.04 D m^3
CONCRETE	(0.1 B + .07) m^3
CEMENT	(.63 B + .44) bags
SAND	(.05 B + .04) m^3
GRAVEL	(.095 B + .07) m^3

For B = .6m, D = .6m, A = .27 m^2
TOTAL MATERIAL COSTS = Rs 100/m
(WITHOUT PLASTER Rs 95/m)

LABOR COSTS	Rs 12/m
TOTAL COSTS	Rs 112/m
TOTAL COSTS FROM CONTRACTOR	Rs 160/m

11.5 cm WALL THICKNESS



MATERIAL COSTS PER LINEAR METER

BRICKS	115 D
MORTAR	0.08 D m^3
CEMENT	0.24 D bags
SAND	0.020 m^3
CONCRETE	(0.1 B + .04) m^3
CEMENT	(.63 B + .27) bags
SAND	(.05 B + .02) m^3
GRAVEL	(.095 B + .04) m^3

For B = .6m; D = .6m, A = .27 m^2
TOTAL MATERIAL COSTS = Rs 74/m
(WITHOUT PLASTER, Rs 69/m)

LABOR COSTS	= Rs 10/m
TOTAL COSTS	= Rs 84/m

Figure 10. Brick Masonry Rectangular Lining with a Concrete Base.

B. Concrete

100 cu. meter of concrete slab will have 154 cu. meter of dry ingredient. The dry ingredients are normally mixed in the ratio of 1:2:4.

1. Find out volume of the concrete slab, say it is 200 m^3 meters.

2. Volume of dry ingredients.

$\frac{154}{100} \times 200 = 208$ cu. meter

Volume of cement = $\frac{308 \times 1}{1+2+4}$ = 44 cu. meter

No. of bags of cement = (@30 bags/m^3): 30 x 44 = 1320

Volume of sand = $\frac{308 \times 2}{7}$ = 88 cu. meters

Volume of stone = $\frac{308 \times 4}{7}$ = 176 cu. meters

Find out the cost of materials according to the current market rates.

Head Loss

1. Head loss will occur through any structure placed in the watercourse.

2. A graph of expected head loss through orifices is shown in Figure 11.

APPLICATION

1. Each trainee will try to install a nakka without applying mortar.

2. Each trainee will prepare estimates of cost of materials used for constructing washing pads, buffalo baths and culverts.

QUESTIONS

1. List the reasons for providing pacca watercourse structures on a watercourse.

2. List the different types of nakkas and check structures installed on a watercourse. Give merits and demerits of each.

3. What precautions would you observe while installing a nakka?

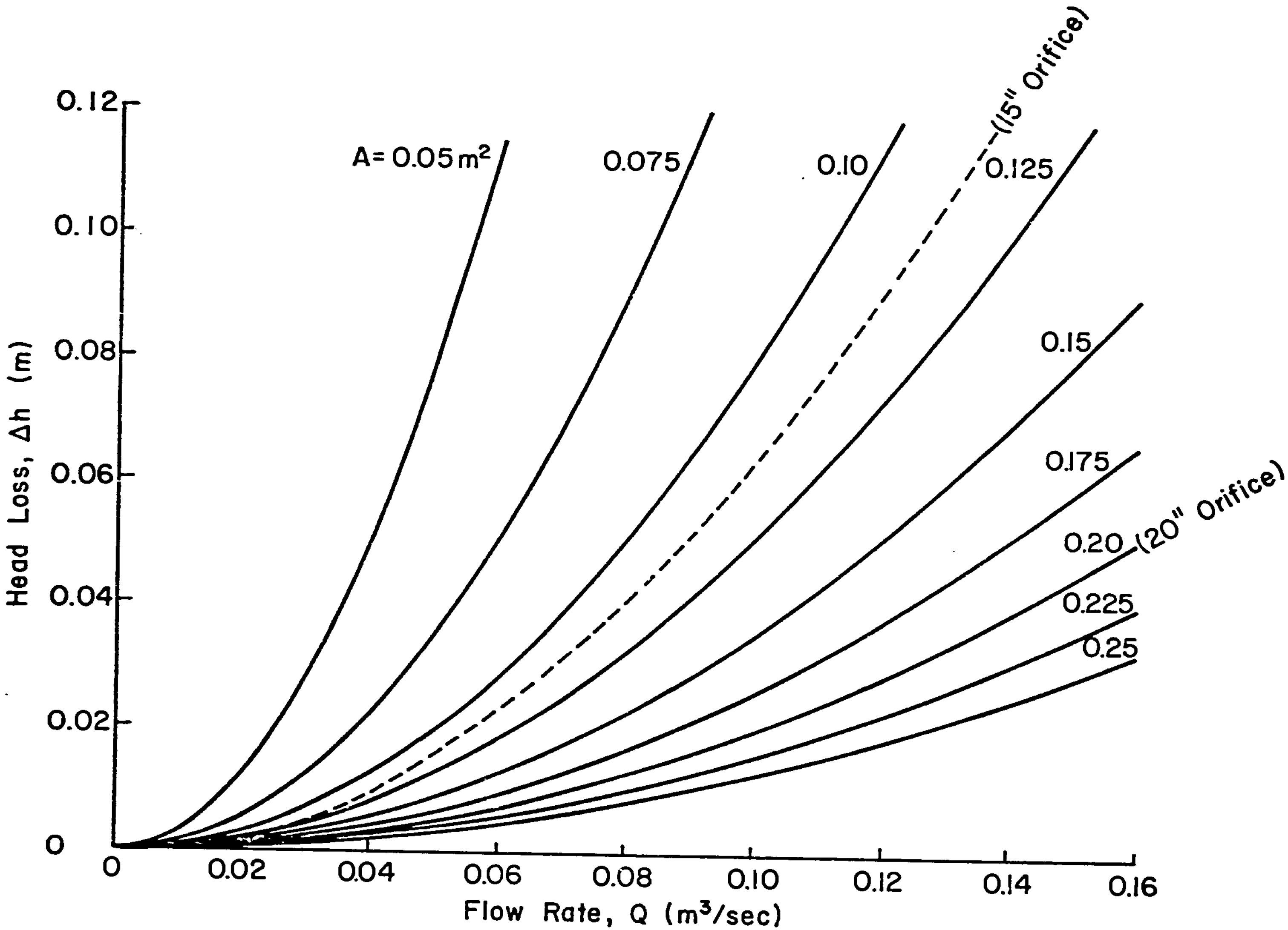


Figure 11. Head Loss Through Submerged Orifice Nakkas of Different Sizes for Varying Flow Rates.

Subject: FIELD TRIP TO ON-FARM WATER MANAGEMENT RESEARCH AND TRAINING CENTER AT LAHORE

Trainer Agricultural Engineer
Class Room 0 hours
Field 1 Days

OBJECTIVES

To familiarize the trainees with the work and achievements of the On-Farm Water Management Research and Training Center at Lahore.

MATERIALS NEEDED

1 - Transportation

2 - Field notebooks

TRAINING AIDS

None

PRESENTATION

A. Training Program (To be explained by Deputy Director T & R)

1. Need for the On-Farm Water Management Research and Training Center.
2. Set up of the On-Farm Water Management Research and Training Center.
3. Training facilities.
4. Output of the center.

B. Research (To be explained by the Agronomist of Institute)

1. A visit to the research and demonstration farm of institute will be made and the activities explained.
2. The results of the application of the various water management technologies will be discussed as a group in the field.
3. The importance of proper water management practices to crop production will be emphasized.

APPLICATION

Trainees will write a report on the trip and submit it to the trainer for evaluation. The practical aspects of the relationship between On-Farm Water Management and crop production will be emphasized.

Subject: METHODS OF IRRIGATION

Trainer Agricultural Engineer & Irrigation Agronomist
Class Room 3 hours
Field ________________Days

OBJECTIVE

To familiarize the students with the various irrigation methods that are in use in todays agriculture so they can determine if improved methods of irrigation are applicable to various areas where they work.

MATERIALS NEEDED

None

TRAINING AIDS

1 - Selected slides from slide set "Planning an Irrigation System" that are applicable to Pakistan's conditions.

2 - Slides showing local good and poor irrigation practices.

INTRODUCTION

What is irrigation?

A. Primarily--artificially providing plants with the water they require to evapotranspire and grow.

1. Since plants take up water through their roots, irrigation entails placing the water in the soil root zone of the plant.

a. root zone depth varies with crops and growth stages.

b. root zone water holding capacity varies with soil type, structure, and condition.

1) adding excess water leads to deep percolation which wastes water and leaches nutrients.

2) too little water decreases crop yields.

2. Crop water requirements depend on growth stage, crop, and climatic conditions.

B. Other Purposes

1. To create favorable crop environment

2. leaching of excess salts below the root zone

3. softening crusts to allow easier germination

4. to reduce soil temperatures during germination and seedling stage.

C. Main objective--to provide water to the crop roots when they need it.

1. efficiently--without wasting water.

2. economically--providing the maximum production with limited resources (water, money, etc.)

PRESENTATION

I. Conditions in the Indus Basin which effect the choice of irrigation method.

A. Water is a limited resource. Water limitations often limit total production and utilizing the water efficiently is a high priority.

B. Crop yields are low and capital investment potential of Pakistan's farmers is low.

C. Most farmers are uneducated, technology level is low. Methods must be simple.

D. Most of the Indus Plain is very flat. The natural field slopes vary from .0001 to .001 in much of the plain.

E. Most tillage is done with bullock drawn equipment, but tractors are becoming more available.

F. Most farmers have small holdings. Average holding size is about 10 acres and is sometimes split.

G. Most Indus Basin soils have low infiltration rates, due to fine texture, low aggregation (low organic matter) and compaction (shallow tillage).

H. Water is usually allocated on a fixed turn rotation. Each cultivator receives a set allotment each week. Private tubewells provide some farmers with flexibility.

I. Soil salinization is a fairly widespread problem and usually is due to a high saline groundwater table. Surface water supplies are good quality (250 ppm).

J. Nearly all of the Basin is presently irrigated in small rectangular level basins.

II. Types of irrigation methods that can be used in agriculture.

A. Sprinkler Irrigation

1. Description: water is pumped through pipes to outlets which spray the water over the area at rates less than the soil infiltration rate.

2. Types of Sprinkler Systems

a. Solid set

b. Portable

c. Center pivot

d. Big gun

e. Side roll

3. Some advantages of sprinkler irrigation
    a. Can achieve high efficiencies
    b. Applicable to most terrains--land leveling not required
    c. Applicable to soils of all infiltration rates
    d. Can have low labor requirements
4. Some disadvantages
    a. High capital costs
    b. High energy costs
    c. Requires moderately high technology
5. Applications in Pakistan
    a. Because of high capital and energy costs, and the technology requirements, would apply on very limited scale where:
        1) Terrain is rolling
        2) Soil infiltration rates are very high
        3) Water is extremely limited
        4) Crop production yields high financial returns
    b. Possible applications on intensive vegetable cultivation on sandy soils or orchard crops in Baluchistan or Swat

B. Drip (Trickle) Irrigation
1. Water is constantly applied at very low rates through small holes from plastic tubing, directly to the plant root zone.
2. Mainly has the same advantages as sprinkler, plus very high water efficiencies can be achieved and can be successfully utilized with highly saline waters.
3. Some disadvantages are very high capital costs and requires high technology level.

4. Applications in Pakistan
    a. only where water is very limited or of low quality and crops yield high financial returns
    b. orchard crops in Baluchistan

C. Sub-Irrigation

1. Water is supplied from the subsoil by closely regulating the water table within the root zone.
2. Advantages are that it can be easy and efficient and low cost.
3. Disadvantages
    a. Requires very specific subsurface geologic conditions to allow creation of a controllable perched water table
    b. Requires a second irrigation method until crops reach near maturity.
4. Applications in Pakistan
    a. Geologic conditions for creating a perched water table are not normally found
    b. Where the natural water table is high, many crops naturally receive a percentage of their water requirements from capillary rise from the water table.
        1) But in a monsoon climate, it's difficult to prevent the water table from coming too high and killing the plant roots, and
        2) High water tables often lead to soil salinization.

D. Surface Irrigation--Graded

1. Water is put on to the high end of a field and allowed to run slowly to the low end. Types of graded surface irrigation include:

a. In furrows

   1) straight on medium slopes

   2) contour on steep slopes

b. Between borders

c. Through corrogations

d. Unguided (wild flooding)

2. Advantages

   a. Low capital and energy costs

   b. Allows irrigation on sloping land (as is found in many irrigated areas)

   c. Allows irrigation of long fields with relatively small flows

   d. Is applicable to soils with moderate to fairly high intake rates

   e. Field drainage of excess rain is made possible

3. Disadvantages

   a. To get relatively high efficiencies, a high degree of management and water control is required

   b. To get relatively high efficiencies, the land must be uniformly graded and shaped.

   c. With moderate to slow infiltration rates, long irrigation times are required. Irrigation time must about equal the required intake opportunity time.

   d. Except for soils with high infiltration rates, a drainage outlet must be available from every field to dispose of tailwater and rain water.

   e. Labor intensive.

4. Applications in Pakistan

   a. Because of slope, water control, and drainage outlet requirement, the applicability is not great except on sandy soils and areas with moderate slope (NWFP).

E. Surface Irrigation - Level

1. Water is ponded on a level field surrounded by bunds and allowed to infiltrate in basins or borders or in furrows.

2. Advantages

   a. Management is very easy
   b. Adapts easily to flat topography
   c. Low cost
   d. Can function with no outlet drainage facilities
   e. Allows easy leaching of salts
   f. Allows full utilization of rain water
   g. High application efficiencies can be achieved
   h. Adapts well to moderate to low infiltration rates
   i. Works well with short term water supplies
   j. Adapts well to small land holdings

3. Disadvantages

   a. Requires level land to achieve high efficiencies (maximum land elevation fluctuation shouldn't be greater than half the applied irrigation depth)
   b. Soils with high infiltration rates require small field sizes which interfere with mechanization
   c. It is difficult to remove excess water, particularly during monsoons.

d. Plants are partly covered with water for sometimes extended time periods (in low infiltration rate soils)

e. It is difficult to apply small irrigations

f. Small basins require extensive delivery channels

g. Small basins are not easily adaptable to tractor mechanization

4. Application in Pakistan

   a. Presently, most land is irrigated in level basins

      1) Topography is quite flat

      2) Most infiltration rates are low to moderately low

      3) Method is simple; technology requirements are low

      4) Method is low cost

      5) Fits well into fixed warabundi

      6) Small plots don't interfere with bullock tillage

   b. But problems still exist that adversely affect yields

      1. Monsoon rains stand for long periods on crops

      2. Land is not sufficiently level to get high efficiencies

      3. The required extensive watercourse branch network creates water losses and removes land from production

      4. Small plots are difficult to cultivate with tractors

      5. Small irrigations cannot be applied

   c. In spite of problems, level surface irrigation is the most adaptable to the present conditions in Pakistan. Best policy is to make required adaptations to minimize the problems and difficulties.

III. Design of Level Basin Irrigation Systems

A. When designing an irrigation system, the following considerations and factors should be remembered:

1. Parameters

   a. Field size

   b. Field shape (square, rectangular, border strips)

   c. Surface shape (flat, ridges, beds)

   d. Levelness required

2. Influencing factors

   a. Soil type (infiltration rate, storage capacity)

   b. Machinery used (bullock or tractor)

   c. Crops grown

   d. Water supply available (flow rate, turn time)

   e. Land layout (parcel size)

   f. Land topography (slope, levelness)

   g. Desired application depths

B. Field size

1. Present sizes observed; from 1 kanal to 1 acre; averaging about 1/3 to 1/2 acre

2. Best size should allow efficient irrigation and cultivation

3. Efficient irrigation

   a. Irrigation application efficiency (E_a) is the water placed in the root zone for crop use divided by the total water applied. Excess application leads to deep percolation and wastage. Deficient application leads to poor crop yields due to stress.

b. The amount of water infiltrated depends upon the time water stands on the surface (intake opportunity time) (see Figure 1).

1) For efficient irrigation, water must lie on the surface of all parts of the field for nearly the same amount of time. The field must be covered quickly and the field must be level.

4. Choose the size which gives quick covering or advance time (t_c) relative to infiltration or intake opportunity time, IOT.

a. Relationship between application efficiency and covering divided by infiltration time (rule of thumb):

t_c/IOT	E_a*
.25	90%
.33	89%
.50	82%
1.0	70%
2.0	58%

*Assumes a level field

So, if a field requires 1 hour for the irrigation water to reach the far end, and an additional 1 hour for the ponded water to infiltrate, the maximum achievable E_a is 70%. By observing farmer irrigations, it can be determined whether his field size is too large for efficient application, or whether he can enlarge it without wasting too much water.

b. Factors which effect proper field size for high E_a

1) Inflow rate: as the flow rate increases, t_c decreases and E_a increases

2) Soil infiltration rate: as infiltration rates decrease, IOT increases and E_a increases

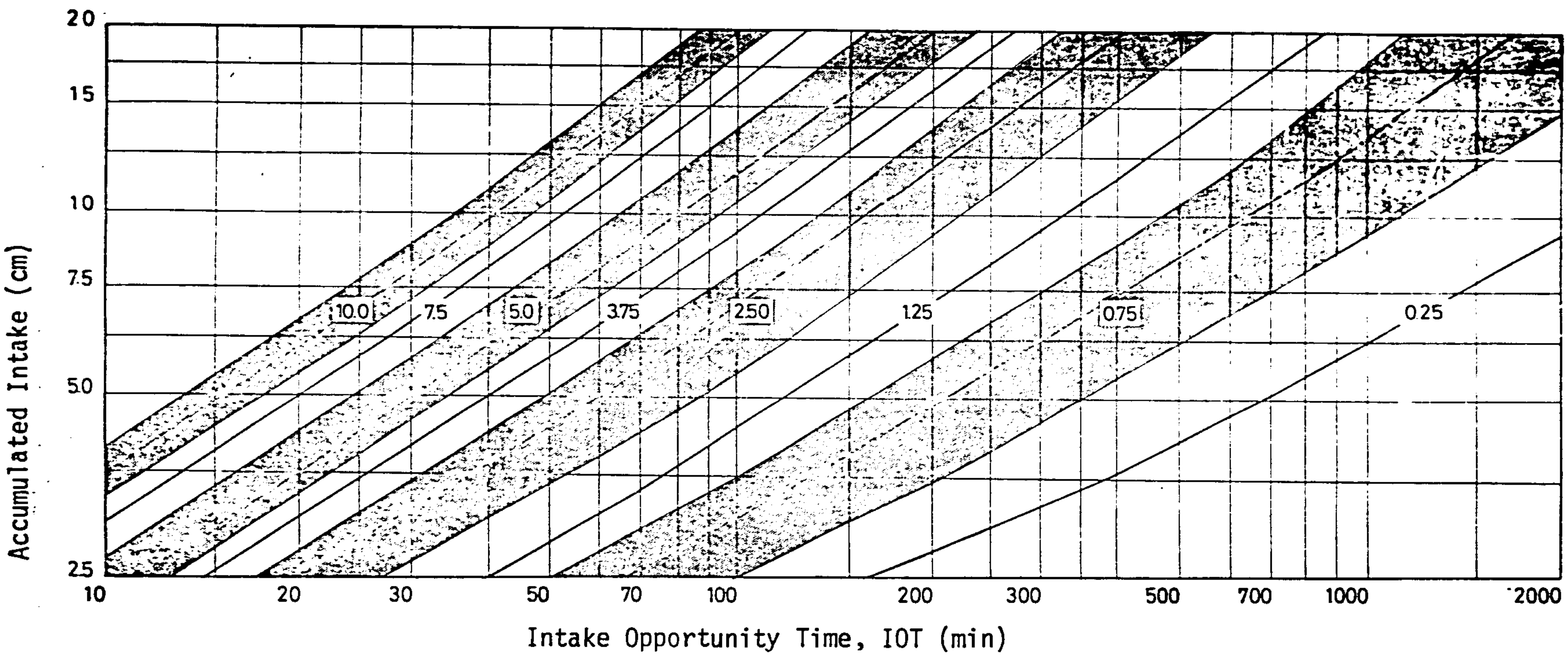


Figure 1. U.S. Soil Conservation Service, Intake Families for Surface Irrigation.

3) Total irrigation applied: as total application increases, IOT increases and E_a increases

4) Crop density: for denser crops (fodders, broadcast wheat), t_c increases and E_a decreases

c. For high inflow rates, low infiltration rates, large irrigations and row crops, larger fields can be irrigated.

d. A rule of thumb

1) Inflow rate (Q) in inches per acre of field size larger than 3 times the soil infiltration. rate (IR), will usually lead to E_a larger than 80%.

2) From this calculation, allowable field sizes would be:

Q (csc)	Infiltration Rate, IR high (2 in/hr)	med (1 in/hr)	low (0.3 in/hr)
1	.16 Ac	.33 Ac	1.1 Ac
2	.33	.66	2.2
3	.50	1.00	3.3
4	.67	1.33	4.4

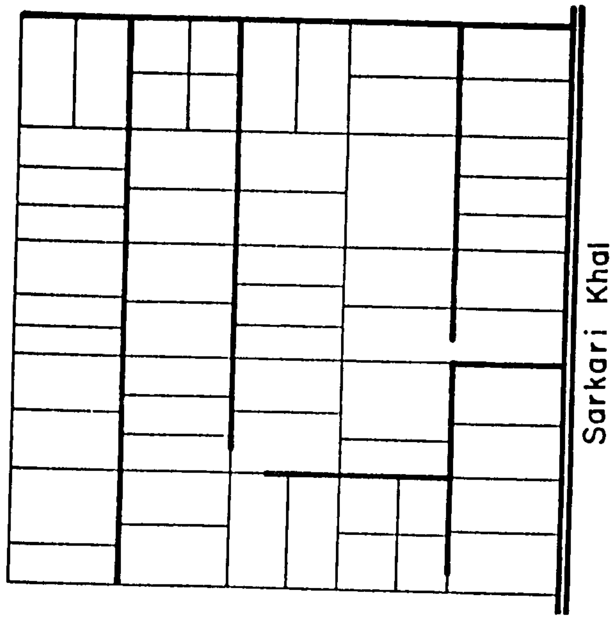
With large Q and low IR quite large fields can be efficiently irrigated.

e. Efficient irrigation will also depend on the levelness of the field. Previous data assumes a level field and so is the maximum. If by reducing the field size the total elevation difference within the field can be reduced, it will lead to increased E_a. This levelness factor will be further discussed later.

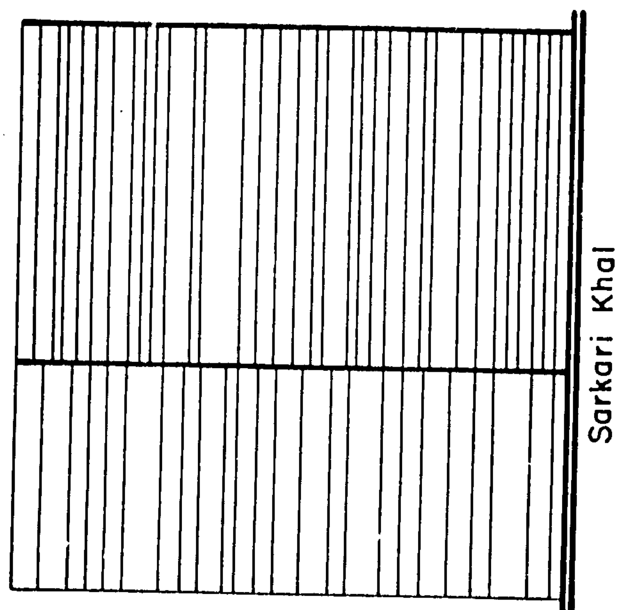
4. Advantages of larger fields are
    a. More efficient tillage operations
    b. Less land wasted in bunds
    c. Less water lost in conveyance because less branch channels are required
    d. Less land wasted in branch channels
5. Other field size limitations
    a. Of course parcel size and cropping patterns of small farmers will constrain field sizes
    b. If warabundi turn time is short; then large fields cannot be fully irrigated.

C. Field Shape

1. Present shapes are commonly from square to rectangular (perhaps width = 1/4 of length)
    a. Square shapes give the shortest covering time and highest E_a, but variation in E_a with shape is small
    b. There are some advantages to irrigating in long, narrow borders
        1) More efficient mechanized tilling
        2) Length of supply channels can be reduced substantially
            a) To go from regular 1/4 to 1/2 ac. plots to 440' to 550' borders (same field size) as shown in Fig. 2 could:
                i) Reduce the length of supply channels by about 90 ft. per acre
                ii) Save about 2 kanals of land per square acre



a.) An example of present field and farmer's branch channel layout showing 4200 ft or 170 ft/ac.



b.) An example of field and farmer's branch channel layout after reorganization of fields into long narrow basins showing 2100 m or 84 ft/ac of channels.

Figure 2. The Effect of Field Shape on Branch Channel Length.

iii) Save enough water to irrigate about 5% more land each week (2 kanals per square) (or reduce conveyance losses by about 5 percentage points)

c. Long fields require a long level strip of land and most areas in the Indus Basin can be economically leveled in 4 to 8 acre plots, so borders 440 to 880 feet long can be used on levelled land. Unleveled land will be difficult to irrigate in long borders unless the natural slope is very small, or borders across the slope can be made.

2. Total size of border will be determined as in the previous section

a. Lengths can vary between 440-880 feet or even longer with high Q, low IR conditions.

b. Widths can be determined by dividing desired total field area by chosen lengths.

c. Computed widths could be reduced slightly to allow for decrease in application efficiency resulting from longer runs.

d. Borders should be laid out to minimize supply channel length.

e. Border bunds can be temporary to allow for more efficient cultivation.

D. Levelness

1. Unlevel fields lead to uneven intake opportunity times, uneven irrigation depths, and poor application efficiencies. When high

spots are sufficiently irrigated, low spots are over irrigated leading to deep percolation losses and leaching of nutrients. When high spots exist, insufficient irrigation leads to poor crop growth and often to salinization (see Figures 2 and 3). The lesson block "Water Management Aspects of Land Leveling" discusses these factors further.

2. For efficient applications, with level surface irrigation, the land must be precisely leveled to within 0.15 feet. Generally, the maximum elevation variation should be less than ½ of the depth applied. As applications increase, elevation fluctuations cause less reduction in application efficiences and sometimes if variations are too great, or natural slopes are large, plots must be subdivided to allow more efficient irrigations.

E. Surface Shaping

1. Basins are normally irrigated flat, but under some conditions, by shaping the soil surface into ridges or beds and furrows, some advantages can be gained. These are:

   a. Smaller irrigations (as little as 1 inch) can be applied. This aids in germinating seeds in dry soil without causing a crust and small irrigations to seedlings can be applied without wastage.

   b. Irrigation water does not cover the crowns of the plants. Some crops (maize, cotton, pulses, vegetables) in hot weather are hurt by standing under water for extended periods. This problem is especially severe during monsoon rains.

   c. If a drain outlet is available, surface shaping will lead to quickler field drainage.

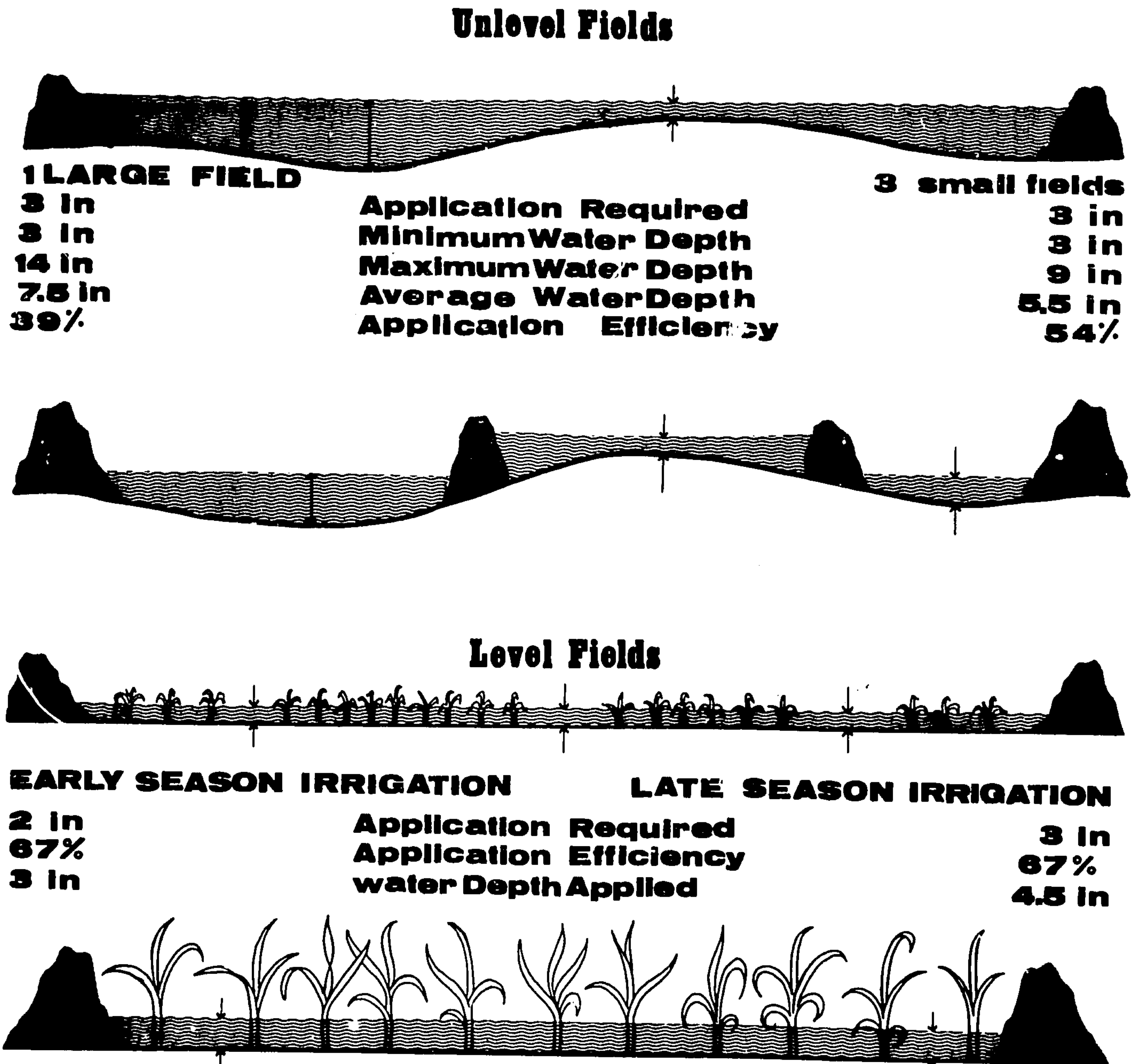


Figure 2. Effects of Unleveled Fields on Irrigation Efficiency and Field Size.

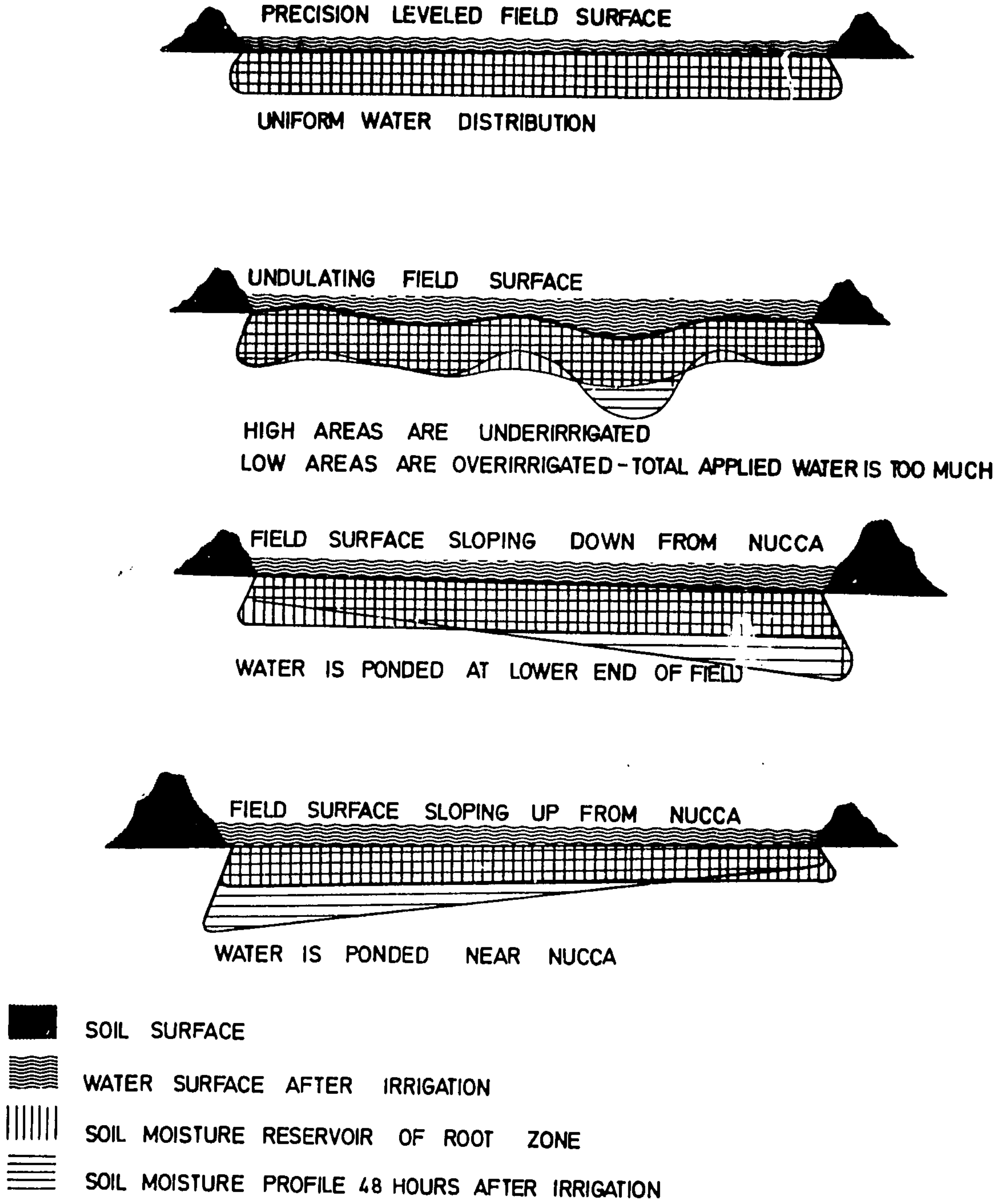


Figure 3. Effects of Leveled Fields on Irrigation Efficiencies.

d. Since all the land is not covered, the covering time (t_c) is less leading to higher application efficiencies. Evaporation losses from the surface is also less (can save as much as 5% of the applied water).

2. Furrows can be formed manually, with bullock scrapers, or with special tractor drawn equipment. Without the proper equipment, the labor required is great. Only where the advantages merit, should shaping be used. If crop rotations are planned well, the same furrows can be used for several crops.

3. Either beds or ridges and furrows can be used. With beds, salinity coming to the surface does not harm the plant growth but emerges between the rows. Because the volume available for ponding the water is small compared to the total surface area, the water must be held in the furrows for a longer time. This requires smaller flows (after initial filling) and longer turn times. This could create problems with a rigid warabundi and a farmer may have to split the water between several fields. Two rows of row crops should be planted near the edge of each bed.

4. Ridges and furrows allow easier, quicker irrigations than beds. They also involve more earth movement. The depths of furrows should be about equal to double the desired irrigation depth to allow quick irrigation. With saline waters, salts will accumulate near the plant and proper management is required.

APPLICATION

Based on the information that has been presented, what changes in the irrigation system would you recommend to be considered for the fields you visited on the last field trip?

QUESTIONS

1. Name 3 types of irrigation systems that are used in agriculture and what are the advantages and disadvantages of each.

Subject: WATER MANAGEMENT ASPECTS OF LAND LEVELING

Trainer Agricultural Engineer
Class Room 2 hours
Field 1 days

OBJECTIVES

To better understand the water wastage and decreased crop yields resulting from unlevel land.

MATERIALS NEEDED

Wooden Stakes and a measuring tape or rule

INTRODUCTION

Evaluation of the soil surface levels found within irrigation basins and the farmer's normal practice of irrigating until the highest point is covered with water, leads to the conclusion that between 10 and 60% of the applied water is lost to deep percolation if the farmer applies adequate water on the high spots. Although deep percolation provides recharge to the groundwater and sometimes (in fresh groundwater areas) provides water needed later for pumping, it also commonly raises the water table causing waterlogging and salinity, leaches away a substantial portion of the nitrate which wastes the fertilizer and reduces yields, and wastes the available, high quality, cheap surface water.

PRESENTATION

The following field procedure can be used to determine the degree of unlevelness of a level basin using ponded water.

a. Make bunds around the field strong and high enough to minimize leakage and avoid overtopping.

b. Divide the area to be evaluated into small rectangular units approximately 10 marlas (about 1/16 of an acre or .025 hectares) in size and place a wooden stake in the center of each unit. This is conveniently done by starting from one corner such as the upper left corner in Figure 1, following the arrows and setting high and visible stakes about 8 meters from the corner on one side of the area to be leveled, and then setting similar stakes at about 16 meter intervals along that side of the field. Proceed to the opposite side of the field as indicated by the arrows in Figure 1 and set the tall visible stakes at the same intervals as on the first side. Beginning at the stake indicated as the first from the top on the right side of Figure 1, walk directly to the tall visible stake on the opposite side of the field putting in a short wooden stake after 8m and setting 3 successive stakes after about 16m intervals along that line. Place stakes in the other parallel lines across the field in the same manner. The tops of these stakes should extend about 15 cm above the field surface.

c. Fill the field with water making sure that the whole area is covered.

d. Let the water come to a steady condition where it is standing still and not running across the surface.

e. Walk into the field and pound each stake down until its top is level with the water surface. If the infiltration rate is high (> 3 cm/hr), two or more persons should assist in pounding the stakes down to the water level so that they are all

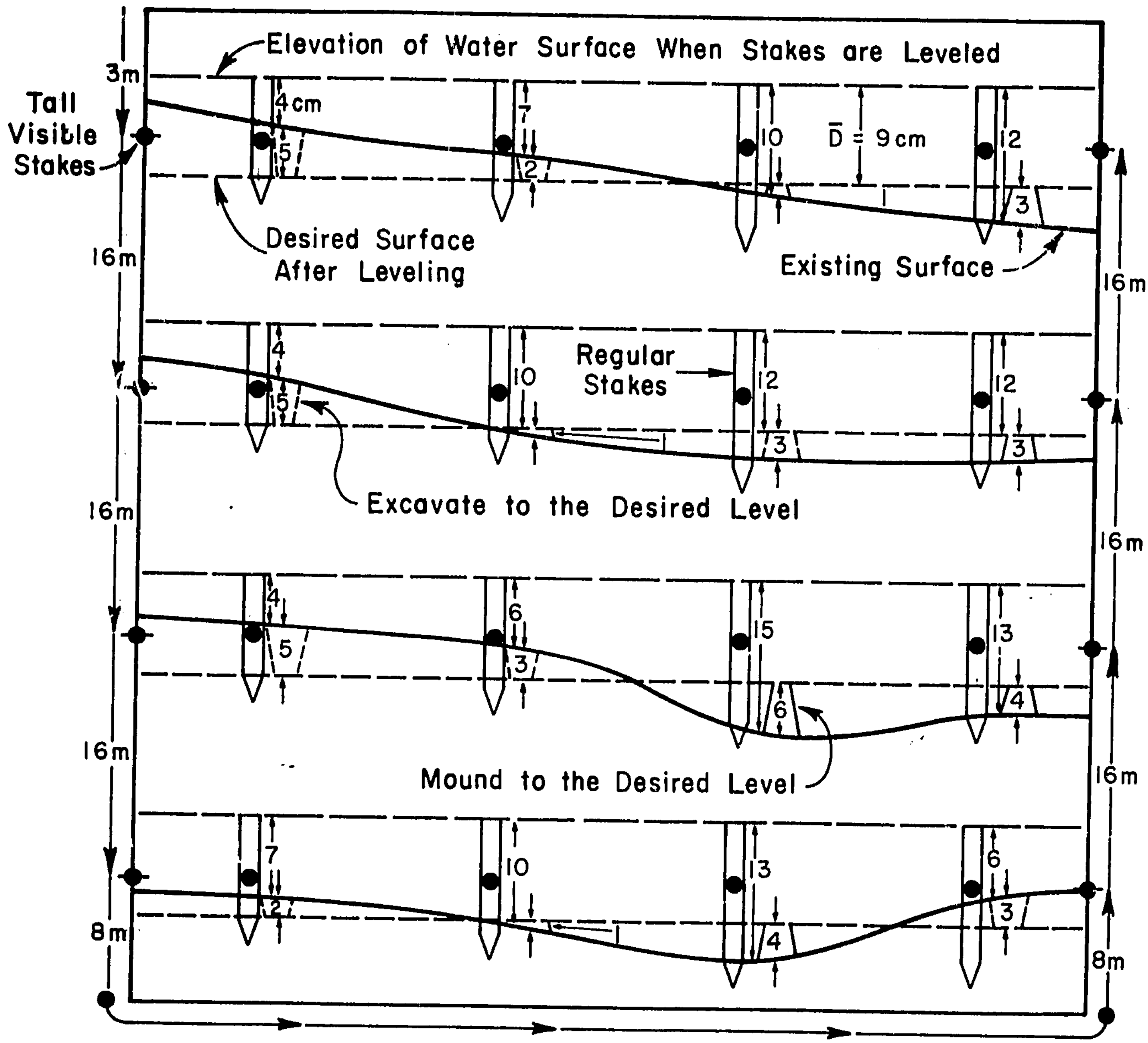


Figure 1. Elevation Profiles Across a Field as Indicated by Level of the Soil Surface on Stakes Set with their Tops at the Level Ponded Water.

pounded down to within ± 0.5 cm of the same level.

f. Allow the water to infiltrate into the soil.

g. Walk into the field and measure height of stakes D_i above the ground (average ground surface in the immediate area).

h. Calculate the average distance $\bar{D}$ from the top of the stakes to the desired field level using the following formula

$$\bar{D} = \sum_{i-1}^{n} D_i/n$$

where n is the number of stakes. For instance in the field represented in Figure 1.

$\bar{D}$ = (4 + 7 + 10 + 12 + 4 + 10 + 12 + 12 + 4 + 6 + 15 + 13 + 7 + 10 + 13 + 6)/16 = 145/16 = 9 cm

i. Draw the contour lines as indicated in Figure 2 to know where hills and hollows occur. The field elevation at each stake can be determined by the formula

$$E_i = \bar{D} - D_i$$

where E_i is the field surface elevation at the stake relative to the average field elevation. Contour lines divide the field into sections with surface elevations falling between a given increment (the elevation of the bordering contour lines). So a +2 cm contour line would run between all field surface elevations above and below +2 cm.

Estimating the Water Wastage

Most farmers try to cover the highest point in the field, or the top left corner of the field shown in Figure 2, when they irrigate. This would imply that the lowest section - that inside the -4 cm contour -

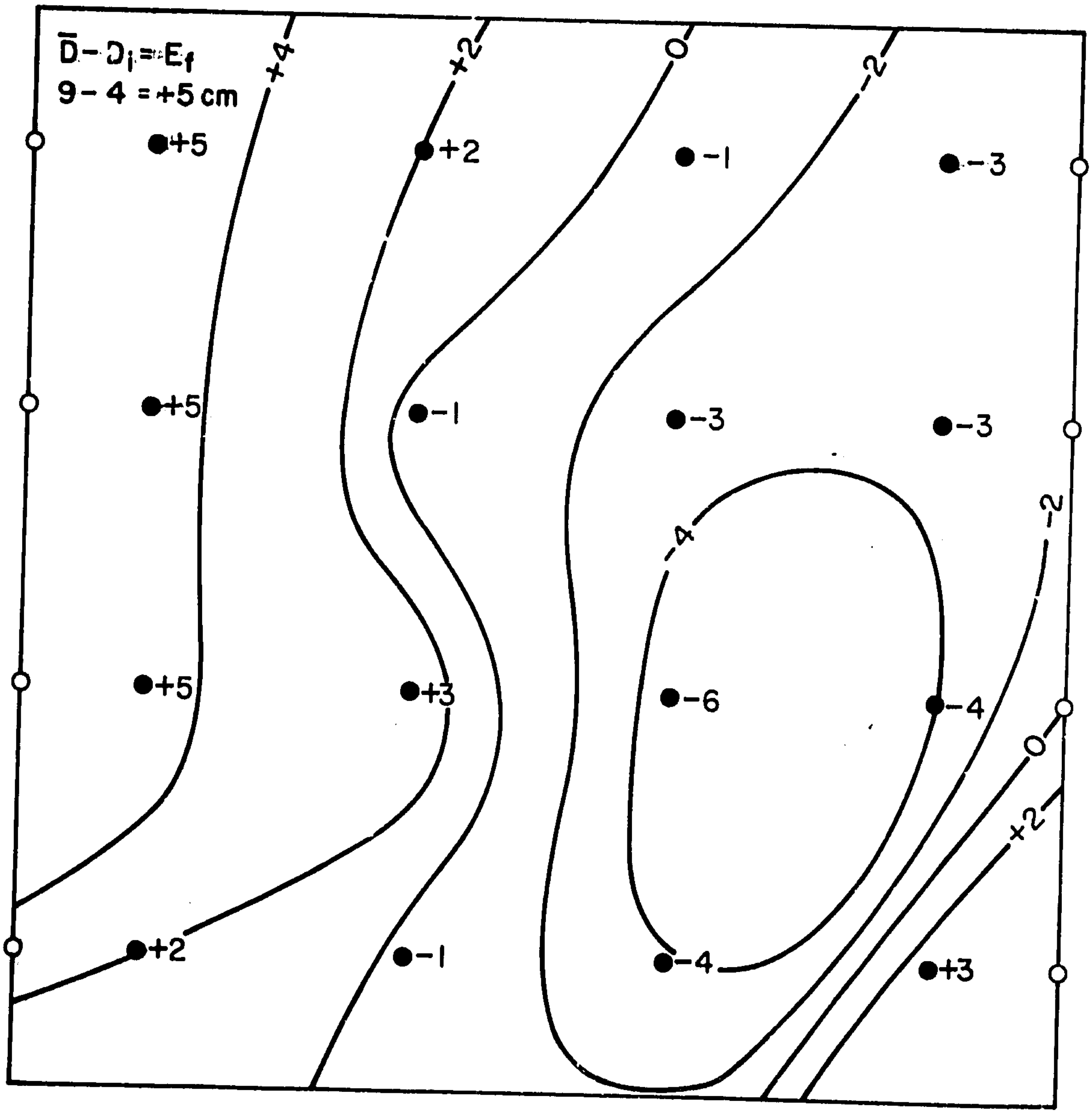


Figure 2. Contour Map of the Sample Field Showing Relative Field Surface Elevation (cm) at each Stake and Contour Line.

will be covered with at least 8 cm and in some places more than 10 cm of water. This is too much water and most will be wasted.
If we assume that the field's high areas are adequately irrigated, then the low sections will be overirrigated by at least 8 cm.

The volume of overirrigation can be estimated as 4 times the volume of water needed to fill the field up to the average elevation. This volume is equivalent to the volume of fill, which will be discussed in the next section. The volume of fill is calculated for each rectangular unit as the surface elevation below the average elevation times the unit area. The unit areas in the example are 16 x 16 m or $256m^2$. The total volume of fill, V_f, in Figure 2 is (starting across the first row of stakes)

$$V_f = 256/100\ (0 + 0 + 1 + 3 + 0 + 1 + 3 + 3 + 0 + 0 + 6 + 4 + 0 + 1 + 4 + 0)$$

$$V_f = 256/100 \times 26 = 66m^3$$

Zeros represent land areas which are higher than the average surface elevation. The estimated volume of water wasted would then be

$$4 \times V_f = 4 \times 66 = 264m^3.$$

or an average of about 6 cm across the one acre field. A farmer would have to overirrigate his field by 120% to give a 5 cm irrigation to his high land. This would result in an irrigation efficiency of 45 percent.

Assuming the farmer irrigates his field 10 times each year, he will waste 2640 m^3 or 65 ac-cm of water. If a farmer can pump water from his well for Rs. 3.3/ac-cm (Rs. 100/ac-ft), and he loses 30 percent of it in his ditches, the water at his field is worth

Rs. 3.3/(1-.3) = Rs. 4.7/ac-cm

and he would be wasting

Rs. 4.7 x 65 = Rs. 306

worth of water in this one acre per year. In saline groundwater areas or regions where the water shortage is acute, the value would be much higher.

Usually farmers don't adequately irrigate their high areas, but just wet them. Thus they stress the crops in these high areas and decrease their yields in order to save water. Similarly, low areas of the field which are consistently overirrigated generally have low fertility levels due to the leaching of nutrients. A study conducted by Wahla and Reuss (1976) indicates the effect of difference in field elevation on cotton yield. The average yields at the lowest areas (base elevation), mid elevation areas (5 cm above base) and the highest areas (11 cm above base) were 3.78, 8.12 and 7.45 maunds (one maund ≃ 37 kg), respectively. These data indicate that the farmers involved in this study were applying less water than needed for optimum growth on the high spots. Similar data (unpublished) has been collected for maize. The relative yields are plotted as a bar graph in Figure 3.

Since leveling and proper amount of water added would achieve the 8.12 maunds indicated, instead of the average 6.45 maunds measured, this shows that, with leveling, farmers whose yields were measured in this study can increase their cotton production by 1.67 maunds/acre. Assuming a value of Rs. 100/maund this would be Rs. 167/acre. Therefore, the total annual benefit in terms of water saved and increased production

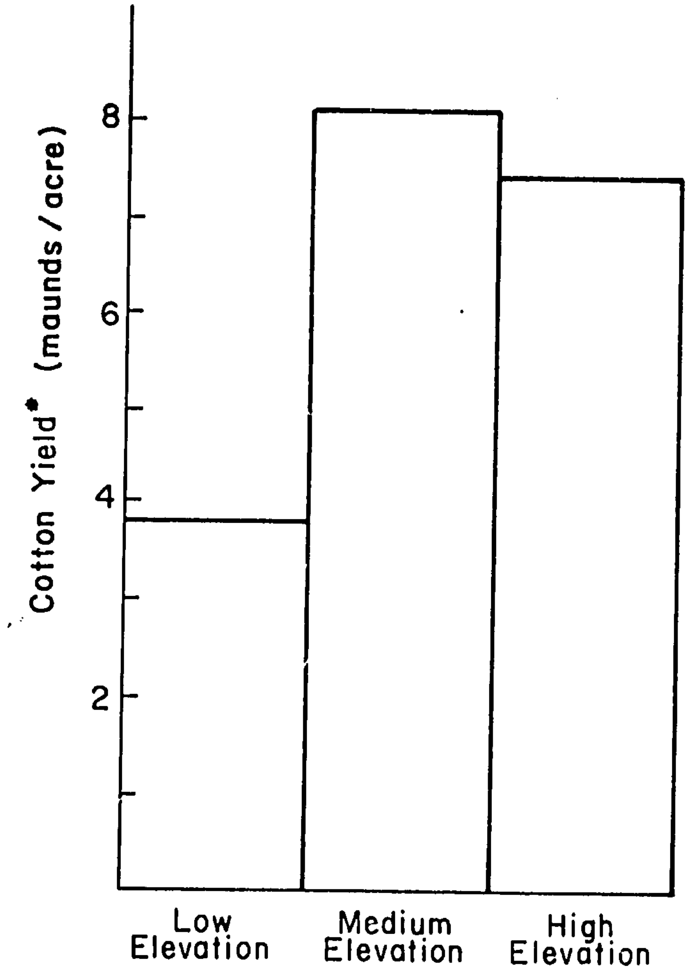


Figure 3. Cotton Yields as Affected by Soil Surface Elevation in Irrigated Basins (from Wahld and Reuss (1976)).

*Lint + Seed.

would come to Rs. 167 + Rs. 153 = Rs. 302/season. This assumes only one crop per year. If a winter crop, such as wheat or berseem is grown, additional benefit should be obtained.

Assuming the cost of moving the soil with either a tractor and scraper or a karah and pair of bullocks to be about Rs. 4/cubic meter, moving the soil to level this acre would cost about 66 m^3 x Rs. 4/m^3 = Rs. 264. The total benefits of Rs. 302 appear to exceed the total cost of about Rs. 264 in only one season. The benefits of this leveling would persist for at least several years, indicating that leveling is a very good investment for the farmer of this field.

It should be noted that the procedures outlined in this lesson for determining field elevation fluctuations could also be used by the farmer to obtain the topographic information necessary to carry out land leveling. Good farmers use ponded water to find high and low places in fields, but the use of stakes could make his earth moving operation much more efficient.

Application

The students will choose a field which is to be irrigated and carry out the procedures outlined to measure relative field surface elevations. They will then question the farmer regarding how he determines how much to irrigate and how many irrigations he gives per season; and from this information calculate his water wastage due to field unlevelness. Measuring irrigation volume with Cutthroat flumes can help verify these calculations. If the measurements can be made on a field which will be harvested soon, yields in the high and low areas could also be measured. Total benefits of land leveling can then be calculated.

Questions

1. What are the benefits of land leveling?
2. What causes lower yields in low areas of fields?
3. What causes lower yields in high areas of fields?

REFERENCES

Wahla, Moh'd Mohsin and John O. Reuss. 1976. Effect of within field elevation differences on cotton stands and yields. Mona Reclamation Experimental Project Report.

Subject: PRECISION LAND LEVELING DATA COLLECTION AND COMPUTATION

Trainer Agricultural Engineer
Class Room 4 hours
Field 4 Days

OBJECTIVES

1. To discuss the need for Precision Land Leveling (PLL) for Irrigated Agriculture.

2. To learn the procedure for conducting a land leveling survey.

3. To understand the method of calculating volume of cut and fill required for Precision Land Leveling for a particular field.

4. To estimate the cost of earth work for leveling a particular field.

NOTE: Since the majority of the trainees will have already completed the OFWM Training Course in PLL, this is for their review and to give those trainees that haven't attended their OFWM training the basic knowledge of PLL.

MATERIALS NEEDED

Engineer's level with stand, staff rod, ranging poles and measuring tape.

TRAINING AIDS

Slides showing effect of surface level on crop stand and water distribution in the root zone.

INTRODUCTION

Precision land levelling consists of grading and smoothing the land surface. The precision levelled fields will make possible a more even stand, improved crop yield, and savings of irrigation water and labor. On steep areas, erosion is reduced. Efficient use of fertilizer applied to the crop is another benefit. When an uneven field is irrigated, the high spots are watered too little allowing salts to accumulate, and the low spots too much leaching out the fertilizer. This factor alone is enough to result in the production of saline patches in the field, spotty crops and reduced yield. The benefits of PLL are shown graphically in Figure 1.

PRESENTATION

The grid system is used for planning the survey. A grid system of 20 meter intervals is considered suitable for most jobs. Walk over the fields to be levelled and prepare a map indicating all the features found in the field.

I. Surveying

(A) Staking a Grid System on Regularly Shaped Field Using Tape and Level (Figure 2).

1. In the field to be levelled, find or establish a corner where at least two straight edges intersect at approximately right angles. The longest edge should be taken as the base line and the shortest edge as the perpendicular line.

2. At a distance of one-half grid interval in from the base line and perpendicular to base line, set a grid stake. At some distance from the grid stake, set a range pole, at a distance of one-half grid interval from the base line. This is range pole #01. Set the level or instrument over the grid stake, and with the horizontal circle set at 0°, orient the instrument by sighting on range pole 01. From this grid point, measure, at full grid intervals, and sight in, with the instrument, the remaining grid points (B-1, B-3, B-4, B-5) setting the grid stakes at these points. When the grid stakes are too short, use a range pole to sight in the grid points.

NOTE: 9 stakes per acre will be required.

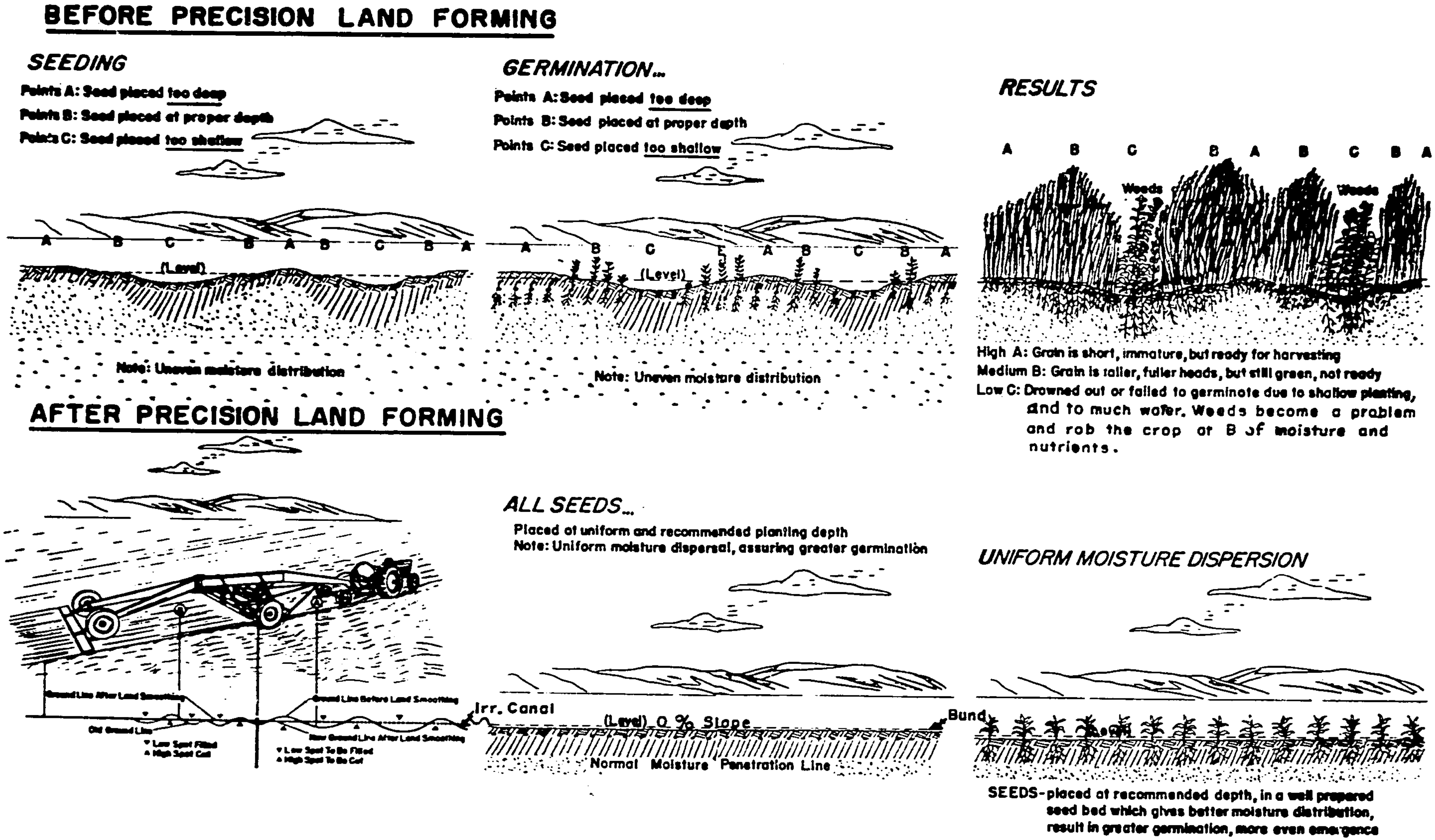


Figure 1. Benefits of Precision Land Leveling.

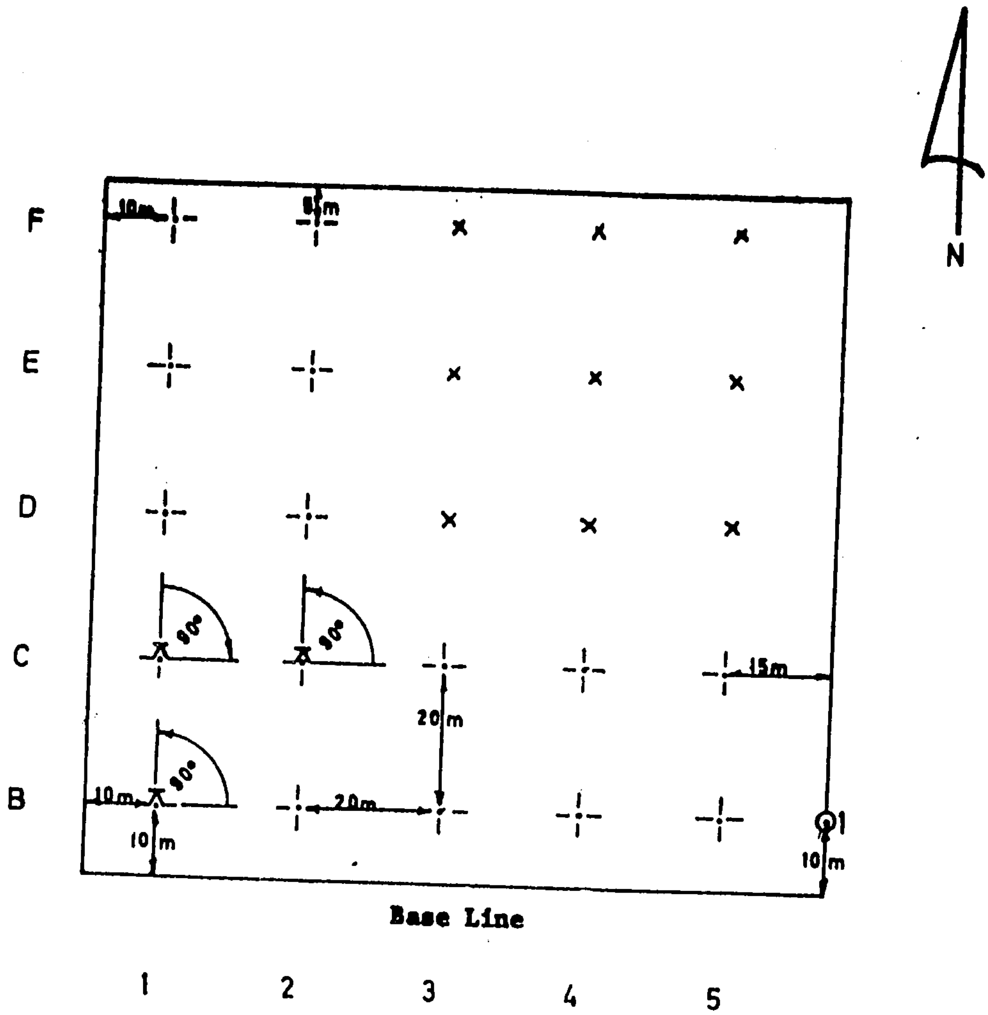


Figure 2. Diagram of Grid System on Regular Shaped Field Using Level and Tape

-¦- Measured Grid Points

× Sighted Grid Points

⊙ Range Pole

⊼ Level Location

3. Turn a 90° angle with the level and measure at full grid intervals and sight in by use of the level, perpendicular grid points (C-1, D-1, E-1, etc.). If the corner is a true 90° perpendicular, the last grid point in this case F-1, should be one-half of a grid interval from the boundary.
4. Move the level and set it over grid point C-1. Orient the instrument by aligning on the grid stakes in both directions on the perpendicular line. Turn a 90° angle from the perpendicular line and sight and measure the grid stakes parallel to first grid row established (C-2, C-3, etc.).
5. Move the level to point C-2 and orient by aligning on grid points set in 4 above. Turn 90° and sight in and measure the grid points (D-2, E-2, etc.).
6. Set the remainder of the grid stakes, without the use of level, by utilizing the grid rows established parallel to the base line and those that are perpendicular to the base line. Carefully align by eye and place the stakes at the intersection of lines.

(B) Staking a Grid System on Irregularly Shaped Field Using Tape and and Level (Figure 3).

1. For irregularly shaped fields, select the longest straight edge as the base line. At a distance of one-half grid interval in from the base line, set two range poles (#01 and 02) at widely separated intervals. At a point on the line of sight passing through these range poles and approximately at the intersection

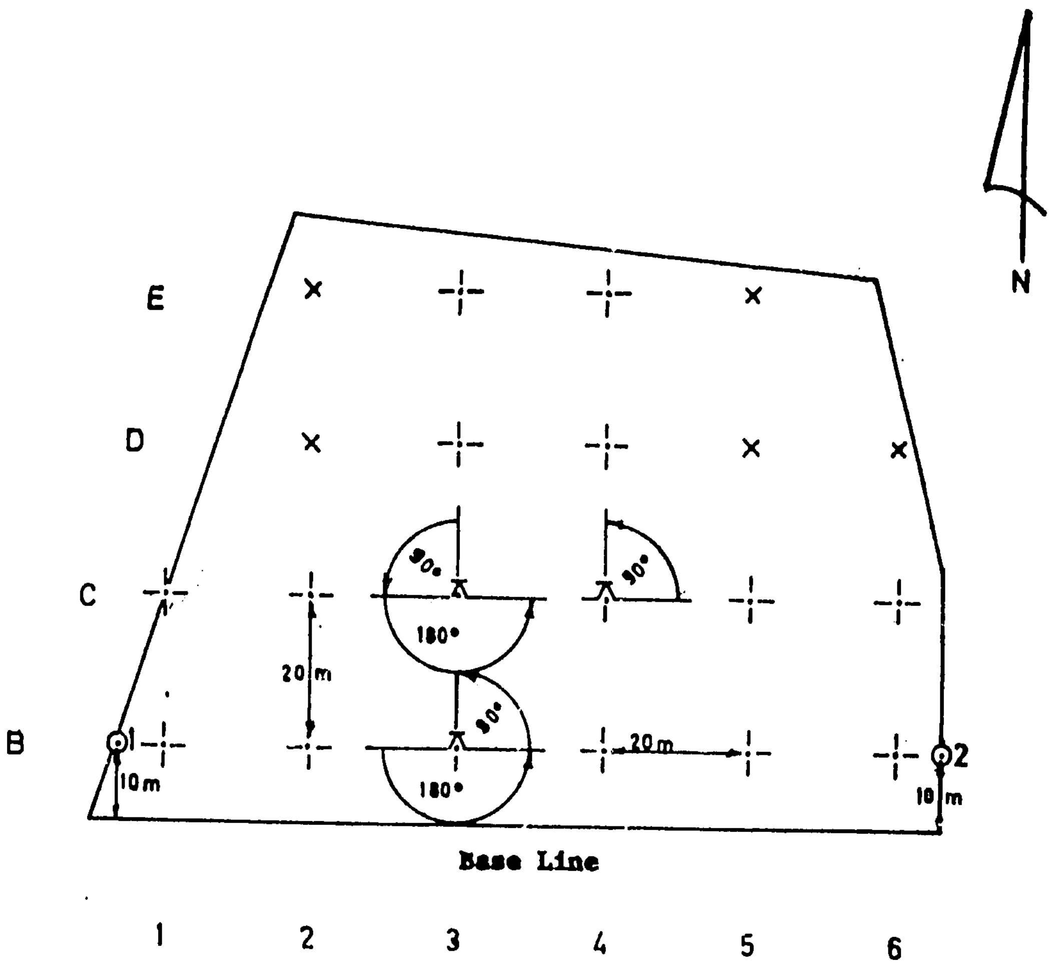


Figure 3. Diagram of Grid System for Irregular Field, Using Level and Tape.

Measured Grid Points

× Sighted Grid Points

⊙ Range Pole

ⴷ Level Location

of the maximum perpendicular dimension of the field, set a grid stake, similar to B-3. Set the instrument over this grid stake. With the horizontal circle set at 0°, orient the instrument by sighting on the most distance range pole. Start from the grid stake at the instrument location, and measure at full grid intervals and sight in with the level the grid stakes toward range pole 01. On the way back to the level, number the grid stakes B-1, B-2, etc., until the level station grid point is numbered. Turn the level telescope 180° and orient on range pole 02. Continue to set grid stakes toward this point.

2. Turn the level 90° and in the same manner establish the perpendicular line, measuring and setting grid stakes. Extend the numerical and alphabetical numbering of the perpendicular grid points, C-3, D-3, etc.
3. Move the level and set it over grid point C-3. With the horizontal circle set at 0°, orient the instrument by aligning on the grid stakes on the perpendicular line. Turn a 90° angle from the perpendicular line and sight in and measure the grid stakes on one side (C-1, C-2, etc.). Turn the level 180° and set the remaining grid stakes (C-4, C-5, etc.). This grid row should be parallel to the first grid row, B.
4. Move the level to the next parallel grid point, C-4, and establish another perpendicular line using the same method as in previous steps.
5. Sight in the remaining grid points in the field by utilizing the two lines established parallel to the base line and those that are perpendicular to the base line. Carefully align by eye and

place stakes at the intersection of lines. You can also stake a grid system on the fields using tape only.

(C) The Grid Sheet (Figure 4).

1. This sheet can best be prepared on graph or cross section paper.
2. Prepare the grid sheet showing location of all grid points and plus stakes if used. Locate the field boundaries by measuring from the boundary to the nearest stake. Depending on the size of the field and available paper, make the scale of the grid map as large as possible.
3. Locate irrigation canals, drainage canals, pump sites, wells, farmsteads, and any other topographic or cultural features of importance.
4. Record directional orientation. North should generally be the top of the sheet.
5. Make sure the scale and location of farm are noted.

(D) Survey for Precision Land Leveling

In surveying for precision land leveling, the same general procedure is used as for differential leveling.

1. Establish a bench mark so that the survey can be easily reoriented at a subsequent date. Use a known elevation if available; if not, assume an elevation. If there is not much difference of elevation in the field, assume an elevation of 3.00 meters so that all recorded data will not have more than 4 figures. Properly identify benchmarks (BM or TBM). Set up the level and close the BM circuit when there are more than two BMs that cannot be seen from one instrument location.

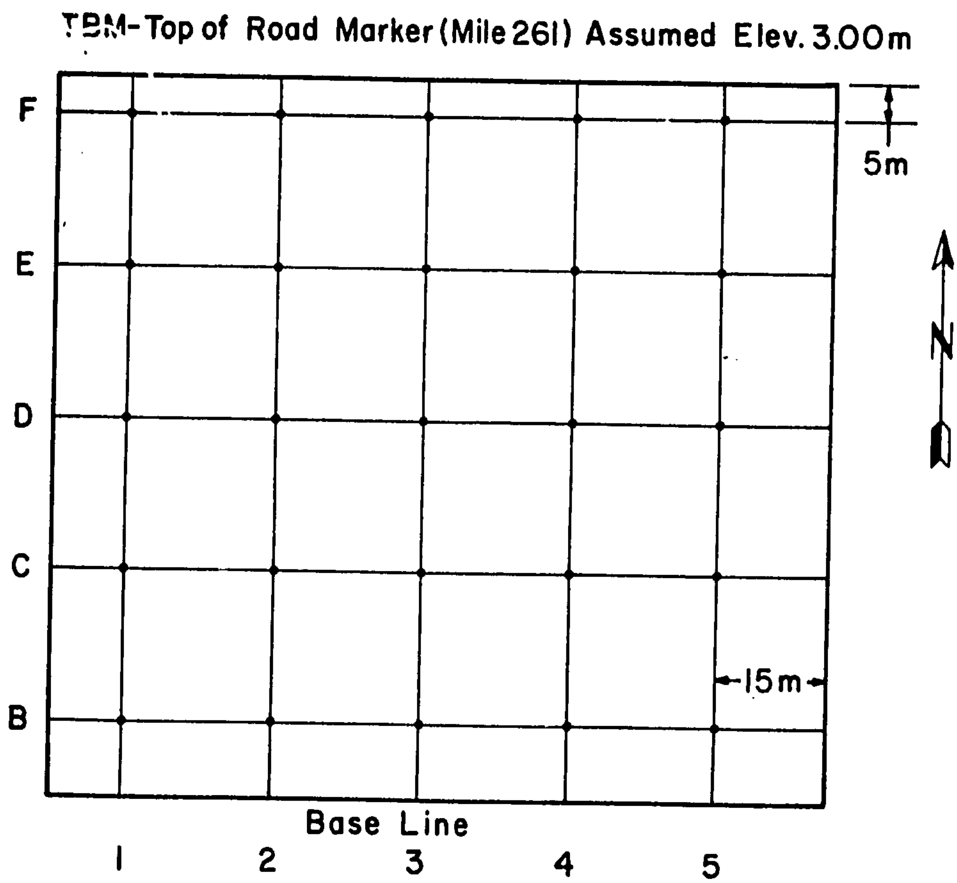


Figure 4. Grid Sheet for Area.

2. If field size and topography are such that all grid point rod readings can be taken from a single instrument setup, make the setup near the center of the field, such as near grid point D-3, Figure 5.

3. If the field size is too large for one set up, divide the field by visual inspection into as many parts as necessary and locate inst.ument near the center of each part.

4. When a single instrument setup is used, record all essential survey data on grid sheet, i.e. BM Elev., BS, HI and FS. See sample survey notes in Figure 5. Where more than one instrument setup is used, the survey data should be recorded in a field notebook or on plain paper in similar format.

5. The instrument man and rodman should proceed as follows after the HI has been determined.

   a. The rodman should start at one end of a grid row next to a field boundary, as an example Row B, taking readings at grid points B-1, B-2, B-3, etc., and then return on next grid row C, taking readings at grid points C-5, C-4, etc. See Figure 5.

   b. The instrument man should read, record, and signal the rodman to move to the next grid point. Record rod reading to nearest .01m. The surveyor should signal the rodman when they want him to proceed to the next grid point.

   c. The rodman must be alert for the signal and must move only when he is given the signal. Following are a few points to consider regarding the orientation of the rodman.

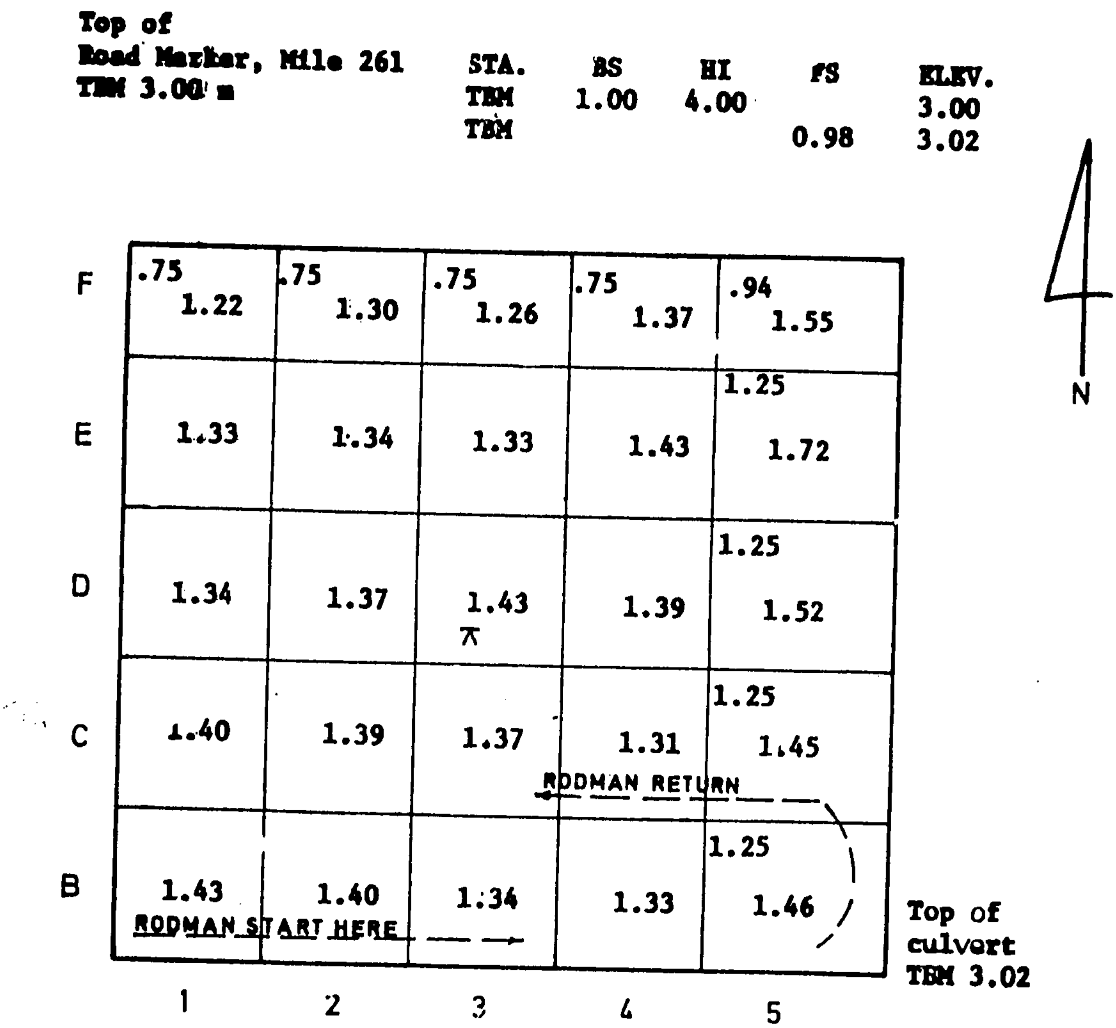


Figure 5. Rod Readings Recorded on Grid Sheet.

(1) He should hold the rod plumb.

(2) He should use his best judgment on where to place the rod so that the resulting rod reading will give as near a true field surface elevation as possible. Since the grid point is to remain during the construction phase, it should be as near to the grid point as possible, but never place the rod in a deep depression or on a bund. The grid point, if the field is staked at 20 m intervals, is to represent an area 10 m in each direction from it. Theoretically, any location of the rod in this area which represents its true surface elevation could be utilized.

(3) He should make sure the grid point stake is firmly driven into the ground or the grid point near where the rod is located is easily identifiable.

(4) The instrument man should confirm the location of the rodman frequently, by noting the movement of the rodman, to assure that data is recorded in proper location on grid sheet or in field notebook. If there is a question relative to a particular rod reading, signal the rodman to return to location in question for a check reading.

(E) Recording of Survey Data on the Grid Sheet (Figure 5).

Use the grid sheet to record rod readings at grid points, and all other essential readings. Also, show locations of the instrument, bench marks and turning points.

II. Calculations

(A) Determining the Average Rod Reading or Average Elevation.

Determine the average rod reading or the average elevation of the segment to be leveled in a single plane. If there is more than one segment, handle each separately.

Procedure:

1. Determine proportionate size of odd grid areas. Each grid point represents a specific area. The standard or normal area in this example has an area of 400 square meters (20 meters x 20 meters). The odd areas may be either larger or smaller than the standard area. Determine and write the proportionate part in the upper left hand corner of each odd grid point area. For example, grid points F-1, F-2, F-3 and F-4 are 0.75 (15 m x 20 m = 300 ÷ 400 = 0.75) of the standard 400 square meter area (Figure 5). Do not describe the standard grid areas since they automatically will be a full unit or 1.00.

2. Prepare a worksheet (See Table 1 for an example) for determining the average rod reading or average elevation.

   a. Record in Column I the total number of grid area that have the same portionate size.

   b. In Column 2 record the proportionate size.

   c. Total the rod readings or elevations for each of the proportionate sizes and record in Column 3.

   d. Adjust the sum of the rod readings or elevations by multiplying each total (Col. 3) by the appropriate proportionate size (Col. 2) and record in Column 4.

Table 1. Worksheet to Find the Average Reading[1] of Field When Standard Grid Area is 400 Sq. M. (Data from Figure 5.)

(1)	(2)	(3)	(4)	(5)
No. of specific sized grid areas	Portion of standard grid area	Sum of Readings by Areas	Adjusted readings (Col.)x(Col.3)	Adjusted grid areas (Col. 1)x(Col. 2)
No.	Portion			No.
16	1.00	21.93	21.93	16
4	1.25	6.15	7.69	5
4	0.75	5.15	3.86	3
1	0.94	1.55	1.46	0.94
	TOTAL		34.94	24.94

Average Reading $\frac{\text{Col. 4}}{\text{Col. 5}} = \frac{34.94}{24.94} = 1.401$ m

[1]May use either rod readings or determined elevation.

e. Adjust the number of specific grid areas (Col. 1) by multiplying by the appropriate proportionate size (Col. 2) and record in Column 5.

f. Total Column 4 and Column 5.

3. The average rod reading equals the sum of adjusted rod readings (Col. 4, Table 1) divided by the sum of adjusted grid areas (Col. 5, Table 1). The average elevation is obtained in the same manner.

(B) Adjustment of Average Rod Reading or Average Elevation for Shrinkage. Adjust the average rod reading or average elevation to allow for for soil texture, construction equipment used, condition of the field (i.e., plowed or unplowed field) and the depth of cut and fill. Shrinkage of soil is expressed as the cut/fill ratio. For example, if one cubic meter of excavation of earth will make 0.80 cubic meter of fill, it may be stated:

$$\frac{\text{Cut}}{\text{Fill}} \text{ Ratio} = C/F = 1.0/0.80 = 1.25$$

Cut/fill ratios usually vary from 1.10 for heavy leveling on firm field surfaces to as high as 2.00 for leveling with very shallow cuts and fills. Generally, the ratio will be between 1.15 and 1.75. On the average field, a ratio of about 1.50 will balance yardage. Where the soil is unusually fluffy, a ratio of about 1.85 may be needed. A well compacted field or sandy field may require a ratio of about 1.25. Experience in a particular area will aid the technician in determining the proper cut/fill ratio. With the modified-plane method of leveling, it is convenient to assume that the entire field surface will be lowered by a certain amount by compaction from the earth-moving equipment. This lowering can range from as little as 0.01 m for very compact soils to as high as .03 for very loose soils. Thus, to allow for shrinkage, the average rod reading or average elevation has be to adjusted.

Procedure:

1. To adjust for shrinkage, add the amount of adjustment to the average rod reading or subtract the amount from the average elevation. The adjustment for shrinkage should be such that the adjusted average rod reading or elevation is made to an even 0.01 meter. The shrinkage adjustment should be at least 0.01 meter but probably less than 0.03 meter. For example, if the average rod reading happened to be 1.405 meters, do not use 1.40, but round to 1.41 meters; the allowance for shrinkage would be 0.005 meter.
2. It is suggested that for the first trial adjustment that a shrinkage value of about 0.01 meter be used.

(C) Determining the Amount of Soil to Cut and Fill.

Procedure:

1. Record adjusted average rod reading (for field with no slope) above each rod reading on grid sheet. Record difference below the rod reading, as in Figure 6. If the adjusted average rod

F	.75 1.42 1.22 C.20	.75 1.42 1.30 C.12	.75 1.42 1.26 C.16	.75 1.42 1.37 C.05	.94 1.42 1.55 F.13
E	1.42 1.33 C.09	1.42 1.34 C.08	1.42 1.33 C.09	1.42 1.43 F.01	1.25 1.42 1.72 F.30
D	1.42 1.34 C.08	1.42 1.37 C.05	1.42 1.43 F.01	1.42 1.39 C.03	1.25 1.42 1.52 F.10
C	1.42 1.40 C.02	1.42 1.39 C.03	1.42 1.37 C.05	1.42 1.31 C.11	1.25 1.42 1.45 F.03
B	1.42 1.43 F.01	1.42 1.40 C.02	1.42 1.34 C.08	1.42 1.33 C.09	1.25 1.42 Adjusted rod reading 1.46 Rod Reading F.04
	1	2	3	4	5


N

Figure 6. Grid Sheet Showing Rod Readings, Adjusted Average Rod Reading, Identified Odd Areas, and Fill and Cut Designations for a Level Field.

reading is larger (a plus value) than the grid point rod reading, a cut will be required. Record the difference below grid point rod reading and identify with a "C" (for cut) in front of the difference (or use a red pencil to designate cut). If adjusted average rod reading is smaller (a minus value) than the grid point rod reading, record the difference below and identify with "F" (for fill) in front of it (or use a blue pencil to designate fill) as in Figure 6. Continue the procedure for the entire field area. If elevations are used the same procedure is used except the cuts will be smaller (a minus value) and fills will be larger (a plus value).

(D) Determining the Volume of Earth Work

Prepare a worksheet similar to Table 2 to find the volume of cut and fill.

1. Volume of cut (use top half of Table 2).
   a. List in Column 2 the proportionate sizes of the various grid areas that have cut.
   b. In Column 1, record the number of grid point areas with that particular proportionate size that has cut.
   c. Total the amount of cut for each proportionate area and record in Column 3.
   d. Multiply the figures in Column 2 times the figures in Column 3 and record in Column 4. This adjustment is necessary so all odd sized areas conform to the standard grid area.
   e. Total Column 4. This gives the total cut for the area.

Table 2. Worksheet to Find Volume of Cut and Fill

To Find the Volume (Cu.Meters) of Cut

(1) No. of grid areas w/cuts	(2) Portion of standard grid area	(3) Sum of cuts for each size grid area	(4) Adjusted sum of cuts (2)x(3)	(5) Vol. of cut soil per m of col. (4)	(6) Total vol. of cuts (4)x(5)
No.	Portion	Meters	Meters		
4	.75	.53	0.40		
0	.94	–	–		
13	1.00	.82	0.82		
0	1.25	–	–		
Total 17			1.22	$400m^3$	488

To Find the Volume (Cu.Meters) of Fill

(1) No. of grid areas w/fills	(2) Portion of standard grid area	(3) Sum of fills for each size fill areas	(4) Adjusted sum of fills (2)x(3)	(5) Vol. of fill soil per m. of col. (4)	(6) Total vol. of fills (4)x(5)
No.	Portion	Meters	Meters		
0	,75	–	–		
1	.94	.13	0.12		
3	1.00	.03	0.03		
4	1.25	.47	0.59		
Total 7			0.74	$400m^3$	296

$$\text{C/F Ratio} = \frac{\text{Volume of cut}}{\text{Volume of fill}} = \frac{488}{296} = 1.65$$

f. Multiply the total in Column 4 times 400 cubic meters per 1 meter of cut (Column 5) to get the total volume of cut and record in Column 6.

2. Volume of fill (use bottom half of Table 2). The same procedure is used except the fill figures are used.

(E) Earthwork Balance

In order to determine if a reasonable value for shrinkage has been used, it is necessary to determine the actual cut/fill ratio. This done by taking the total cut and total fill, Column 6, Table 2, and computing the C/F ratio.

$$C/F = \frac{\text{Sum Col. 6, Cuts (487)}}{\text{Sum Col. 6, Fill (295.88)}} = 1.65$$

This ratio should conform to the discussion on shrinkage. If a reasonable C/F ratio is determined, it is said that the earthwork is balanced.

Where the Cut/Fill ratio is not within reasonable limits of what was planned, then the entire calculations are repeated. The average rod reading or elevation or the adjusted rod reading or elevation is readjusted upward or downward. In the example in Figure 6, lowering the plane 0.01 meter provided a C/F ratio of about 1.65. Lowering an additional 0.01 meter would raise the C/F ratio to about 2.28 and raising it a 0.01 meter would give a C/F ratio of about 1.28. Generally, and after acquiring some practical experience in an area, the proper adjustment can be made and ratio obtained on the first trial.

(F) Construction Map (See Figure 7).

1. Prepare a map similar to the one shown in Figure 7.

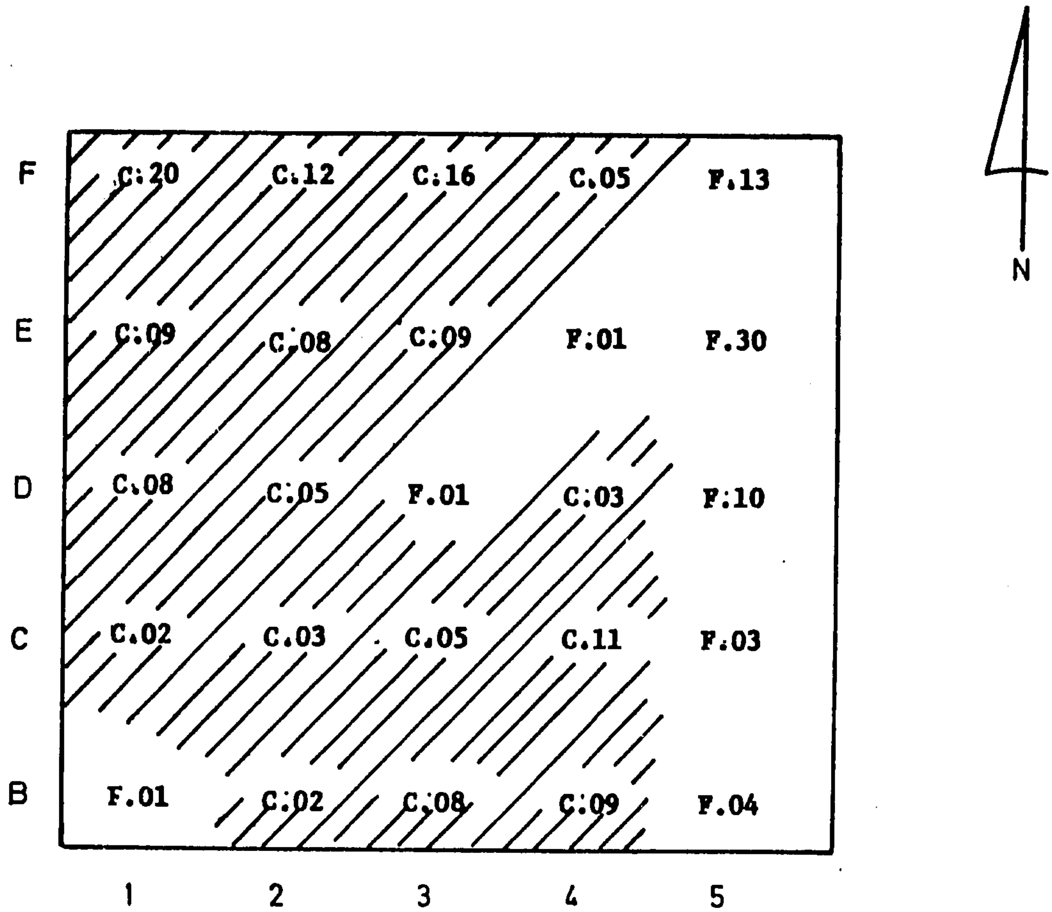


Figure 7. Construction Map Showing Cuts and Fills

2. Show cuts and fills as determined in paragraph C.

3. The technician must, in consultation with the scraper operator, orient the map with the field and show the operator what system he should use to make the final job of soil moving the most efficient and consequently economical.

(G) Marking the Grid Stakes for Tractor-Scraper Operator Guidance.

1. The grid stake points must be marked for easy guidance during construction. The primary purpose is to depict to the tractor-scraper operator the job he is to accomplish. Numerous methods have been devised and used. It is proposed in the beginning to use a system which is used in road construction and is called the "Blue Top" system. A wooden peg is driven into the ground and sighted in by use of the level, to the adjusted rod reading or elevation. Using the example in Figure 5, the instrument is set up and a back sight (BS) is taken on the bench mark (BM). Assume this time it reads 1.05 m. The height of the instrument (HI) then would be 4.05 m, and since the original adjusted rod reading was 1.42 (Fig. 6) and the HI was 4.00 m, the rod would have to read 1.47 m. The difference between HI's would be added to or subtracted from the new BS, (4.05 - 4.00 = .05; 1.42 + .05 = 1.47) to determine reading of the rod at which all pegs should be set. When elevations are being used, the instrument must be set up and a back sight (BS) taken on the bench mark (BM elevation = 3.00). If it read 1.05 m, then height of instrument (HI) would be 4.05 m. The original adjusted rod reading 1.42 m gave the Blue Tops an elevation of 2.58 m (4.05 - 2.58 = 1.47).

2. It will work best to have a rodman and an assistant. They will need something to pound with, either axe or hammer, and something to dig soil with. They will proceed from grid point to grid point and drive pegs to levels as directed by the instrument man. The instrument man can signal by motioning downward with his hand to indicate that the peg should be driven down and to indicate that peg should come up, he can motion his hand upward. It is desirable to set these pegs on the same side of the grid stake so that they can be found much easier when they become buried.

3. The operator must be instructed and realize that these stations are not to be disturbed until construction and final checking is completed.

(H) Checking of Field After Construction has been Completed.

1. At least one or two engineering inspections should be made during construction to see that the system is being constructed as planned. During the initial stages when both the engineer and/or the contractor lack experience, it may be desirable to check more often.

2. The field should be smoothed with a land plane between rows prior to checking. (Stakes should not be removed until field meets specifications.) Rod readings should be taken approximately as shown in Figure 8.

3. Set up instrument near same location as in original survey. Take rod reading on several blue top pegs; the reading obtained will be the rod reading for checking entire field, if field is designed with 0% slope. If pegs have been destroyed, take

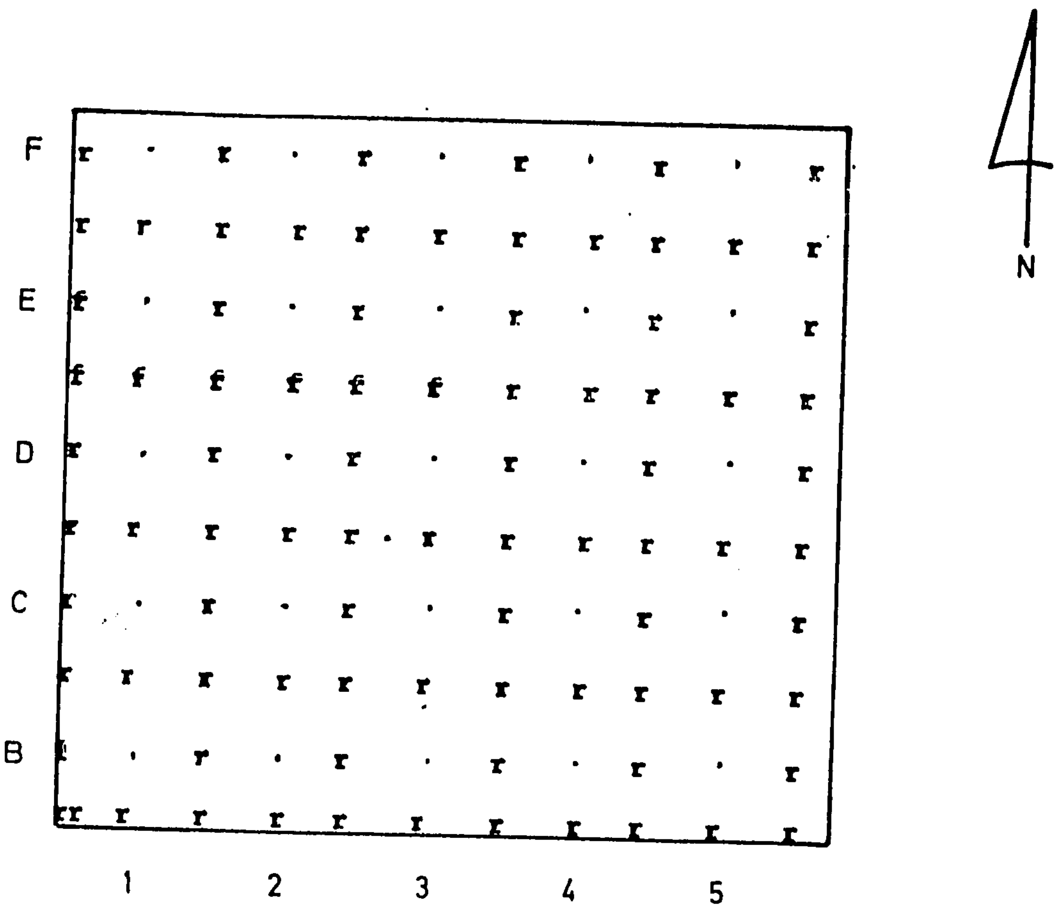


Figure 8. Checking Construction Job Using Graph Paper.

Original grid stakes take rod reading at a location representative of finished level near grid point.

r rod reading at one-half interval.

backsight on BM and establish rod reading. Rod readings should be taken at the midpoint of design survey stakes, e.g., first shot on boundary line then every 20 meters thereafter. Small steel wires with plastic flags (glued on the end) are very helpful in determining where the rod readings were taken. They shall be placed in the ground, by the rodman, at the time the reading is taken. They make an easy reference point to return to if additional work is needed. By having two different colored flags, red and blue, they can also be used to indicate to the tractor-scraper operator where he is to load the soil scraper and where he is to deposit his load. Use red for cut and blue for fill.

4. After studying the checking shots, the engineer or his assistant can, by the use of the flags placed while taking the checking shots and the original grid points, return to the field and remove all flags at locations that are at the correct elevation and place red flags where cuts are to be made and blue flags where fills are to be made. The number of colored flags may further be coded to indicate to the operator how many loads he is to take from a particular location or how long he is to work around the coded location. As technician and operators get practical experience and become familiar with the system, many helpful methods will evolve.

APPLICATION

The trainees will go to the field and survey a field for precision land leveling. They will calculate the cut and fill required and turn in their plans. An "after leveling" inspection will be made on a field that has been previously leveled by the OFWM field team.

QUESTIONS

1. Why should a farmer undertake PLL?
2. What considerations should be remembered when determining shrink?
3. Why is it important to perform an "after leveling" on-site inspection?

Subject: EVALUATING LEVEL BASIN IRRIGATION SYSTEMS

Trainer Agricultural Engineer
Class Room 3 hours
Field 2 Days

OBJECTIVES

To teach students the concepts and methods of evaluating water use efficiency on level basin irrigation systems.

MATERIALS NEEDED

Soil sampling tube, soil containers, balance, oven, Cutthroat flume, flume tables, graph paper, wooden stakes, watch and measuring tape.

INTRODUCTION

Nearly all of the commanded land in Pakistan is irrigated in small level basins. As was discussed in the lesson block "Methods of Irrigation", for the local soil, topographic, and economic conditions, level basins are usually the best irrigation system to use. However, within this one type of system, irrigation water use efficiency can still be highly variable due to differences in field sizes, soil types, field levelness, inflow rates, and total water applications. The purpose of this lesson is to evaluate existing level basin efficiencies in order to determine the problems in the systems and thus be able to instruct farmers in ways to increase their water use efficiencies.

PRESENTATION

A true water use efficiency refers to the amount of crop which can be produced per unit of water input. However, since this concept involves several inputs in addition to water, a simpler definition will be used. Water application efficiencies, E_a, as will be used in this lesson, refers to the amount of water stored in the crop root zone, V_s, relative to the total water application, V_a, or:

$$E_a = {}^{V}s/V_a \times 100 \qquad (1)$$

Application efficiencies will have two overlapping components. The first involves water wasted because of the nature of the physical system such as high soil intake rates, unlevel fields, or small flow rates. These factors will prevent the applied water from being distributed evenly across the field. In order to irrigate all areas sufficiently, some areas must be overirrigated.

The second component involves water wasted due to applying too much water or overirrigation. This is usually due to;1) a lack of understanding on the part of the farmer for the crop water usage, the capacity of the soil-water reservoir, or the amount of flow in his channel; 2) a lack of control over his water supply system; and 3) laziness or lack of need for the water.

Wastage of water during field application often involves costs beyond the value of the wasted water. Water which deep percolates below the root zone carries with it valuable nutrients such as nitrogen and thus wastes another valuable and costly resource. In high water table areas, deep percolation water also helps create waterlogging and sometimes salinity problems.

Application efficiencies are determined by measuring how much water is added to a field, and then determining how much of that water is stored in the root zone and available to plants for use.

The first information which should be collected is the soil moisture, or the amount of water in the root zone just before the irrigation begins.

Methods to determine the soil moisture are discussed in Attachment 1 to the next lesson block "Irrigation Scheduling". Because of variabilities across the field which cause nonuniform water application, the soil moisture level will also vary. Consequently, several locations must be sampled. It is suggested that the field be divided into several (3-6) equal sized subplots and a soil moisture sample be collected from each plot. The soil moisture for each plot is then averaged to get a soil moisture level expressed in units of depth (cm) for the field.

The next information required for the evaluation is the inflow volume. The inflow volume or volume of water applied, V_a, can be measured with flow measurement devices at the nucca such as Cutthroat flumes. The flumes should be installed in the farmer's branch just upstream of the nucca so that the water is flowing straight towards the flume for at least 4 meters. The flume should be installed before the water is turned into the field. Measurements should begin as soon as the flow reaches the flume or the nucca is opened, and continue until the flow through the flume stops or the nucca is closed. Flow measurements should be taken every 2 or 3 minutes while the rates are changing and each 5 to 10 minutes when flows are steady.

Flow measurement devices measure flow rates (liters per second (lps)). To convert these rates to a volume of inflow, they must be multiplied by the measurement time. This can be done either mathematically or graphically. Mathematically, each measured flow rate should be multiplied by the time interval from the previous measurement and then the products should all be added together. This calculation is shown in Table 1. The graphical method involves plotting the flow rate data on a graph versus time and then determining the area under the curve or integrating the curve. The area can be found by

Table 1. Sample Flow Rate Data for Inflows into a Field

Time (hr-min)	Elapsed Time (min)	Flow Rate (lps)	Elapsed Volume (liters)	Comments
10:00				farmer's turn begins
10:05	Start	0	0	water reaches flume
10:07	2	1	120	
10:10	3	3	540	
10:12	2	5	600	
10:15	3	8	1440	
10:18	3	12	2160	
10:21	3	16	2880	
10:24	3	22	3960	
10:27	3	23	4140	
10:30	3	24	4320	
10:35	5	24.5	7350	
10:40	5	25.5	7650	
10:45	5	27	8100	
10:50	5	28.5	8550	
10:55	5	29.5	8850	
11:00	5	29.5	8850	
11:10	10	29.5	17,700	
11:20	10	29.0	17,400	
11:30	10	29	17,400	
11:40	10	29	17,400	
11:50	10	29	17,400	
12:00	10	29	17,400	field check opened
12:02	2	29	3480	& nucca closed
		TOTAL VOLUME =	177,690ℓ =	177.7 m^3 = 1.78 ha-cm

counting squares, using a planimeter, or numerical integration such as the trapezoidal or Simpson's Rule method. Figure 1 demonstrates this process. Whichever method is used, the end result should be a volume of water applied to the basin in units of hectare-cm (ha-cm). (1 ha-cm = 100^3m = 1 x 10^5 liters.) The inflow volume can then be easily converted to a depth measurement for the field by dividing by the field size.

Approximately 2 days after the irrigation (from one day for sandy soils to 3 days for heavy clays), soil moisture samples should again be collected to determine the change in root zone moisture storage, or how much of the applied water was stored in the root zone. The same locations and depths as were measured before the irrigation should again be sampled. The soil moisture measurements should again be averaged to determine how much water is stored in the field root zone after irrigation. Table 2 shows a sample of soil moisture data for a field of sugarcane.

The difference between the average soil moisture after and before irrigation, plus an allowance for water consumptively used by the crop between the two measurements will equal the amount of applied water which is or can be utilized by the crop. Methods for determining this consumptively used (ET) water are also given in the lesson block "Irrigation Scheduling". With the total amount of water applied, V_a, and the amount which can be used by the crop (stored in the root zone plus the interim ET), V_s, known, the irrigation application efficiency, Eq. 1, can be calculated.

Example: You wish to evaluate the application efficiency on a 0.2 ha (½ ac) field of sugarcane. The farmer plans to irrigate the field during his regular warabundi turn on 24/8. Before he begins irrigation you collect soil samples from each quarter of the field at three depths down to 90 cm (normal rooting depth of sugarcane) with a soil tube, weigh them and prepare them for

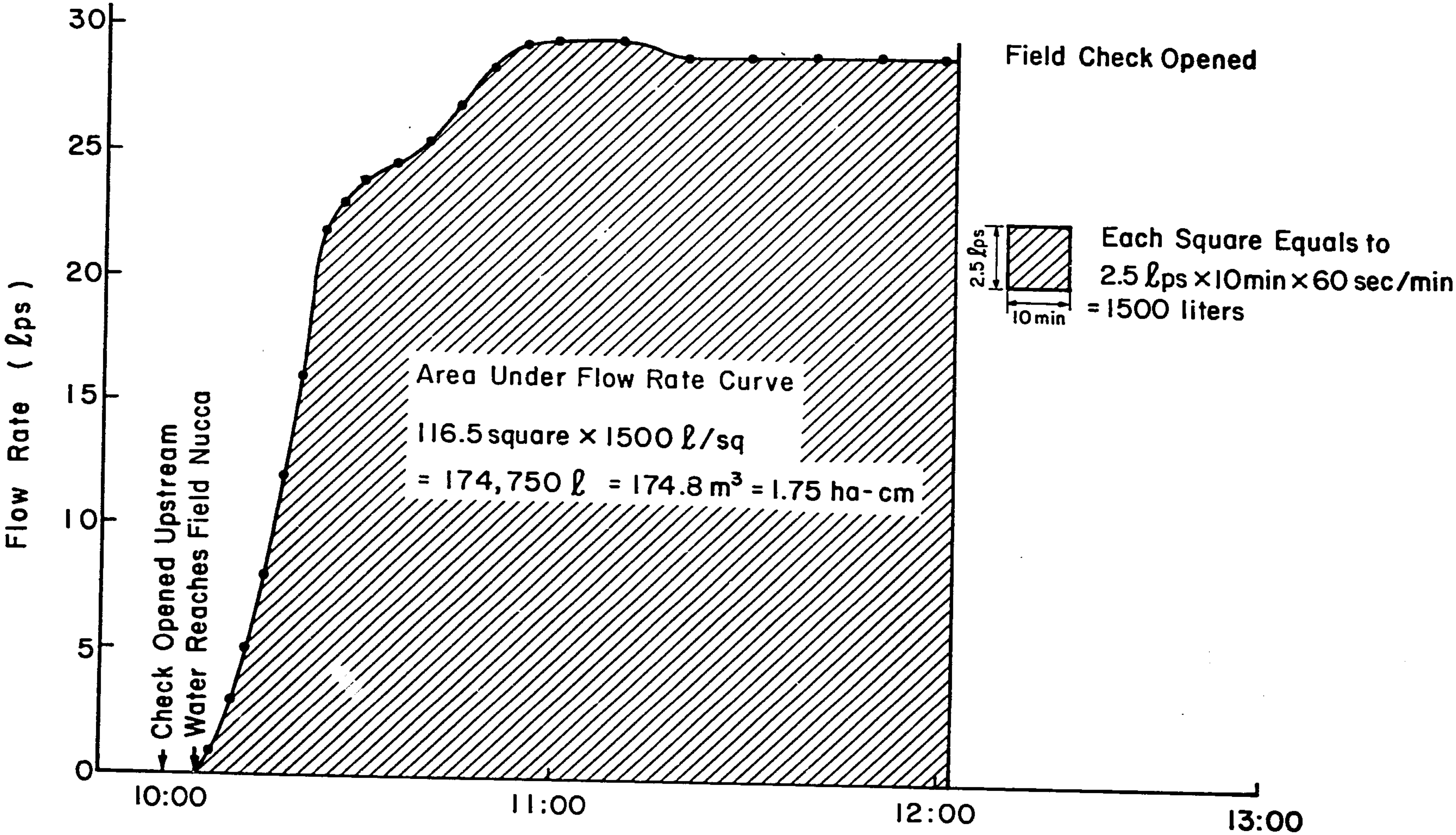


Figure 1. Graph of Flow Rates in Table 1 with Calculations for Total Inflow Volume.

Table 2. Sample Soil Moisture Data

Data Collector Khan & Saeed
Before Date 24/8
Irrigation Date 24/8
After Date 26/8

Farmer Khalid Saeed
Field #3
Crop Sugar Cane
Growth Stage Mature
Soil Type Silt Loam
(FC = 32%, TAW = 17%)

Location	Depth (cm)	Soil Moisture Before % Vol.	Before cm	After % Vol.	After cm	Difference cm
1	0-30	23%	6.9	31%	9.3	
	30-60	20%	6.0	30%	9.0	
	60-90	30%	9.0	33%	9.9	
	Total		21.9		28.2	6.3
2	0-30	18%	5.4	30%	9.0	
	30-60	17%	5.1	23%	6.9	
	60-90	26%	7.8	28%	8.4	
	Total		18.3		24.3	6.0
3	0-30	22%	6.6	32%	9.6	
	30-60	26%	7.8	33%	9.9	
	60-90	28%	8.4	31%	9.3	
	Total		22.8		28.8	6.0
4	0-30	20%	6.0	31%	9.3	
	30-60	23%	6.9	29%	8.7	
	60-90	18%	5.4	19%	5.7	
	Total		18.3		23.7	5.4
Average		21.8%	20.3	30.0%	26.2	5.9
Deficit(SMD)		10.2%	8.4	2.0%	2.6	

sun drying. The soil moisture data is shown in Table 2. Meanwhile, a Cutthroat flume is installed just upstream of the field nucca and flow rate data is collected and recorded on Table 1. Two days later after moisture movement is essentially complete, you collect another set of soil moisture data from the same locations and depths as before. These data are also recorded in Table 2.

Calculation of application efficiency:

Moisture stored in root zone (from Table 2)

26.2 cm - 20.3 cm = 5.9 cm

Evapotranspiration in 2 day interval (from Table 3 and Figure 1 in Lesson Plan "Irrigation Scheduling")

$$ET = 2\ (K_c \times PET) = 2\ (1.05 \times 0.47\ \text{cm/day}) = 1.0\ \text{cm}$$

Volume used and stored, V_s

$$(5.9\ \text{cm} + 1.0\ \text{cm}) \times 0.2\ \text{ha} = 1.38\ \text{ha-cm}$$

Volume applied, V_a (from Figure 1): 1.75 ha-cm

$$E_a = V_s/V_a \times 100 = 1.38/1.75 \times 100 = 79\%$$

Several things can be learned from this example. First, the farmer did a very good job of irrigating to meet his average soil moisture deficit. The average deficit was 8.4 cm and he applied 8.75 cm. However, because of the variation in soil moisture across the field and the nonuniformity of application, he still achieved only 79% efficiency. Although in two of the sampling locations, the root zone was fully filled to field capacity, at the other locations, only the top 30 cm was fully wet and the lower layers were still left with a deficit. This is a result of nonuniform application which both allows a higher deficit to be built up from previous irrigations and causes less water to be applied to these drier areas. This tendency is illustrated in Figure 2 in which, because of both field surface undulations and the inflow

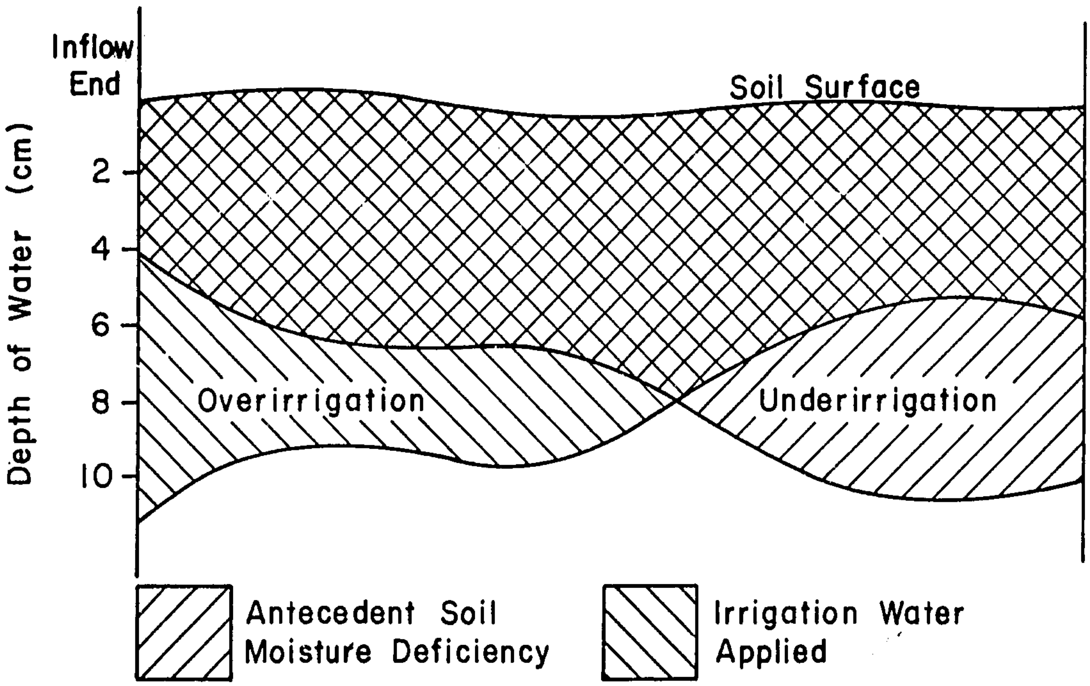


Figure 2. Illustration of the Effects of Nonuniform Applications on Moisture Deficiencies and Irrigation Efficiencies.

(nucca) end of the field receiving more water, areas of the field with the greatest need (soil moisture deficit) receive the least water, and vice versa.

The example also points out the need for an evaluation unit other than application efficiency. A field which is underirrigated (irrigation depth is less than the soil moisture deficit) would have a 100% irrigation efficiency However, if the moisture deficit becomes high enough to stress the crops and reduce yields, it is not a good irrigation. Part of the sample field (location 2 and to some extent location 4) was stressed prior to the irrigation and the irrigation did not fully refill the root zone storage, so it may again become too dry before the next irrigation. To express underirrigation, a second term, application completion, R(%), is used which is defined as:

$$R = V_a/V_R \times 100 \qquad (2)$$

where V_R indicates the volume of water required to fill the root zone to field capacity, or the soil moisture deficit (SMD). The harm of application completions less than one can only be determined with long-term information which indicates whether the deficit does become critical and crop yields are reduced. In fact, during water short periods or if there is a reasonable chance of precipitation, and the water supply is reliable, irrigation with R values less than one could be desirable.

Figures 3, 4, and 5 show bar graphs of measured irrigation application efficiencies and completions on fields on three difference watercourse systems measured over three-week warabundi studies. The first (Figure 3) shows that the farmers tended to irrigate near or slightly over the requirements with 41% irrigating between 10% under and 30% over the SMD (R = 90% to E_a = 70%). On the second watercourse, the farmers obviously did not have a good understanding

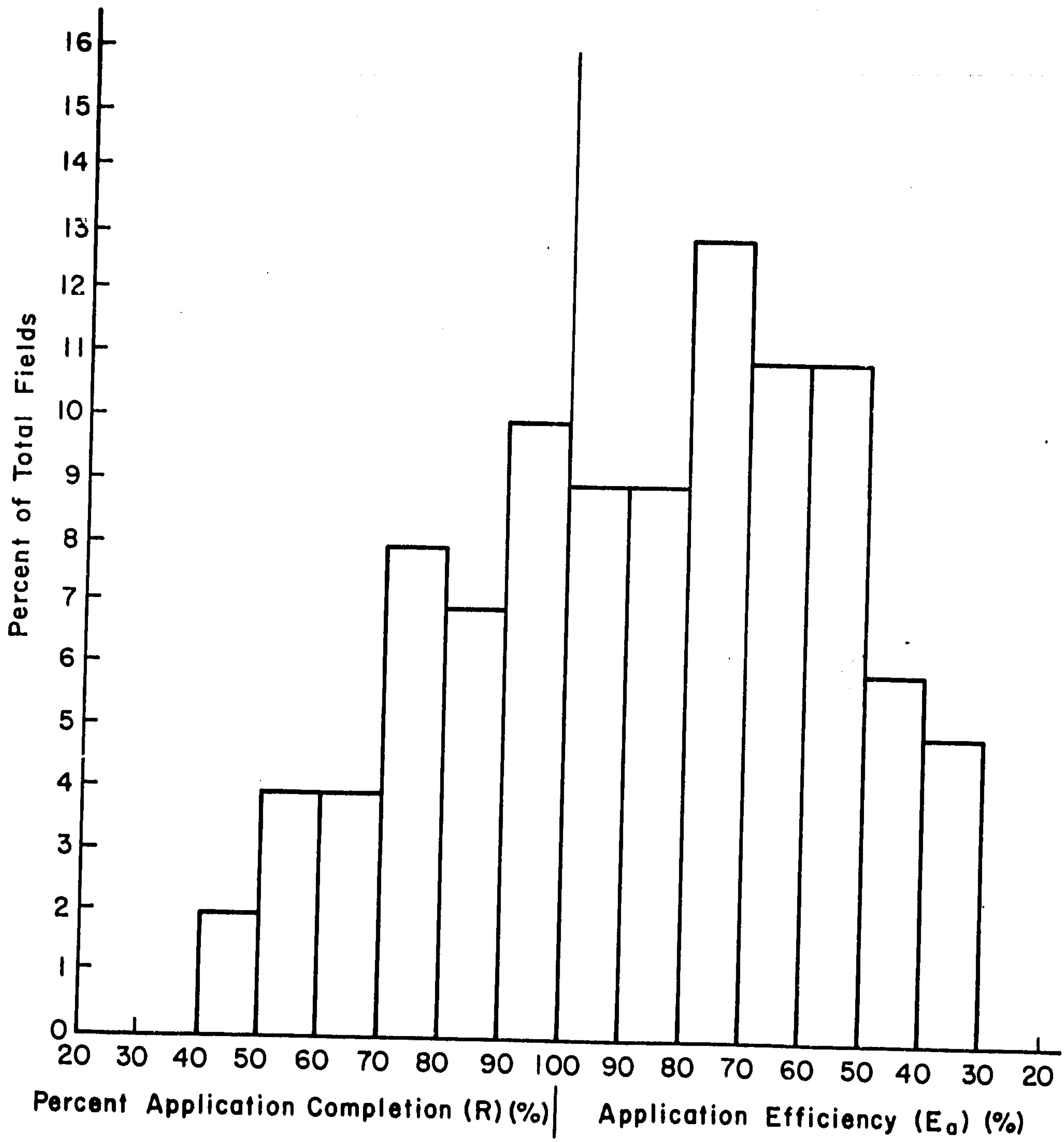


Figure 3. Distribution of Water Application on the Fields of One Watercourse Over 3 Weeks.

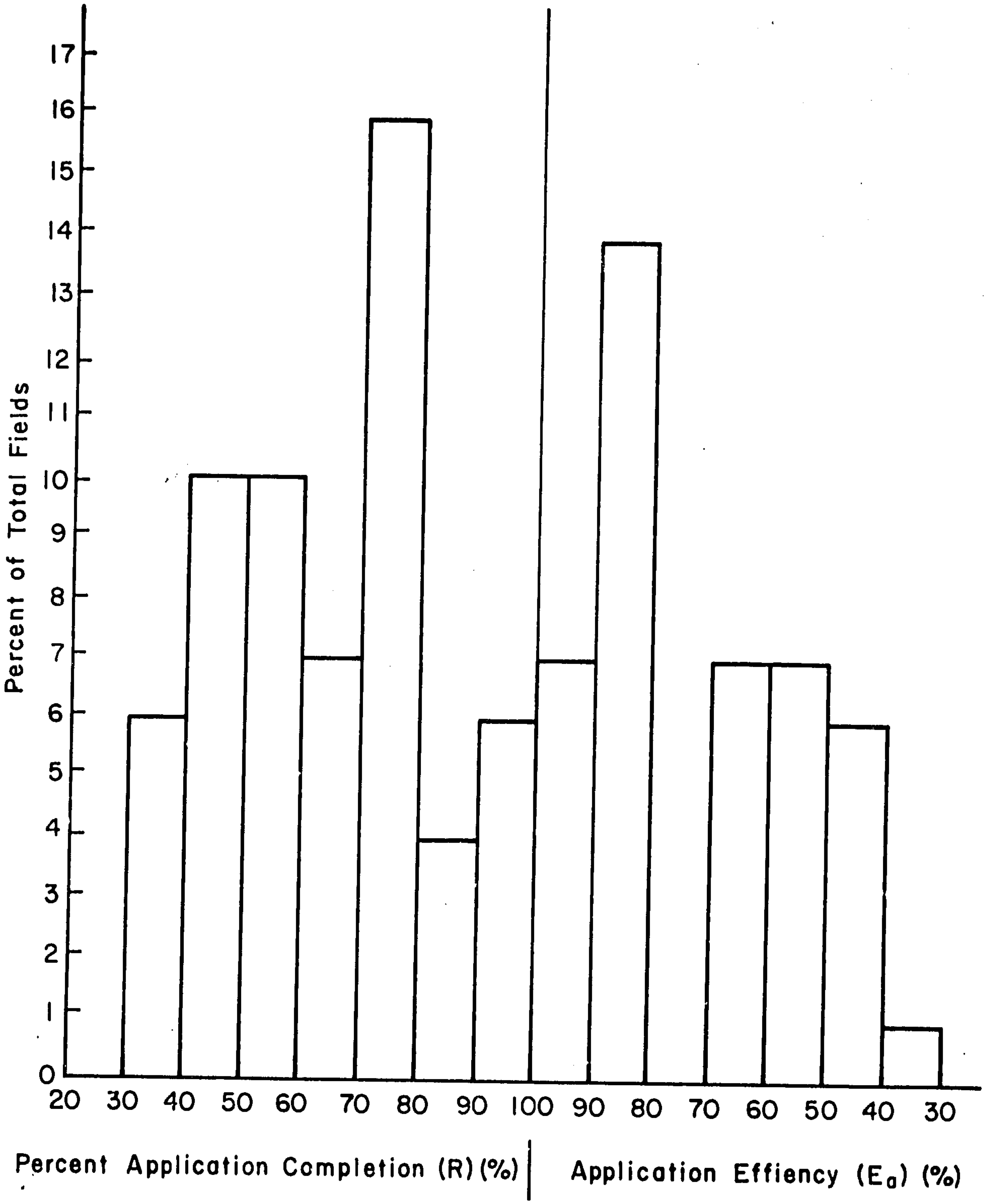


Figure 4. Distribution of Water Application on the Fields of a Second Watercourse over 3 Weeks.

of their soil, crop, and water systems, because the irrigations were randomly above or below the requirements and less than 1/3 of the irrigations with R or E_a values above 80%. On the third watercourse (Figure 5) nearly all farmers badly overirrigated their crops. There are two reasons for this. First, this watercourse is located in very sandy soils (Thal canal) with very high infiltration rates. Consequently, in order to adequately irrigate the far end of the field, the areas near the nucca were severely overirrigated. Second, the irrigation being applied was the last for the wheat crop. Maturing wheat has low water requirements and consequently, the SMD was low. But it is difficult to efficiently apply small irrigations to porous soils. Also, many farmers don't realize that crop water requirements decrease upon maturation. In addition, the canal water was available and had to be put somewhere whether there were needs or not. So, there are many possible causes for the overirrigation beyond simple lack of understanding on the part of the farmers.

Diagnosing the Causes of Low Application Efficiencies

As was explained earlier, low efficiencies can be caused either by problems in the physical system or a lack of understanding on the part of the farmer. If a farmer seems to be consistantly overirrigating (or underirrigating) his fields, he probably does not understand the basic soil-crop-water relationships. Many Pakistan farmers think roots extend only a few centimeters below the surface, and that mature crops need water just as growing ones do. Also, after finishing a season with a final irrigation to a mature crop, farmers will often apply a 12 cm or more rauni irrigation even though most of the root zone is already full of water. These types of inefficiencies and wastage of water can only be alleviated by educating the farmers via extension programs.

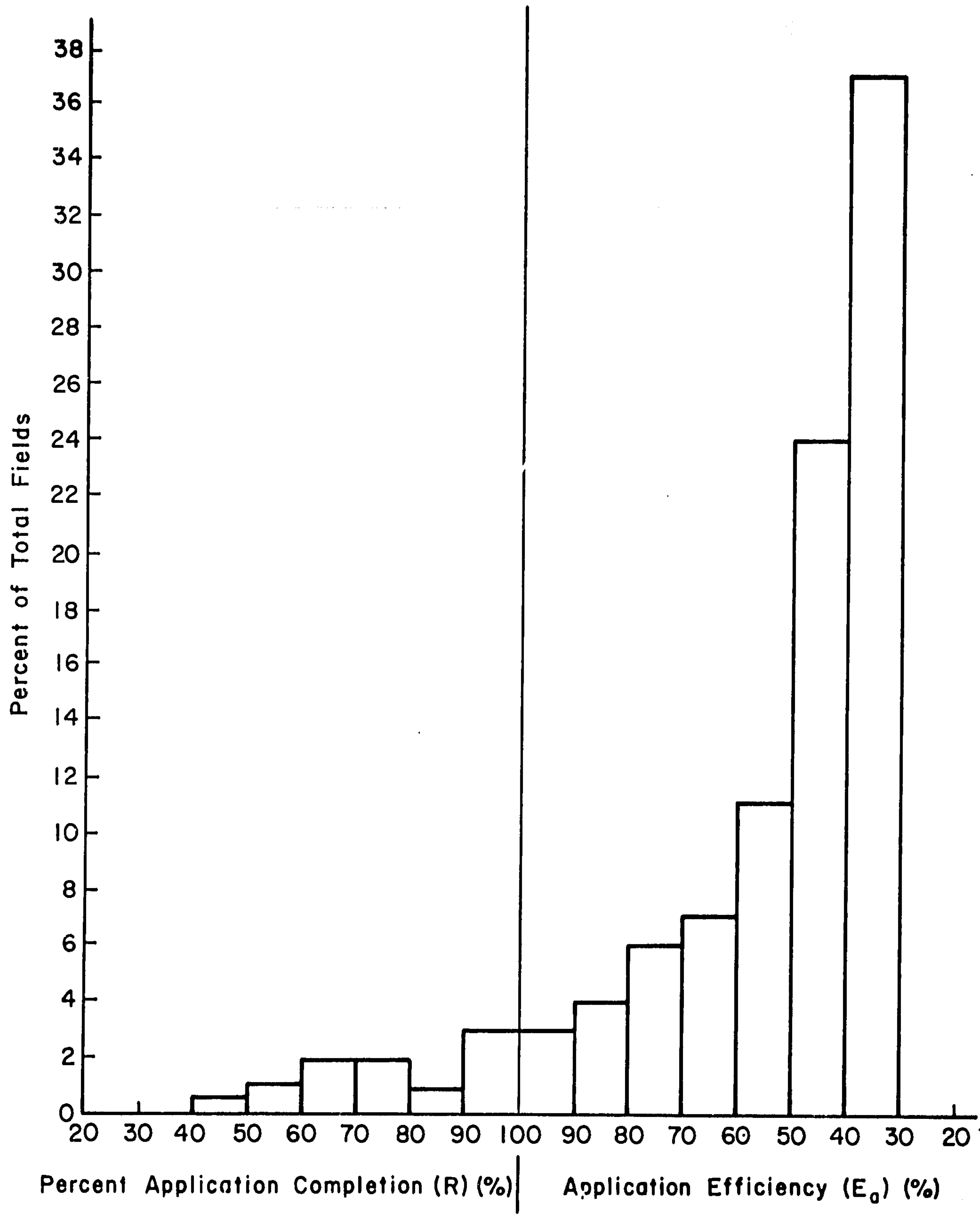


Figure 5. Distribution of Water Application of the Fields of a Third Watercourse Over 3 Weeks.

The causes of overirrigation can also be problems with the physical system such as porous soils, fields too large for the available flow rates, or unlevel fields, all of which cause an uneven distribution of the water across a field.

Two factors determine how much water is infiltrated into a soil: the soil infiltration or intake rate, and the intake opportunity time (IOT) or the amount of time which water stands on the soil surface. Variations in either of these factors in a basin will cause an uneven distribution of the water. Figure 6 shows an example of the cumulative infiltration of water into two soils over time. These curves show the wide variabilities between the amount (depth) of water which can be absorbed by soils in the same period of time. Although soil types and thus infiltration rates usually don't vary this widely in a small basin, ring infiltrometer data does indicate wide variability in some basins. Intake rate variations can be caused by silt accumulations from the irrigation water, crusting, compaction, plow pan layers, or sodicity, as well as variations in soil type. Such a problem can best be verified by running ring infiltrometer tests in a field, although measurements of infiltrated soil moisture after a small irrigation on areas of the field with nearly equal intake opportunity times can also indicate such intake rate variability. To alleviate the problem, basins should be reorganized so that each one includes soils with similar intake characteristics.

Uneven distribution of irrigation water across a level basin is more commonly the result of variations in the amount of time water is ponded on the surface of different parts of the field. This variation in the IOT depends both on how quickly the water advances across the field and covers it initially, and how evenly the ponded water recedes from the surface. Figure 7 illustrates

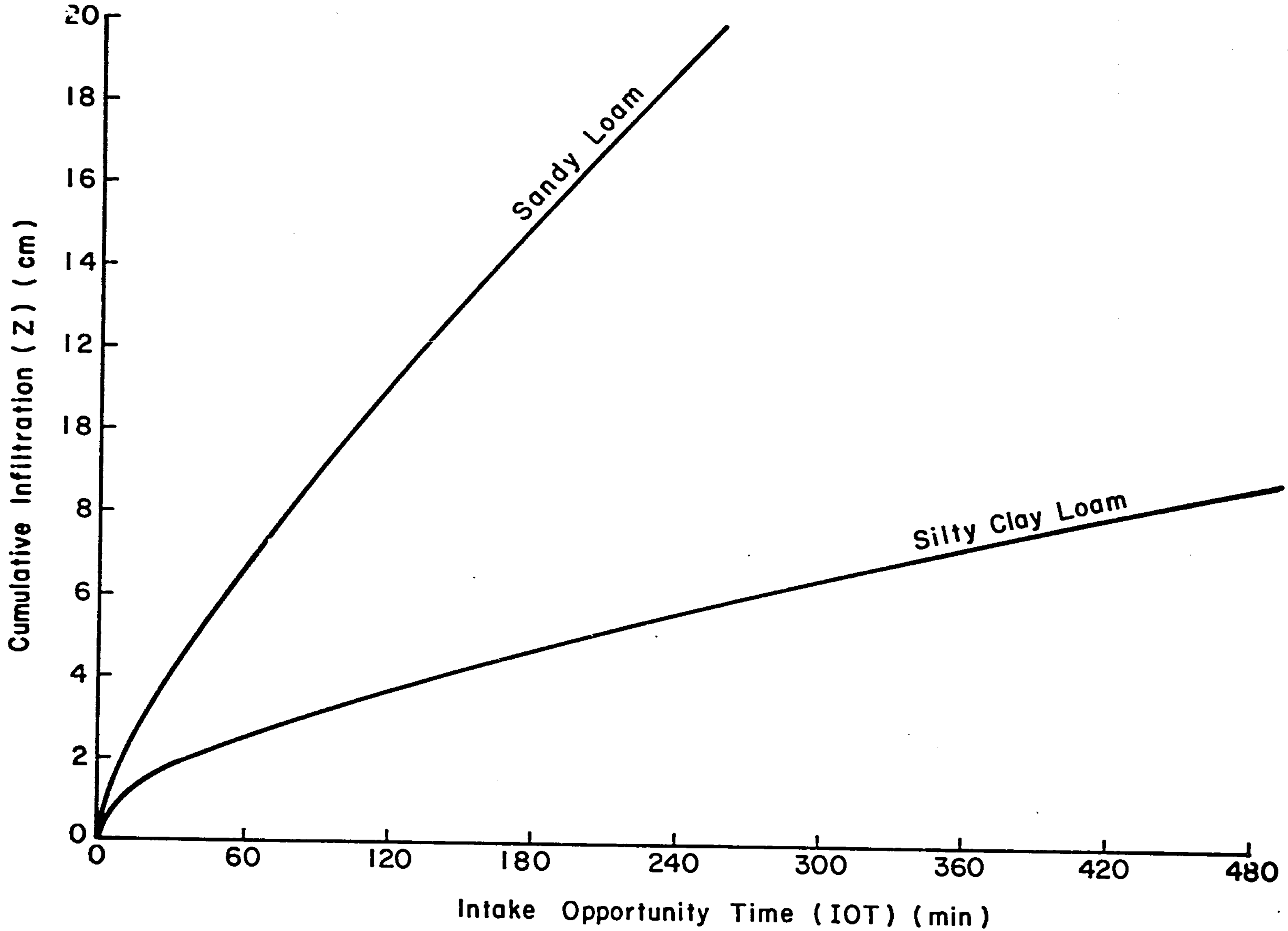


Figure 6. Cumulative Infiltration vs. Intake Opportunity Time for Two Pakistan Soils.

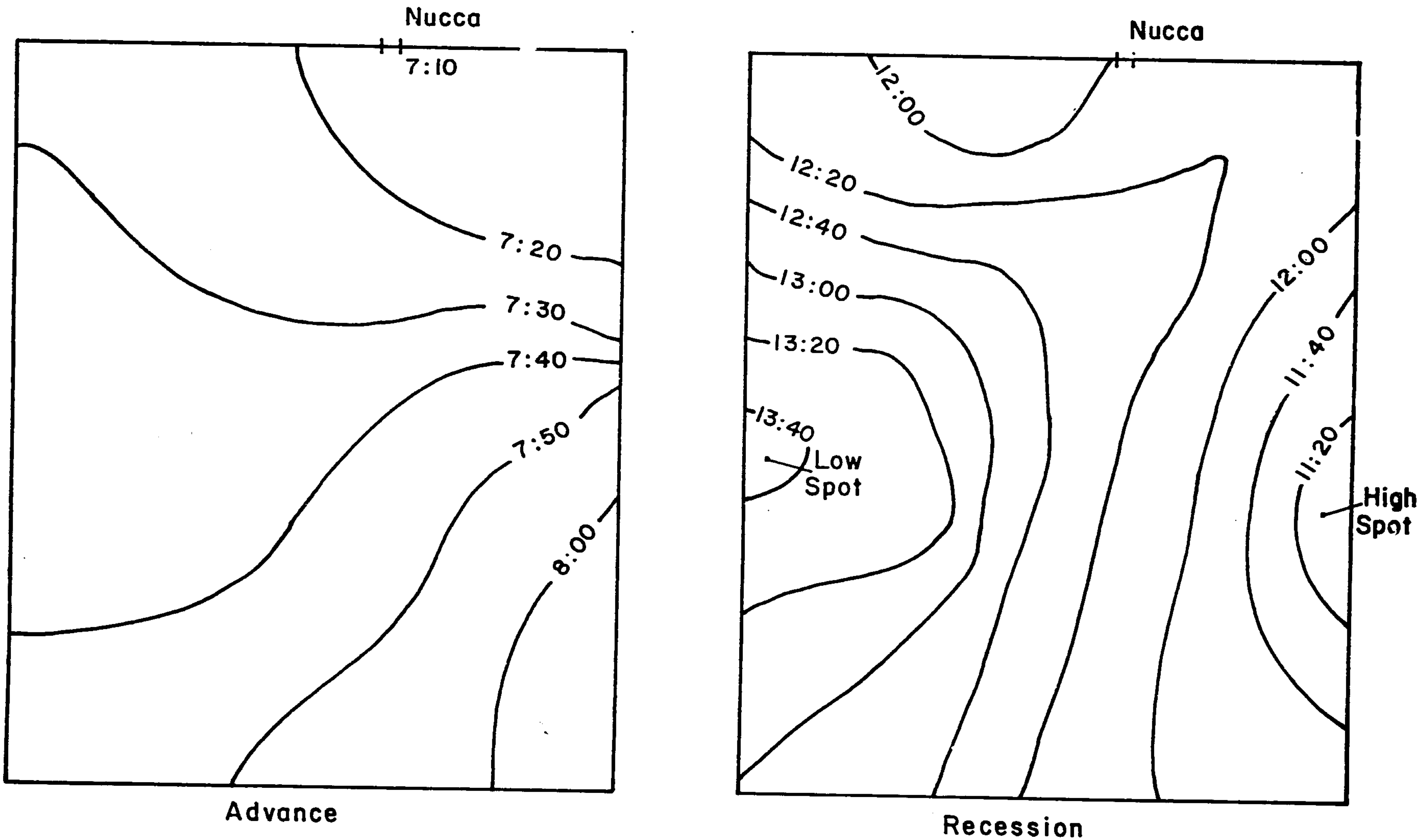


Figure 7. Advance and Recession of Water on a Level Basin.

the advance and recession of water across a small level basin. The water requires about an hour to advance from the nucca to the highest/farthest point. This advance map is constructed by sketching the water advance front after each 10 minutes. Since the total advance time is only about 20% of the total average intake opportunity time of about 5 hours on the silty clay loam soil, it will not lead to low E_a values and is acceptable. However, if the soil had been sandy with an IOT of only 2 hours, then the resulting E_a would have been too low and the advance would have to be speeded up to get reasonable efficiencies either by increasing flow rates, decreasing the field size, reducing the soil infiltration rate, removing high spots and/or creating a slight downward slope away from the nucca. The lesson block, "Irrigation Scheduling" discusses basin design to achieve acceptable advance times and application efficiencies. Advance time less than 1/3 of IOT are generally acceptable and should be easy to achieve in medium and heavy soils.

The water recession map in Figure 7 shows that the field is not quite level, but that there is a high spot on one side about 3 cm higher than a low area on the opposite side. Even this slight undulation allows water to stand 140 min longer in the low area than in the high spot on this low intake rate soil. However, since the total IOT for the field was about 5 hours, again the recession time difference does not cause the efficiency to be too low. However, most fields in Pakistan are not this level and the undulations will cause large differences in recession times as well as slow advance time across the field. If this is the case, it should be recommended to the farmer that he should level his field to reduce the wastage of water. The recession map will be a valuable guide as to which areas of the field are high and which are low. The lesson block "Water Management Aspects of Land Leveling" further discusses the advantages of level land.

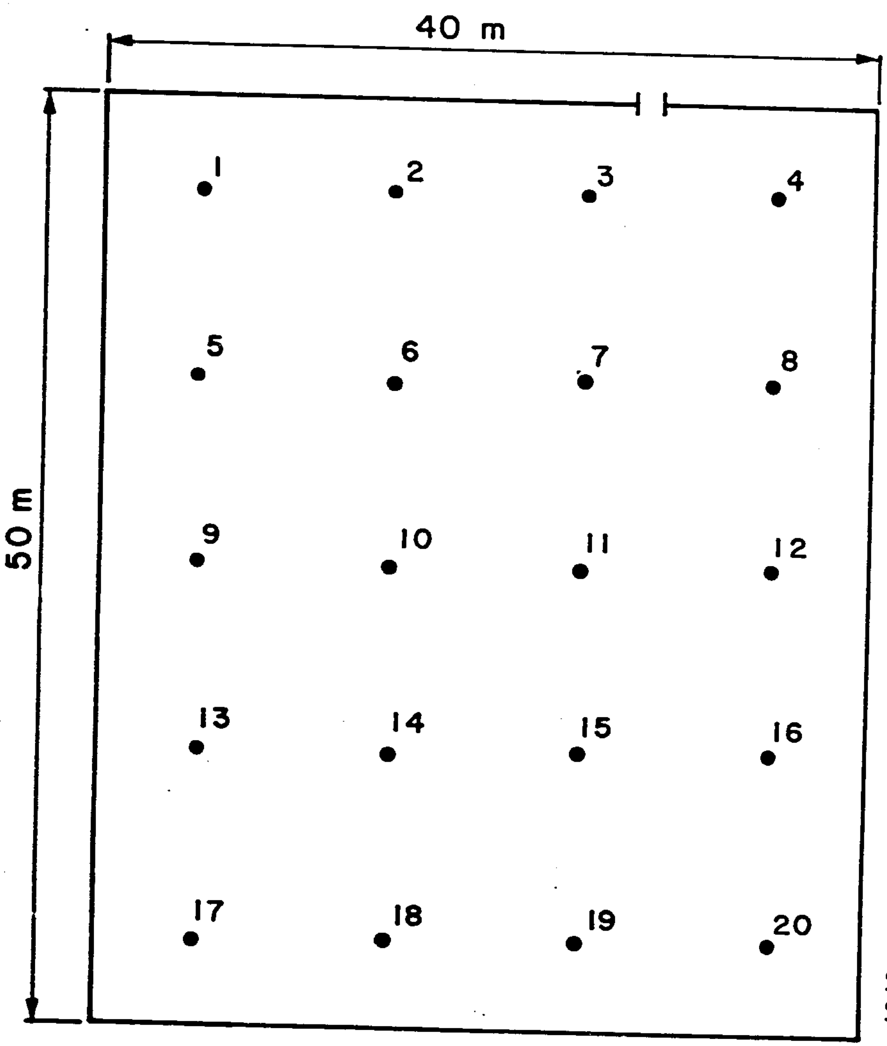
The application efficiency for this field, assuming a total average application of 6.25 cm would be 81%, assuming all the field is adequately irrigated and the precident moisture was evenly distributed. The minimum depth irrigated was 5.1 cm and the maximum, 7.3 cm.

Methods for calculating irrigation efficiencies and uniformities from advance and recession data and infiltration curves are illustrated in Figures 8 and 9. A grid of stakes are installed in the field, each representing an equal area, and the time ponded water reaches and leaves each stake is recorded. The lapsed time (IOT) is converted to a depth infiltrated with either intake functions determined from ring infiltrometers or the SCS characteristic curves (lesson block "Methods of Irrigation"). This function can be checked by comparing the field inflow volume, measured with flumes, to the predicted infiltrated volume (average depth times total area). Figure 9 then shows conceptually the distribution of water applied to the field, from most to least. The efficiencies given assume that the previous soil moisture deficiency was met everywhere across the field. Distribution curves are also shown which would result in 65% and 90% application efficiencies. Soil moisture measurements can be used to verify these calculated distribution curves.

If the measurements indicate that the distribution of the water across the field is too uneven, then the cause of the problem should be determined and solutions proposed to the farmer. Table 3 lists potential problems and possible causes.

APPLICATION

Conduct an irrigation evaluation of a level basin using the techniques described including:



Nucca Opened: 7:10
Nucca Closed: 8:20
Inflow Volume: 1.25 ha-cm

Stake No.	Advance Time hr/min	Recession Time hr/min	Intake Opportunity Time (min)	Accumulated Infiltration (cm)
0				
1	7:28	12:15	287	6.2
2	7:22	12:00	278	6.1
3	7:13	12:12	299	6.4
4	7:14	12:10	296	6.4
5	7:32	13:05	333	6.9
6	7:27	12:50	323	6.7
7	7:24	12:28	304	6.5
8	7:20	11:53	273	6.0
9	7:35	13:42	367	7.3
10	7:34	13:10	336	6.9
11	7:39	12:20	281	6.1
12	7:46	11:35	229	5.4
13	7:37	13:18	341	7.0
14	7:40	12:50	310	6.5
15	7:47	12:10	263	5.9
16	7:58	11:30	212	5.1
17	7:44	12:56	312	6.6
18	7:49	12:35	286	6.2
19	7:55	12:05	250	5.7
20	8:05	11:50	225	5.3
				ΣD=125.3
				$\bar{D}$= 6.3 cm

Soil Type: Silty Clay Loam
SCS Intake Family: 0.75

Figure 8. Advance and Recession Data Collection Sites and Times.

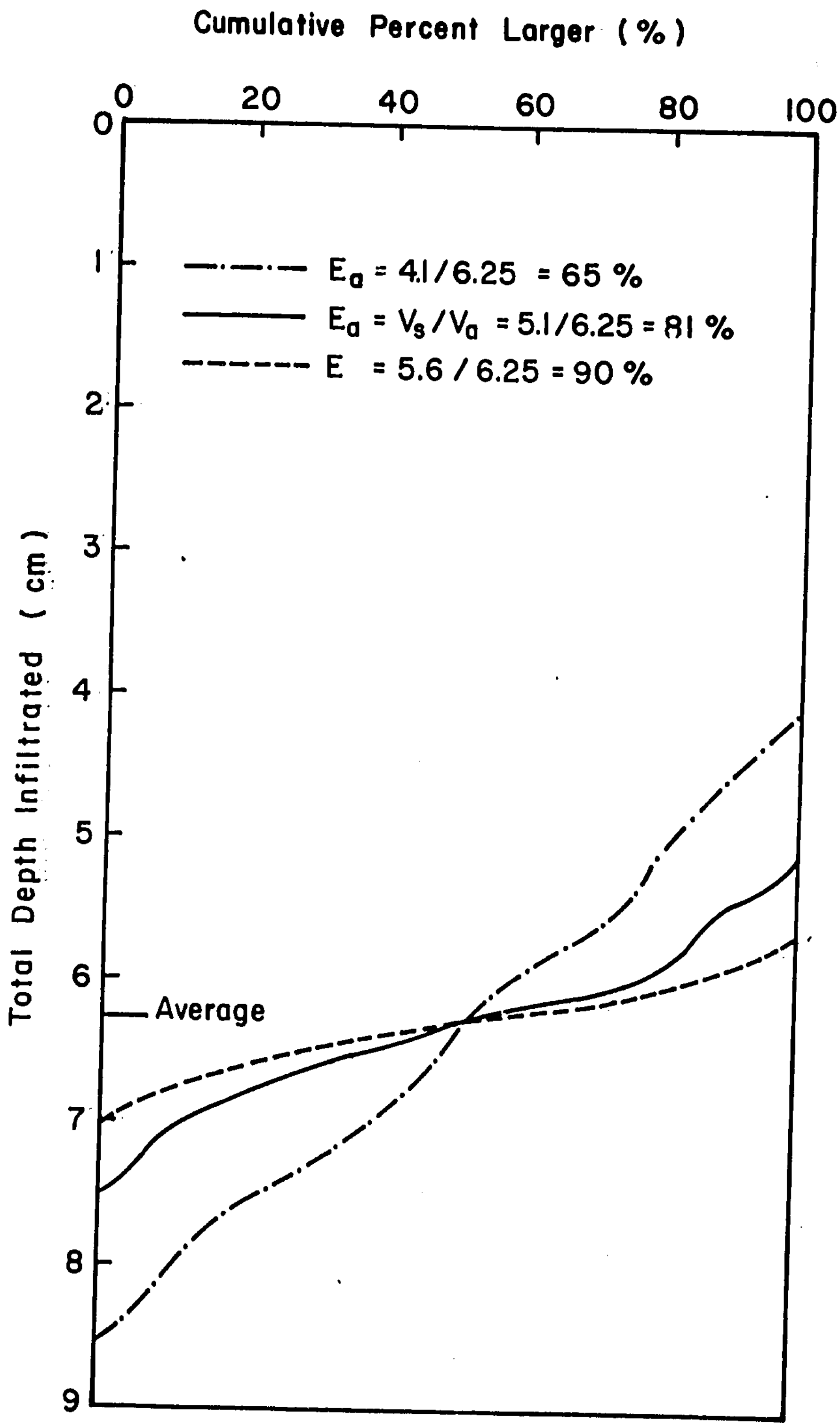


Figure 9. Distribution of Water on the Level Basin Shown in Figures 7 and 8 and Comparable Distributions Which Would Result in 65% and 90% Application Efficiencies.

Table 3. Irrigation Application Problems and Possible Causes.

Problem	Causes
Over or Under Irrigation	Lack of farmer understanding Too much or too little water Porous soils, small flows and large fields
Poor Water Distribution	
Slow Advance Times	Porous soils Fields too big Flows too small Unlevel fields
Uneven Recession	Unlevel fields
Other	Variable soil infiltration rates

1) divide the field into a grid and sample soil moisture before and after irrigations, and inflow volume to calculate E_a.

2) plot advance and recession curves of the field and measure or estimate infiltration rates. Plot the water distribution curve (Figure 9). Compare this distribution data with the soil moisture measurements.

3) discuss the application efficiencies and water distribution problems with the farmer and work out a plan to alleviate the problems.

Subject: DETERMINING IRRIGATION REQUIREMENTS AND IRRIGATION SCHEDULING

Trainer Ag. Engineer

Class Room 6 Hours

Field 1 Day

OBJECTIVES

To teach the trainees the basic concepts and methodologies of irrigation scheduling, including the measurement of soil moisture depletion.

MATERIALS NEEDED

1 - Sampling Tube

2 - Sampling Cans

3 - Oven

4 - Weighing Arrangement (Balance)

INTRODUCTION

For efficient use of irrigation water and optimum irrigated crop production, three important questions must be answered. These are:

1. How to irrigate.
2. How much to irrigate.
3. When to irrigate.

The answer to the first question may be obtained through studying various methods of irrigation such as basin, border, furrow ridge and furrow bed methods. This subject is covered in the lesson block "Methods of Irrigation." The decision will depend upon such factors as the topography, soils, crops to be grown, climate, water supply and economics. However, once an efficient physical system is constructed, only if the water is applied at the proper time and in the proper amount will the water be used to raise the maximum possible crops. This process is called irrigation scheduling.

PRESENTATION

Irrigation scheduling is the process of irrigating crops to replenish the soil water they have utilized (consumptively used), before they are damaged by a shortage of water (crop water stress). The scheduling will thus depend both upon the rate at which the crop uses water, and how much water can be stored in the crop root zone. Thus the crop, soil, and weather all affect irrigation scheduling.

Soil Moisture Storage

The soil, like other porous media such as a piece of cloth, will hold water if it is wetted. There is a maximum amount of water each soil can hold, called the field capacity. Additional water just percolates through to the groundwater. Like a cloth from which you can wring out only part of the total water while some still remains in the cloth, plants can extract only part of the water from a soil. Additional water left in the soil after the crop has extracted all it can is called the wilting point percentage, since crops will permanently wilt if the soil becomes this dry. The amount of water a soil can hold between field capacity and wilting point is called the total available water (TAW). A soil's available water is generally expressed as a percent. If the field capacity is 30 percent and the wilting point is 16 percent, then the available water is 14 percent (30 percent - 16 percent = 14 percent) or 14 cm per meter depth of soil.

The yields of most crops are reduced if the soil moisture gets near the wilting point, especially during critical growth periods. So instead of considering the usable soil moisture reservoir to include all of the available water, only a part of the total is usually used, which is called the readily available water (RAW). Often 50 percent of the available water is considered readily available or easy for the plants to utilize. This percentage is somewhat arbitrary and will vary from crop to crop. In the above soil, the RAW (using 50 percent of TAW) would be 7 percent or 7 cm per meter depth of soil. Table 1 lists typical available and readily available water holding capacities for soils with various textures.

The available moisture remaining in a soil at any time can be determined by measuring the water content of soil samples. Attachment 1 describes methods of determining soil moisture. Comparing the measured moisture content with the field capacity will indicate the amount of the depletion of the TAW, or the amount used by plants or evaporated. Field capacities for typical soils are listed in Table 1, but because the ranges are so large, it is best to measure each soil's moisture content when it is at field capacity (one or two days after it has been fully irrigated). If the depletion is approaching the amount of readily available water, (50 percent of TAW), then the crop should be irrigated.

The total soil-water storage available to the plant will depend not only upon the soil water holding capacity, but also upon the crop root zone, since the roots absorb the water. Table 2 lists rooting depths. Of course roots don't reach their full depth immediately, although perennial crops like alfalfa do maintain full root systems over several seasons. The table lists when mature roots can be expected. Before this time the rooting depths are growing from 0 at planting to full depth and can be estimated.

Since both water extraction by crop roots and soil types vary with depth, the moisture deficiencies should be measured for each

Table 1. Typical available and readily available water holding capacities based on soil texture.

Textural Class	Available Water % or cm/m	Readily Available Water (at 50% depletion) % or cm/m	Field Capacity % or cm/m
Coarse Sands	2- 6	1- 3	6-12
Fine Sands	6- 8	3- 4	10-18
Loamy Sands	9-10	4- 5	15-25
Sandy Loams	10-12	5- 6	15-30
Silt Loams	17-21	9-11	25-35
Silty Clay Loam	15-17	8- 9	30-40
Silty Clay	13-14	6- 7	30-40
Clay	11-13	6- 7	30-45

Table 2. Mature rootzone depths for several crops.

Crop	Mature Rootzone Depth	Approximate Time to Reach Mature Rootzone Depth (days)
Maize	105	60 days
Wheat	105	75
Berseem	105	60
Vegetables	60	Variable
Sugar Cane	90	130
Cotton	140	120
Rice	90	70

representative strata, or at least every 30 cm. The deficiency measured at each depth to the bottom of the root zone can then be multiplied by the strata thickness each sample represents to get the total soil water deficiency. If this deficiency is equal to the readily available water at any depth, then the crop should be irrigated soon. The choice of a 50 percent depletion level does allow for some safety factor if water cannot be applied immediately.

The amount of water to apply will be equal to this measured rootzone soil depletion divided by an efficiency factor. One hundred percent efficiency cannot be achieved due to nonuniformity of application resulting from the time required to spread water across the field and the slight undulations or unleveIness of the field surface. In most small level basins, an efficiency of 80 percent should be achievable. In precisely leveled basins with fine soils, 90 percent application efficiencies are possible.

In a few situations, where the surface soils are salty, a leaching allowance must also be added to the irrigation requirement. However, monsoon rains or overirrigation when water needs are low is a preferable way to manage salt problems as compared to adding a leaching allowance to each irrigation.

When the required irrigation depth D_i (cm), is known, it must be converted to an irrigation time, T (min), for the given field size, A (ha), and flow rate, Q (liters per second (lps)).

$$T = \frac{ADC}{Q},$$

where C is a constant equal to 1668 for the units given.

Example: The measured moisture content in a silt loam soil with a field capacity of 30%, 50 percent TAW depletion content of 20 percent:

Depth	Soil Moisture Content	Soil Moisture Depletion
0-30 cm	19%	11%
30-60 cm	21%	9%
60-90 cm	23%	7%
90-110 cm	24%	6%

Total soil moisture depletion is:

30 cm x 11% + 30 cm x 9% + 30 cm x 7% + 20 cm x 6% = 9.3 cm.

Since the upper soil strata moisture content is at about 50% depletion, the field should be irrigated. Assuming an 80 percent irrigation efficiency, total irrigation depth required to fill the soil-water reservoir to field capacity would be:

9.3 cm/0.8 = 11.6 cm

If the flow rate at the field is 40 lps and the field size 0.2 ha, the irrigation time for the field would be:

$$T = \frac{ADC}{Q} = \frac{(0.2)(11.6)(1668)}{40} = 97 \text{ mins.}$$

Crop Water Use

How quickly a crop uses its available moisture stored in the root zone depends on the crop and its growth stage, the moisture availability, and the weather. This crop water usage is usually termed either consumptive use or evapotranspiration (ET).

The potential evapotranspiration (PET) of an area is a measure of the water evapotranspired by a "reference" crop (such as alfalfa), which has full cover and is adequately watered. Potential evaporation is dependent only on climatic conditions. It depends essentially on the energy available to evaporate moisture and carry it away, and can be calculated from climatological data such as solar radiation, temperature, humidity, and wind. Table 3 lists average daily PET during each month for several locations in Pakistan. Attachment 2 at the end

Table 3. Average daily potential evapotranspiration, PET, (mm) for selected locations in Pakistan.

LOCATION	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Rawalpindi	1.1	1.3	2.5	3.9	6.2	5.9	5.2	4.4	3.8	3.0	1.9	1.1
Lahore	1.4	1.6	3.1	4.7	6.9	6.4	5.3	4.7	4.4	3.8	2.2	1.3
Multan	1.6	1.9	3.4	5.0	7.1	6.8	6.4	5.8	4.9	3.8	2.3	1.6
Bahawalpur	1.6	2.2	3.9	5.2	7.2	7.0	6.4	5.8	5.2	4.1	2.3	1.7
Hyderabad	2.6	3.1	4.9	6.4	7.9	7.1	5.9	5.5	5.5	4.7	3.4	2.5
Peshawar	1.1	1.1	2.2	3.6	5.2	5.8	6.0	5.6	4.7	3.4	2.0	1.2

of this lesson describes several methods for determining potential evapotranspiration. Consumptive use experiments are presently being carried out in several locations in Pakistan to calibrate these PET equations for Pakistan conditions.

Once potential evapotranspiration for an area and day (or week) is known, the crop ET can be calculated using a crop coefficient (K_c), and stress factor (K_s):

$$ET_c = K_s \times K_c \times PET$$

The stress factor, K_s, depends upon the ratio of the soil water depletion to the total available water, and varies from 1.0 at no depletion to about 0.9 at 40 percent depletion to about 0.8 at 60 percent depletion and on to 0.5 at 90 percent depletion. The crop coefficient, K_c, for each crop varies with growth stage. Figure 1 shows crop coefficient curves for maize, rice, wheat, cotton, and sugar cane developed for Pakistan conditions. Most crops similarly start near 0 at planting, increase to about 1 when full ground cover is reached, and then plateau until the crop is fully mature and growth stops.

Scheduling the Irrigation

As stated, irrigation scheduling is using the soil, crop and climatological data to determine when and how much water should be added to the root zone moisture storage reservoir to satisfy crop water requirements. Consequently, scheduling involves matching inflows to the outflows from the soil storage. The factors in this "water balance" technique are illustrated in Figure 2 and include:

D_i = irrigation water applied (cm)

D_r = effective precipitation (cm)

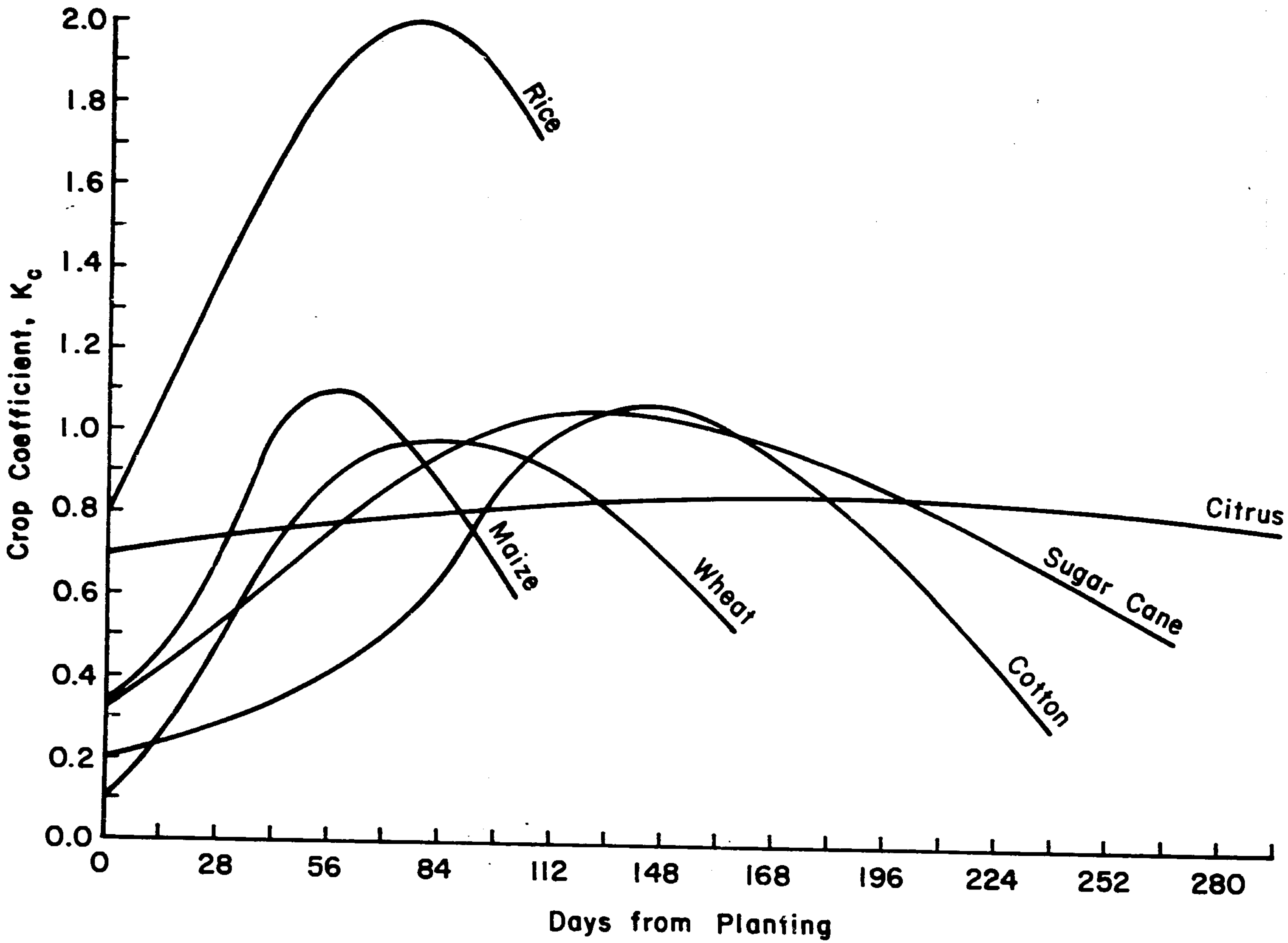


Figure 1. Crop coefficients K_c, vs. days since planting, for 6 crops commonly grown in Pakistan.

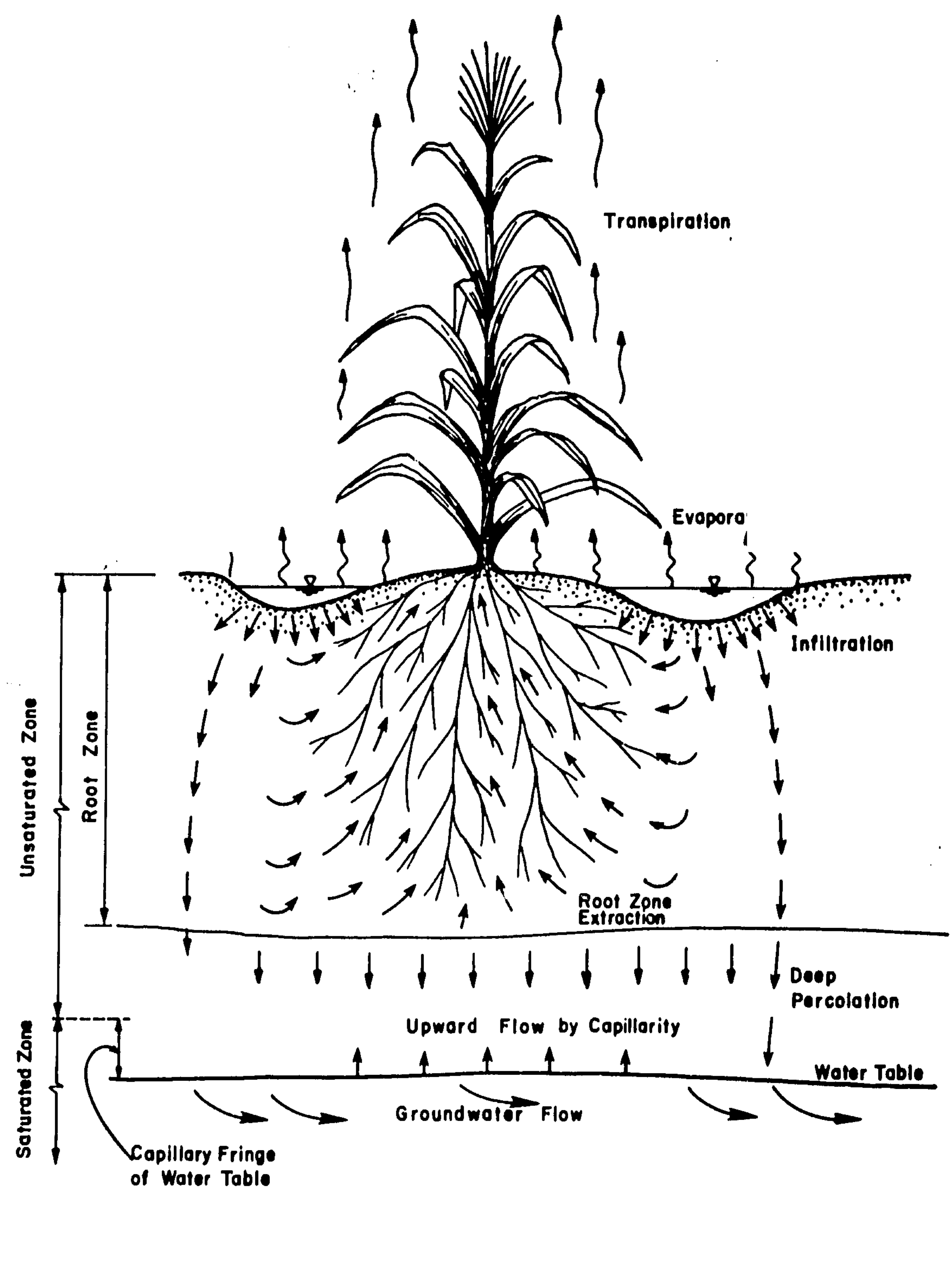


Figure 2. Definition sketch for water balance equation.

D_e = evapotranspiration (cm)

D_l = deep percolation (cm), and

D_c = water uptake from the water table (cm).

The sum of these inflows and outflows over a given period of time equals the change in rootzone moisture storage (ΔD_s) over that time:

$$\Delta D_s = D_i + D_r - D_e - D_l + D_c$$

Effective precipitation is the rain water which infiltrates to the root zone or total precipitation minus runoff and that water which evaporates from the plant or soil surface immediately after a rain. Deep percolation will be about equal to the amount of overirrigation or rainfall in excess of the soil moisture deficiency. Uptake from the water table is upward movement of water from a high water table to the rootzone. It is very difficult to estimate, but can be used to explain reduced water requirements in high water table areas. Methods to calculate evapotranspiration were given earlier.

This water balance technique can be used to calculate only changes in soil water storage. Consequently, an initial measurement of the soil water must be made to start out the scheduling process. If the soil moisture at planting were known, this technique could ideally be used to schedule all the remaining irrigations. In reality, the measurements and estimates of several of the factors are too inaccurate to allow this, so the technique is generally used instead as a simple accounting procedure of the soil moisture status while corrections are constantly made with soil moisture measurements.

For example, assume that on June 10, the soil moisture depletion of a silt loam soil was 10 cm, which is about 30 percent depletion in the 110 cm rootzone (Table 2). The average daily PET for the region (Lahore) in June is 6.4 mm (0.54 cm) per day (Table 3), and the crop coefficient for the corn is 0.9, giving a daily ET (D_e) of 0.58 cm. This means that if there is no precipitation in the next two weeks, the soil will reach 50 percent depletion (16.7 cm) in 11 days. This is calculated by solving the water balance equation for D_e and setting the change of storage (ΔD_s) as the difference between the present storage and storage at 50 percent depletion,

$$D_e = D_i + D_r - D_l + D_e - \Delta D_s,$$

$$D_e = 0 + 0 - 0 + 0 - (10 \text{ cm} - 16.7 \text{ cm}),$$

$$D_e = 6.7 \text{ cm}$$

and dividing the total allowed ET by the daily ET rate (6.7/0.58 = 11 days). Thus the time of the next required irrigation would be June 21, or whenever the warabundi turn comes near that date. If 2 cm of precipitation falls during that time and all of it is effective the next irrigation could be delayed until:

$$D_e = 0 + 2 - 0 + 0 + 6.7 = 8.7 \text{ cm}$$

no. days = 8.7 cm/0.58 cm/day = 15 days, or June 25.

Likewise, if, because of the warabundi turn, it is desired to irrigate the field every 14 days, then using the scheduling equation, the amount of irrigation required can be determined. Since D_i, D_r, D_l, and D_e are assumed to be 0 during this interval

$$\Delta D_s = -D_e = 0.58 \times 14 \text{ days} = 8.1 \text{ cm}$$

or each irrigation in June should be of 8.1 cm plus an allowance for application inefficiencies. If rain falls the depth of irrigation should be reduced by the amount of the effective rainfall.

In reality, the PET values in Table 3 are average values and actual PET during a season can vary significantly from these. Therefore, unless PET values are measured at the site or nearby, the soil moisture deficit should be measured again before the irrigation to determine actual soil water deficit.

Irrigation scheduling using the water balance technique, and knowledge of the soils, crop, and climate is a very powerful tool for predicting irrigation schedules and estimating irrigation amounts. When used in conjunction with regular soil moisture measurements, it can lead to the most efficient utilization of water within the physical limits of the irrigation system.

Application

1. Assume you wish to grow a crop of maize on a sandy loam soil in the Multan area. The soil is filled to field capacity (20%) during rauni irrigation and no additional leaching is required. The maize is planted on the first of March. Assume a 2 cm rain is received on April 20 and a 6 cm rain on May 15. The farmer has no tubewell, so water is available to him only weekly during his warabundi turn, the first of which is March 3. Schedule the irrigations (timing and quantity) for his maize. Assuming 80 percent application efficiency, indicate how much of his 5 hour warabundi turn will be required to irrigate 0.4 ha (1 acre) of maize each turn. The flow at his field is 40 lps.

2. Determine the moisture content of a field before irrigation at 0-30, 30-60, and 60-90 cm depths using the oven and sun dry gravimetric methods and the touch and feel method. Compare the results of the different methods. Collect samples at 4 locations in the field and compare these samples to find the variability. Two days after a heavy irrigation or rain, measure the moisture content again to

determine the soil field capacity. Then calculate the moisture depletion of the first samples.

ATTACHMENT #1

SOIL MOISTURE DETERMINATION TECHNIQUES

To determine when a crop must be irrigated or how much water should be applied, the soil moisture content must be known. Soil moisture can be measured gravimetrically, if scales and a means of drying the sample (an oven or, in the proper climate, the sun), are available, or by the simple and quick but less accurate touch and feel method.

First the sample must be collected. Although surface layers can be sampled with a shovel or spade, it is much easier to sample lower layers with a soil tube. For deep samples from heavy soils, a tube with a hammer, or king tube, will be the easiest sampling tool.

The soil layer sampled will depend upon the crop and growth stage. The normal procedure is to collect a sample representative of each 30 cm depth to the bottom of the root zone. Since soil moisture will vary in a field depending on soil texture, relative soil surface elevation, closeness to the inlet, and crop stand, several representative locations should be sampled to get an average soil moisture value for a field.

As soon as a soil sample is collected, it must be protected from moisture loss until the initial wet weight has been measured or until the touch and feel analysis is completed. Airtight metal or plastic containers are used for this purpose. Tightly closed plastic bags can be used if storage time isn't too long.

GRAVIMETRIC DETERMINATIONS

The gravimetric (measurement by weight) determination involves the determination of weight differences at the time the sample is collected and it has been dried to measure the amount of the water contained in the soil. Since most calculations of soil moisture for irrigation purposes is on a volumetric basis, this weight measurement (in %) must be converted to a volumetric measurement (%) by multiplying by the soil bulk density. Soil bulk densities vary between 1.7 for coarse soils to 1.2 for fine soils. Medium loamy soils often have a bulk density between 1.3 to 1.4.

<u>The Oven</u>

The oven is the tool utilized in the laboratory to determine soil moisture content. It provides an exact analytical measurement of the amount of moisture contained in the soil, and through the combination of the results from samples representing various segments of the soil profile, the water content of the field within the root zone of the crop to be produced can be calculated. The exact requirements of the research scientist are provided for by this method.

Standard procedures in the use of the oven are:

a. Weigh and record the weights of the airtight containers and the soil they contain.

b. Open the containers and place in the oven which has been set at $105^{o}C$.

c. Dry for 24 hours.

d. Record the dry weight.

e. Subtract dry weight from the weight of the field-collected sample. The difference is water.

f. Divide the weight of water by the weight of dry soil and multiply by the soil bulk density.

This procedure may be repeated as necessary until the weight becomes constant, since some soils dry more readily than others.

The Sun Drying Method

Since ovens are not generally available to the worker in the field, an alternate method has been developed which utilizes solar energy for the purpose of drying soil samples. In areas where the climate is warm and dry, results have been found to be very close to those obtained from oven-dried samples.

This procedure calls for the use of plastic sheets or of the same plastic bags in which the samples are stored to be exposed to the sun after the sample has first been weighed. Procedures utilized in the sun-drying of samples are:

a. determine weight of sheet or bag by weighing 100 of them and determining the average weight.

b. spread the sample out and break any clods present, thus providing maximum exposure of the soil to the sun.

c. place the samples in a convenient, protected area where maximum exposure to the sun is available.

d. exposure time.

Time of year	Sheet	Bag
Hot Season	3 hours	5 hours
Cool Season	4 hours	7 hours

These tabulated times assume this number of hours of bright sunshine. Drying cannot be conducted during cloudy or partly cloudy weather.

Overnight drying is not recommended since wind or storms can ruin samples very quickly.

(NOTE . . . these exposure times have been found to approach 1% of oven dry weights in Pakistan, where the climate is warm and dry and sun intensity is high.)

Specifications of drying sheets or bags:

Sheets

a. Sheets should be 2 to 6 mil. polyethelene plastic, 24 inches square.

b. Sheets need not be weighed if a special weighing dish is used.

Bags

a. If the same bag is used for drying as that in which the sample is collected, larger bags are needed. 15" x 15" plastic bags are recommended so that they may be folded to provide a two-inch rim around the exposed sample. The use of the bag provides somewhat more protection against spillage than the sheet, and requires fewer supplies and less handling.

The Touch and Feel Method

The touch and feel method is not intended to replace field samplings and laboratory techniques. Rather, it is intended to enable the technician to develop a practical, quick estimate in the field when decisions relative to water use or irrigation planning are necessary.

The attached table presents descriptions of the appearance of the soil as it is examined. First, determine the texture of the soil.

Wet a small handful of the soil and work it into a uniform consistency by squeezing and kneading it.

A coarse soil when squeezed will leave moisture in the hand. The sample shows little cohesion and will not form a "ribbon" when squeezed between the thumb and forefinger.

A light soil leaves a wet outline on the hand when squeezed. Shows some cohesion when manipulated and will form only a very weak "ribbon" when squeezed between the thumb and forefinger.

A medium soil leaves a slightly wet outline when squeezed in the hand. It shows definite cohesion, and will form a moderate ribbon (up to 1 inch in length), between the thumb and forefinger.

A fine soil hardly leaves a moisture outline when squeezed in the hand. It is strongly cohesive, and will sometimes ribbon out to almost two inches between the thumb and forefinger.

Once the basic textural group has been determined and the proper column in the Table 1 has been chosen, the samples in field moisture condition are examined. The procedure is to squeeze the sample into a ball, about an inch in diameter. Test the ball for strength and compare it's strength with the descriptions in the column of the table representing the textural grade of the sample. Estimate soil moisture deficiency in percent or cm per m depth from the table - last column.

The chart assumes the average soil available soil moisture, for the four textural classes to be:

Coarse - 6%

Light - 11%

Medium - 15%

Fine - 17%

This figure divided by the bulk density of the soil will provide available moisture on a weight basis (which the gravimetric procedure provides).

Comparison of the three techniques

Actually the three techniques which are discussed here are not designed to replace one another. Rather, they are each utilized in that manner which will expedite the management program most efficiently.

Table 1. Soil moisture chart for the touch and feel method.*

SOIL MOISTURE APPEARANCE CHART

MOISTURE Deficiency (cm/30 cm)	COARSE (Loamy Sand)	LIGHT (Sandy Loam)	MEDIUM (Loam)	FINE (Clay Loam)	MOISTURE Deficiency (cm/30 cm)
0.0	(field capacity) Leaves wet outline on hand when squeezed.	(field capacity) Leaves wet outline on hand, makes a short ribbon.	(field capacity) Leaves wet outline on hand, will ribbon out about one inch.	(field capacity) Leaves slight moisture on hand when squeezed will ribbon out about two inches.	0.0
0.5	Appears moist; makes a weak ball.	Makes a hard ball.			0.5
1.0	Appears slightly moist. Sticks together		Forms a plastic ball; slicks when rubbed	Will slick and ribbon easily	1.0
1.5	slightly. Very dry, loose; flows through fingers (wilting point).	Makes a good ball	Forms a hard ball.	Will make a thick ribbon; may slick when rubbed.	1.5
2.0		Makes a weak ball	Forms a good ball.	Makes a good ball.	2.0
2.5		Will not ball.			2.5
3.0		Wilting point.	Forms a weak ball.	Will ball; small clods will flatten out rather than crumble.	3.0
3.5			Small clods crumble fairly easy.	Clods crumble.	3.5
4.0					4.0
4.5			Small clods are hard. (wilting point)		4.5
5.0				Clods are hard cracked. (wilting point)	5.0

*Adapted from "Field Method of Approximating Soil Moisture for Irrigation," by John L. Merriam, Transactions of the A.S.A.E, Vol. 3, No. 1, 1960.

The procedure which provides the true analytical analyses of soil moisture availability is the use of the oven. The other methods have been developed to supplement, not replace, this one. The accuracy of the sun-drying method is determined by the care with which the sample is handled; the temperature, humidity, and intensity of the sun. Its accuracy might not be dependable in cool or humid climates, but in warm, dry areas like Pakistan the results have been found to be practical and accurate when samples are properly handled and protected.

The TAF method is not intended to replace gravimetric procedures. It has been developed for use by the technician to make quick, practical field decisions. If this procedure is to be accurate and effective, the person using it should constantly calibrate his "feel" against gravimetric results. For this purpose it is suggested that he develop a graph, similar to that in Figure 1, on a regular basis.

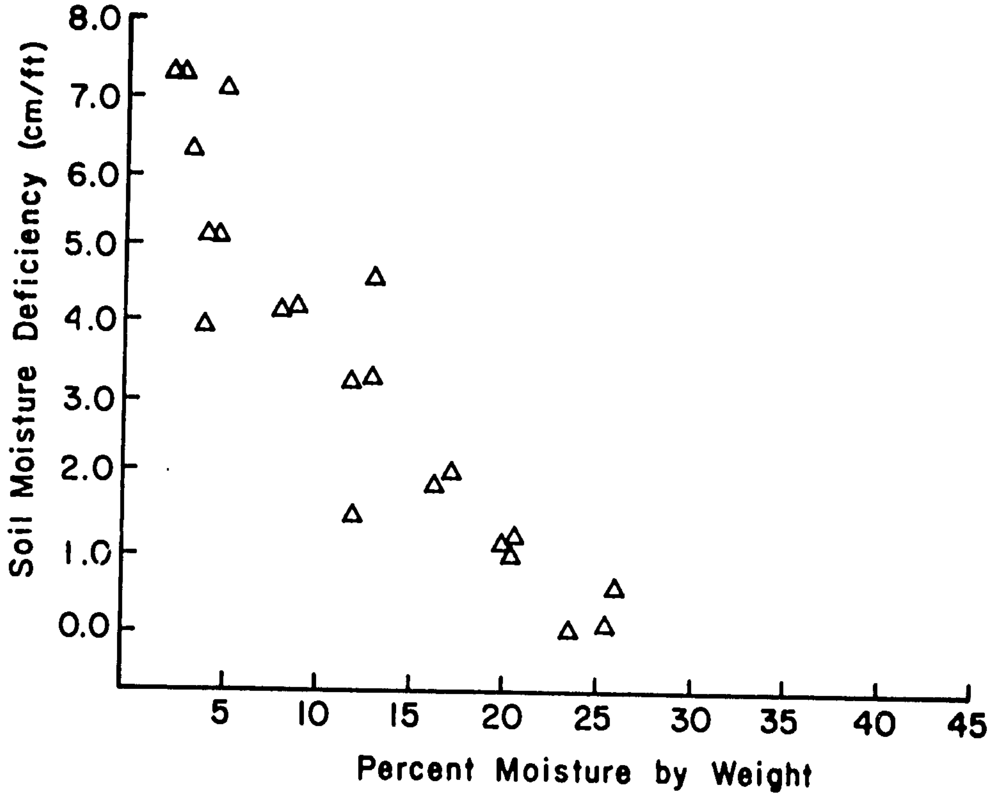


Figure 1. One individual's calibration of his "feel" using the gravimetric method.

ATTACHMENT #2

MEASURING POTENTIAL EVAPOTRANSPIRATION

Potential evapotranspiration is a measure of the ability of the atmosphere to evaporate water from moist soil and plant surfaces. It is dependent purely on climatological factors.

Evaporation

Evaporation is a process whereby liquid water is converted into gaseous water. The gaseous water is at a higher energy state than is liquid water when the gas and liquid are at the same temperature. Evaporation, therefore, requires energy, the energy requirement being approximately 540 calories per gram of water evaporated under standard conditions. One calorie is defined as the heat required to change the temperature of one gram of water from 3.5^{o}C to 4.5^{o}C. The energy required for evaporation of one gram of water corresponds to the energy required to lift one gram 230 kilometers. The energy used in evaporation comes originally from the sun in the form of radiation.

Radiation Energy

The radiation energy which arrives on a horizontal[1] plane at the Earth's surface from the sun is called incident radiation, R_I. Because the sun radiates energy at an extremely high temperature, that energy has a high frequency and a short wave length and is called short-wave radiation. It may arrive directly, or it may first be scattered due to dust particles in the atmosphere, or it may be reflected off clouds. Some of the incident radiation arriving at

[1] If the surface receiving the radiation is not a horizontal plane, then calculations are made on the basis of the projection of that surface on to a horizontal plane.

the Earth's surface is reflected back. If the reflection coefficient is r, the total short-wave radiation absorbed by the Earth is $R_I(1-r)$.

There is also a long-wave radiation component. Long-wave radiation originates from bodies having temperatures of the same order of magnitude as those of the earth. The downward flux of long-wave radiation toward the earth is R_d, and the upward flux of long-wave radiation away from the earth is R_u. The net long-wave radiation absorbed by the earth is thus R_d-R_u.

The downward flux of long-wave radiation energy, R_d, is received mainly from heated air masses, and by energy reflected from clouds. The upward flux of the long-wave energy, R_u, is radiated or reflected from heated soils, plants, buildings, etc.

The net radiation, H, (which includes both long- and short-wave radiation, is

$$H = R_I(1 - r) + R_d - R_u \quad (1)$$

An equivalent expression for net radiation is

$$H = R_{in} - R_{out} \quad (2)$$

where R_{in} is the sum of all incoming radiation (long- and short-wave), to the surface and R_{out} is the sum of all outgoing radiation (long- and short-wave), from the surface.

The net radiation is transformed into other forms of energy, e.g. the higher energy state of water vapor as compared to liquid water and perhaps a higher temperature of the soil and the atmosphere. Energy of an air mass associated with its water vapor is called latent heat and that associated with its temperature is called sensible heat or thermal energy. Latent heat can be converted into sensible heat by condensation, and sensible heat can be converted into latent heat by evaporation. Net radiation depends primarily on the season and the latitude. Thus the net radiation of the area around Washington, D.C. is about the same as that around Denver. The incoming radiation in the Denver area during daylight hours is much greater than that in the Washington, D.C. area. This is because of the higher elevation and less frequent cloud cover of the former. The outgoing radiation in the Denver area, especially during nighttime, is also greater. The difference in temperature between day and night, therefore, is much greater in Denver than in Washington, D.C. The extremes in temperature are also greater, but the monthly means are about the same.

Net radiation over a long period of time correlates quite well with the mean temperature over the same period of time. The correlation over short periods, however, may be poor.

In humid regions air masses passing over moist surfaces or dense vegetation contain nearly as much water vapor as the air is capable of holding (without further heating). Additional water can be evaporated only as the air in contact with such surfaces has its temperature increased by the radiant energy. The sensible heat (associated with the higher temperature), in this case is usually small compared to the latent heat. Consequently, the energy used in evaporation is almost equal to the net radiation. By contrast, in places where the Earth's surface is not moist (or covered with vegetation), the net radiation may be almost entirely converted to sensible heat. For this reason, dry surfaces become warmer than moist surfaces. This leads to more radiation as well as conduction of heat from dry surfaces as compared to moist surfaces, with the result that the underlying soil and the air in contact with dry surfaces also become warmer.

Conduction, Convection and Latent Heat of Evaporation

Thermal energy can be removed from an air mass by conduction to a cooler body (soil, water or plant surface). Conduction is a process whereby heat is transferred from one part of a body to another part of the same body (or from one body to another in contact with it) in response to a temperature gradient, the heat moving from points of higher to points of lower temperature. This is in contrast to heat transfer by convection (bulk flow) whereby heat is transferred as the result of the transfer of matter as, for example, in a moving air mass. Conduction and convection usually take place simultaneously as an air mass moves over a surface.

Thermal energy (sensible heat) of an air mass also can be converted into latent heat without any net change in its total energy, although its temperature will be reduced. However, the cooling effect of this energy conversion may induce conduction of heat from warmer soil beneath the surface, thereby adding slightly to the total energy of the air mass.

The importance of the conversion of thermal energy from air masses as a source of energy for evaporation depends upon the state of "saturation" of air masses with water vapor as they pass over a particular area. In arid and semi-arid regions, the air masses are frequently "undersaturated" as they start over a moist surface, e.g. an open body of water or a cropped field. In this case, a substantial part of the energy for evaporation may be supplied by the air masses. In humid regions, where the air masses are already practically saturated with water vapor, the energy supplied by this source may be negligible.

Energy for evaporation supplied by moving air masses is sometimes called advective energy.

In arid and semi-arid regions, the variation in evaporation rates, from place to place and from one side of a field to another, is much greater than in humid regions. This is because the degree of saturation of air masses with water vapor changes greatly from point to point. The increase of evaporation in moist areas (of relatively small size) due to dry air from surrounding dry areas is known as the oasis effect.

Relative Humidity

One way of characterizing the wetness or dryness of air is by its relative humidity, the ratio of the quantity of water present to the maximum quantity that can exist in a given volume at the existing temperature and pressure, usually expressed as a percentage. When the relative humidity is 100 percent, the air is fully saturated with water. Any cooling of such air will result in precipitation, providing condensation nuclei are present. An increase in temperature of the air reduces its relative humidity to less than 100 percent, because warm air has a larger capacity to hold water than does cool air.

Factors Affecting Evaporation from Moist Surfaces

Evaporation from moist surfaces is influenced by the following factors:

(a) intensity of incoming radiation, which in turn is affected by (1) cloud cover, (2) season, (3) time of day, (4) latitude, and (5) altitude,

(b) color and other reflective properties of the moist surface, which determine the back radiation for a given temperature of the surface,

(c) the relative humidity of the air moving over the surface,

(d) the speed of the air,

(e) the turbulence of the air,

(f) the temperature differential between air and surface,

(g) exposure of surface of moving air and incoming radiation.

Factors (a) and (b) determine the amount of energy converted from incident radiation to latent heat. Factors (c) and (g) determine the amount of thermal energy from moving air masses converted to latent heat. The factor (f) also affects the energy from heat stored in the soil. The soil at different times may act either as a source or a sink for energy, the net effect over a long period of time being negligible.

Evaporation from Fallow Soils

Where initially moist fallow soils exist, the rate of evaporation is initially equal to the potential evaporation, which is the maximum possible evaporation rate for a flat surface under the existing climatic conditions, and is governed, therefore, by the factors listed above. Unless a water table exists near the surface, however, the suface will eventually begin to dry. When this happens, the rate of evaporation begins to decrease rapidly, being no longer governed, primarily by the factors affecting the potential evaporation.

When the soil surface finally becomes dry, evaporation takes place below the soil surface. At steady state, the rate at which liquid water can reach the zone of evaporation equals the rate at which water vapor can diffuse through the dry soil above. This condition exists only if a water table is present at a constant depth below the soil surface.

When a water table does not exist, the soil continues to dry from the surface, thus creating a thicker layer of dry soil through which diffusion of water vapor takes place, which results in a slower rate of evaporation. The dry layer of soil, therefore, creates an effective barrier to rapid evaporation.

If the dry layer exceeds a few millimeters in thickness, the rate of diffusion through this layer is vastly slower than the potential evaporation which would occur if the surface were moist.

Most of the water which evaporates from bare soils, therefore, is lost within a few days following a rain or irrigation unless the period between rains is very long. After a few days the surface dries and the rate of water loss is controlled by the rate of diffusion through the dry layer. The appearance of dry soil at the surface does not mean that the soil below has lost most of its water. It means merely that the soil cannot supply water to the soil surface as fast as evaporation could take place there.

Evapotranspiration

When plants are growing in the soil, the barrier of a dry surface soil is effectively "short circuited." This is because water is able to move upward in a liquid state from moist soil below to the parenchyma cells of the foliage. From there it passes into the air as vapor at a rate depending primarily on the atmospheric conditions, but to some extent on the plant. Evaporation that takes place from parenchyma cells through stomatal cells is cal[illegible] transpiration. The total evaporation occurring from soil an[illegible] surfaces and that through stomatal openings is called evapotranspiration. It is usually expressed as a volume of water per area of land surface (L^3L^{-2}) and is designated as ET. Sometimes ET may be used to designate a rate, i.e., $L^3L^{-2}T^{-1}$. During a 24-hour period ET may be equal to (or somewhat greater than) evaporation from a corresponding area of moist soil or open water, whenever foliage covers as much as 60 percent of the ground surface. This is because plant foliage, being surrounded by moving air, can absorb more energy from air masses than can flat soil or water surfaces.

For short periods of the day, during peak radiation, ET from cropped areas may lag behind evaporation rates from an equal area of open water or moist soil. This is due to the closing of stomatal openings associated with loss of turgor in plant cells. But because of the greater energy supplied from air masses, ET from cropped areas tends to persist at a higher rate for a longer portion of the day than does evaporation from moist soil only.

In addition to ET, plants use a very small amount of water in tissue building. The sum of ET and water used in building plant tissue is called consumptive use. However, because the water removed in plant tissue is usually very small compared to ET, the terms consumptive use and evapotranspiration are commonly used interchangeably. "Consumptive use" or ET may be applied to a particular crop, field, farm, river basin, project area or any arbitrary subdivision of land surface.

Potential Evapotranspiration

The evapotranspiration rate of a particular crop e.g. grass or alfalfa (when ET is not limited by the soil water and when the crop is growing vigorously with full foliage) is called potential evapotranspiration, ET_p. The ET_p for a particular reference crop is regarded as a function of climatic factors only although this is an appproximation.

DETERMINATION OF POTENTIAL EVAPOTRANSPIRATION

Most methods for determining ET_p are based on measurements of ET from plants growing in a container of soil, measurements of evaporation from a wet surface, or by calculations from measured climatic factors.

Lysimeters

Lysimeters are devices for the direct measurement of evapotranspiration from plants growing in a container of soil. The evaporation rate is determined through a water balance in any one of a number of ways.

(a) The soil in the container is supplied with water at a controlled pressure which is slightly less than atmospheric at the soil surface. The rate at which the soil imbibes water at this pressure is equal to the potential evapotranspiration rate when the system reaches a steady state and the crop grown is a reference crop. Such a steady state is reached only when no water is added to the soil for a prolonged period of time except that which comes from the controlled pressure source. An example of a controlled pressure lysimeter is shown in Figure 1.

(b) The entire container including soil, water and plants periodically is weighed and supplied with measured quantities of water. The decrease in weight plus the water added over a period of time gives the evapotranspiration rate for that period. If the periodic weighings and irrigations are frequent, the moisture level is kept near field capacity, and the crop grown is a reference crop, the evapotranspiration rate is close to the potential evapotranspiration rate.

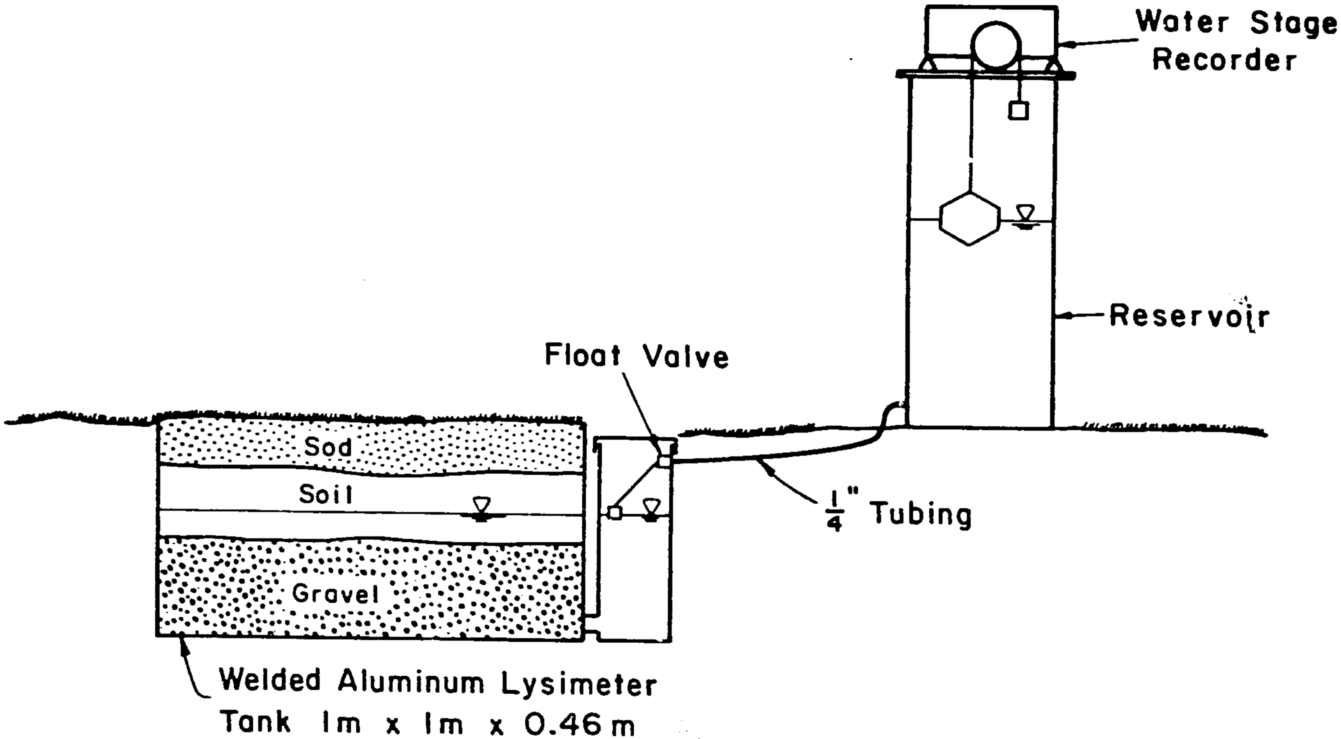


Figure 1. Controlled pressure (constant water table) Lysimeter.

Lysimeters are necessary because they constitute the only method by which other methods of determining evapotranspiration for short time periods can be checked or calibrated.

The usefulness of this method for determining evapotranspiration (as it occurs under normal field conditions) is limited, however, because of the difficulty of making the lysimeter an accurate sample of the field conditions. In order to accomplish the latter, it is necessary that the root environment (with respect to soil and water) be the same as elsewhere in the field. The vegetation within the lysimeter must also be the same as that of the surrounding vegetation. This is extremely difficult to accomplish in practice. A failure to reproduce precisely the normal conditions of the field does not necessarily preclude the use of this method for calibration of formulas based on the energy balance or weather data correlation principles, and they are often used for the determination of K_c.

An excellent review of the various kinds of lysimeters and their use has been given by Tanner (1967). In most cases, the use of lysimeters is confined to research and calibration rather than to engineering planning and design.

Evaporation from a Wet Surface

Probably the most common measurement related to ET_p, for engineering use, is obtained with standard evaporation pans, such as that of the U.S. Weather Bureau. The pan is relatively reliable as a tool for potential evapotranspiration over a long period of time, the longer the period the more reliable the measurement. Evaporation from the water surface in pans, of course, is affected by the heat storage, radiation exchange, and the transfer characteristics for heat and vapor of the pan and its surroundings. These may not be especially good analogues of the natural environment of a reference crop under consideration. If carefully positioned and exposed, however, the evaporation from pans may be a fair measure of local evaporation. In any case, it should correlate well with ET_p so that a calibration coefficient can usually be applied to the pan evaporation that will permit a reasonably accurate estimate of ET_p, especially over weekly to monthly periods.

Energy Balance Calculations

If a portion of an evaporating surface is considered, the equation of energy flux (energy crossing an area per unit time) can be written as

$$E = H - K - C \tag{3}$$

where E is the energy available for evaporation of water from the surface, H is the net rate at which radiation is received at the surface, K is the rate at which heat is tranferred from the surface to the air above the surface, and C is the rate at which heat is transferred from the surface to the water and soil below the surface, all quantities being expressed as an equivalent amount of water evaporated (mm H_2O/day). Both K and C may be either positive or negative, being positive when heat flow is away from the surface. The problem is to estimate E from knowledge of H, K and C. A multiplicative factor can relate E to ET_p.

The daily flux of heat into the soil and the soil water, C, can often be considered equal to zero. In some cases, however, it may be desirable to estimate this from a knowledge of the soil's thermal conductivity (dependent upon soil characteristics and water content) and the temperature gradient within the soil. In other cases, it has been found possible to relate this heat flux empirically to daily changes in air temperature (Kincaid and Heermann, 1974). At any rate, C can be estimated. The heat transfer, K, also can be estimated from temperature and velocity profiles of air moving over the surface.

Net radiation, H, can be determined with a net radiometer. One such instrument is constructed of two identical blackened sensing elements placed back-to-back, one facing upward and the other one downward. The temperatures of these elements are measured. The device is suspended over the evaporating surface at an elevation such that the portion of the evaporating surface shaded by the instrument is small and thus does not change the back radiation (to the underside of the net radiometer) materially. Knowing the heat conductivity and the thickness of the plate, the net flux of energy between the elements can be determined from the difference in temperature. This is the net radiation. In cases where air masses moving over the surface are essentially saturated, a fair approximation of ET_p can be obtained simply by measuring net radiation.

<u>Vapor Transfer Calculations (Aerodynamic Approach)</u>

This approach regards evaporation as being due to turbulent transport of vapor by a process of eddy diffusion, and until recently, the approach was more or less empirical.

Dalton, in 1798, proposed an equation of the form

$$E = (e_s - e_d) f(u) \qquad (4)$$

where e_s is the vapor pressure at the evaporating surface and e_d is the vapor pressure at some distance above the surface where the wind speed, u, is measured. The function f(u) depends on the roughness and homogeneity of the surface, thermal stratifications in the air, the value of u, and other factors. Early empirical studies by Rohwer (1931) expressed f(u) as a linear function of wind speed.

Combination Energy Balance and Vapor Transfer Equation

Penman (1948) developed an equation for evaporation from a free-water surface by neglecting the term C in Equation (3). He assumed that the heat transfer to the air, K, takes place by a process similar to that of vapor transfer (Eq. 4) and obtained

$$E = \frac{\Delta}{\Delta+\gamma} (H - C) + \frac{\gamma}{\Delta+\gamma} (E') \quad (5)$$

As can be seen, the modification accounts for the soil heat flux.

Area Water Budget

This method includes the techniques of catchment hydrology and soil-water depletion sampling. They are used more often for measuring actual evapotranspiration rather than potential evapotranspiration, but when the area (on which the water budget is made) is one supporting a dense vegetation without water stress, a measure of ET_p also can be obtained.

Techniques of catchment hydrology are those in which an attempt is made to carry out a material balance measurement on a relatively large area, often a single watershed. Precipitation is measured over the area using rain gauges. Runoff is determined from streamflow measurements, and the changes in storage of ground water are determined from changes in water table elevations and sometimes soil sampling. The evapotranspiration is obtained by a water balance calculation for the entire watershed. The method is discussed in textbooks dealing with hydrology. It is not suitable for determining ET_p over short periods of time.

Soil water depletion measurements also are based on the water balance principle. The reduction in soil water stored within the root zone (over a period when no water is added at the surface and none is lost by deep percolation) is taken as the evapotranspiration for the period. The principal difficulties involved are: (1) the large number of soil samples necessary to measure the amount of water lost from the soil with sufficient accuracy and (2) the uncertainties involved in the assumption of zero deep percolation.

The usual procedure is to wait at least two days following a substantial rain or irrigation and afterwards to measure the water content as a function of depth at increments of time before more water is supplied at the surface. The measurements of moisture content are made on soil samples taken with a soil tube or by use of a neutron probe. Other methods are available but these are the most widely used.

When soil samples are taken, samples from a particular depth should be composited from at least 5 to 10 holes in an area because the error in measurement from an individual hole may be excessive. Tubes that take samples consisting of a known bulk volume of soil are required so that the water content on a volume basis can be determined.

In the case of row crops or orchards, the neutron measurements or sampling should be done at locations such that the lateral as well as vertical distribution of soil water is determined.

<u>Other Methods</u>

Equations for estimating ET_p have been developed for areas where the available data for solar radiation, wind speed, temperature and relative humidity are insufficient for the calculations described above. One of the simplest of these is the Hargreaves (1974) equation which uses temperature and relative humidity data only, along with the month and latitude, to estimate ET_p. It has been used in South America where it has been found to be a reliable estimate of ET_p when applied to periods of a month or longer.

Another popular method is that of Jensen and Haise (Jensen, 1975). With this method, ET_p is correlated with temperature and solar radiation. Separate correlations have been made for various areas to account for local climatic factors omitted from the correlation. The American Society of Civil Engineers (ASCE, 1974) has presented a discussion of these methods along with other methods for estimating ET_p. The Food and Agriculture Organization of The United Nations (Doorenbos and Pruitt, 1974) has analyzed a number of ways of determining potential (and crop) evapotranspiration.

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Subject: THE NEED FOR WATERCOURSE CLEANING AND MAINTENANCE

Trainer Agricultural Engineer
Class Room 6 hours
Field 2 Days

OBJECTIVES

To develop a basic knowledge of the reason for regular cleaning and maintenance of an improved watercourse and the benefits derived.

MATERIALS NEEDED

Transportation to the field and previous watercourse survey and design sheet.

TRAINING AIDS

Charts showing benefits of cleaning and maintenance on delivery efficiency to be shown to farmers. Testimonial from farmers from a neighboring village that have had good success with proper cleaning and maintenance.

INTRODUCTION

After a watercourse has been improved, its delivery efficiency will be at a maximum and will decline with time as silt accumulates and weeds grow up in the watercourse and the banks start to degrade due to unauthorized animal traffic. When the field team organized the farmers to undertake a cleaning and maintenance program, an organization for cleaning and maintenance should have been established. It is not at all unusual for this organization to have lost its effectiveness or to have dissolved due to poor leadership. Therefore, the responsibility of convincing the farmers to undertake a cleaning and maintenance program will usually be your reponsibility.

PRESENTATION

I. Approach to the Farmers

To develop a preliminary understanding of the farmers' system and its need for cleaning and maintenance, the trainees should inspect the watercourse. However, prior to taking this inspection tour, the trainees should identify the village leaders who can organize the cleaning and maintenance of the watercourse. These gentlemen should be contacted, and the trainee should accompany them on an inspection of the watercourse. This should be planned for when the water will be going to fields near the end of the watercourse.

A map of the watercourse,discharge rates of any tubewells,and authorized and actual mogha discharge should be on file at the area OFWM office. This should be obtained and used as needed during the inspection and cleaning and maintenance program.

The tour should begin at the outlet where the canal water enters the watercourse. Information indicated in Table 1 should be obtained along with other relevant facts observed on this tour.

If the flow through the mogha is not obviously free flow, the head loss from the canal to the water level in the watercourse below the mogha should be determined using the plastic tube method. The type of mogha involved should also be determined, which along with the head loss and equations and figures covered previously, will allow the trainee to estimate how much water the farmers are keeping out of their watercourse by allowing the watercourse level to rise to the existing level. The amount of water flowing from the canal (and tubewell, if they contribute) should also be measured.

Table 1. WATERCOURSE INSPECTION TOUR DATA SHEET

1. Names of farmers who take the lead in organizing cleaning and maintenance of the watercourse. a. ________________, b. ____________________,
c. ______________________, d. ____________________.
2. Authorized mogha discharge: ________ liters/second (lps).
3. Designed tubewell discharge: ___________ liters/second.
4. Head loss at mogha: _________ cm.
5. Type of mogha: submerged pipe, orifice, or open flume ________________.
6. Estimate of increased flow that could be achieved by lowering water level in the channel. _____________%
7. Measured flow rate at head of the watercourse. Total _________liters/second. (If desired, mogha flow ________lps, tubewell ________lps.
8. Seepage damage

	Square meters	Owners
a.		
b.		
c.		
d.		
e.		

9. Flow rate at intermediate points: if changes in soil texture or condition of banks indicate differences in loss rates.

	Distance from Mogha (Estimated in Meters)	Flow Rate (lps)
a.		
b.		
c.		

10. Head loss at structures (with estimated flow rates where convenient).

Location	Head Loss (ΔH in cm)	Flow Rate (liters/second)

11. Flow rate at (or near) the field being irrigated ____________lps.
12. Loss Rate _________________liters/second; ______________%
13. Approximate distance from mogha to field ______________meters.
Loss rate _________________liters/second/100 meters.

Observable leakage should be noted on the map and areas damaged by seepage should be estimated. Names of owners of this damaged land[2] should be recorded.

Head losses through existing structures should be determined. Degraded banks caused by animal activity and borrowing of soil for dams at unauthorized locations should be noted and obvious leakage occurring in these reaches should be discussed with farmers.

Deposition of sediment in the channel, depth of the channel and weeds and grasses in the channel should be noted and the farmers should be encouraged to discuss their problems and the frequency and type of cleaning and maintenance that takes place on this watercourse.

The rate at which water is reaching the farmer's field should be measured using orifice plates or flumes in the watercourse near the field nacca. Loss rate should be calculated by subtracting the flow rate through the naccas into the field from the mogha flow (canal into the watercourse), and dividing by the conveyance distance.

As these measurements are being taken, their magnitude and significance should be discussed with the farmers. The primary objective on this inspection tour is to show the farmers the potentials which their watercourse has for cleaning and maintenance and to let them know that OFWM is there to help if they desire the help. A meeting time should be set when the trainees can meet with the villagers and outline the benefits of cleaning and maintenance.

[2]Land damaged by seepage is most commonly found near the head of the watercourse. Farmers with their lands near the head of the watercourse do not receive as much increase in water supply, when a watercourse is cleaned as do farmers in the lower reached. Consequently, these farmers near the head of the watercourse are often the most difficult to convince to cooperate a cleaning and maintenance program. They can often be motivated in terms of eliminating seepage damage.

II. Need for Cleaning and Maintenance

The life of a watercourse after it has been improved will be entirely dependent upon the cleaning and maintenance program that it is subjected to. Some very good examples can be seen in the field where watercourses that have been improved are badly choked with weeds, the banks are overtopping and the cement structures are broken, or stolen, after only a few months due to poor cleaning and maintenance. The long range effect of good vs bad maintenance is demonstrated in Figure 1. If a watercourse is subjected to a poor maintenance program, the water delivery efficiency will decrease rapidly and within two years the delivery efficiency will have decreased dramatically. In contrast to this situation, if a watercourse is subjected to good cleaning and maintenance, the delivery efficiency remains high and most of the increased water supply that resulted from improvement will be retained over the years.

III. The Effect of Water Level Changes and Cleaning and Maintenance on Losses

Digging into watercourse banks will usually expose many rat, snake and ant holes running through the inner banks, especially in the upper banks above where water normally flows. Piles of dirt left by burrowing rats on watercourse banks are further visible evidence of the unseen holes in the banks. When a watercourse is flowing extra full, leakage through these burrows can often be seen, as well as ants scurrying on the surface who have been flooded out of their holes. Also, the silt which deposits on the beds of watercourses and reduces leakage through channel bottoms often does not lay on watercourse banks, especially the upper portions, because of the steep side slopes.

These two factors, the rat and insect holes and a lack of silt deposits, cause leakage into the upper portions of watercourse banks to be much greater

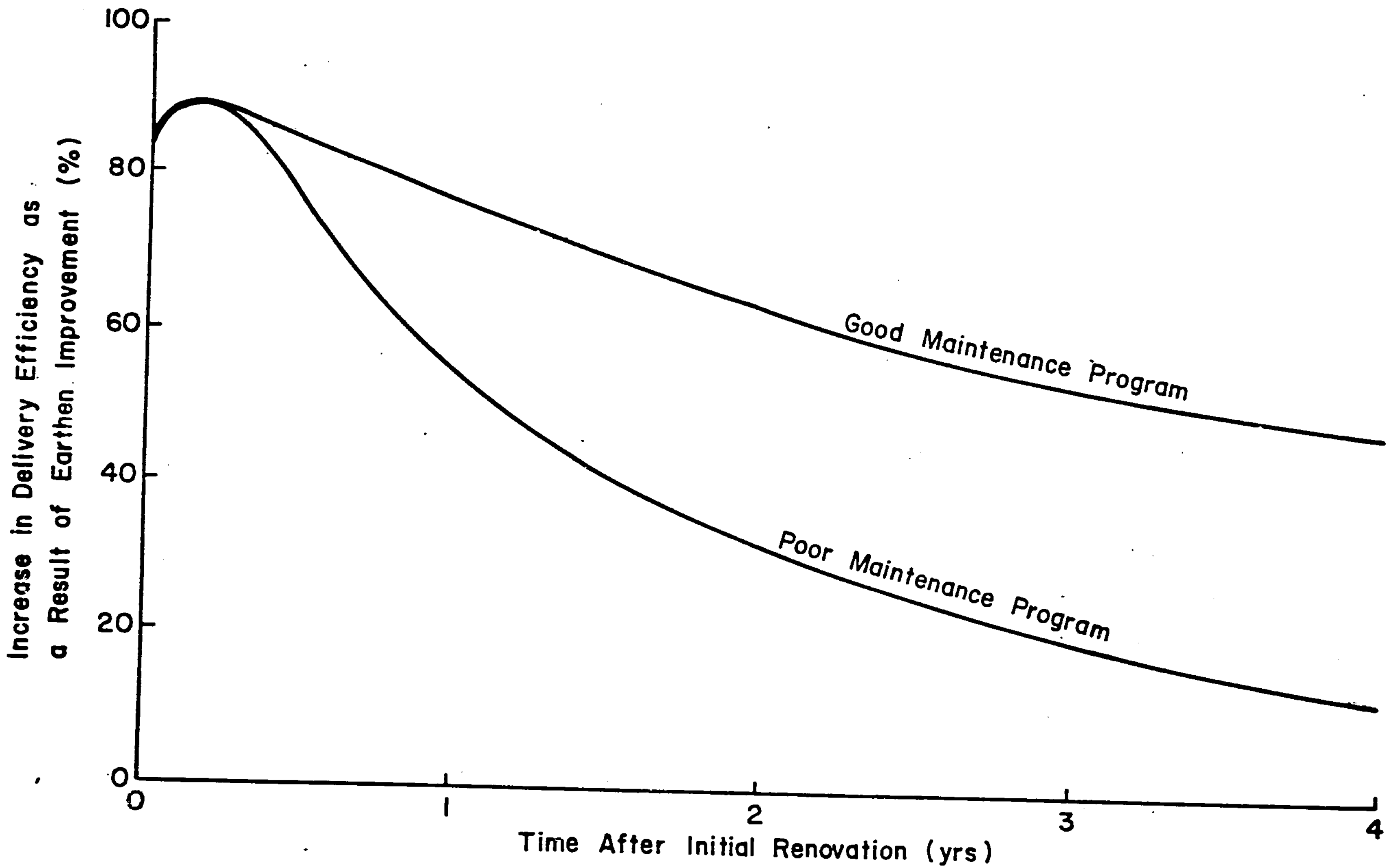


Figure 1. The comparison of good and poor cleaning and maintenance on the delivery efficiency of an improved watercourse.

than leakage into the bed. In fact, water seepage into upper banks has been measured to be 50 to 100 times greater than seepage into the bed (Figure 2).

This high seepage rate causes water loss rates to increase rapidly as the depth of flow in a channel increases. In over 150 watercourses where water losses have been measured by the ponding method, this effect has been seen. When the ponded water level is high, the surface level drops quickly, but when the channel section is only 1/2 or 1/3 full, the remaining water will lie in the section for a long time, sometimes for several days.

Ponding loss measurements have shown that the relationship between water loss rate and water level is as shown in Figure 3. This curve, which gets progressively flatter at higher water depths, can be described by an exponential equation:

$$Q_L = Q_{LO} e^{b \Delta d} \quad (1)$$

where:

Q_L = the water loss rate at a depth Δd above or below the normal water level (lps/100m)

Q_{LO} = the water loss rate at the normal water level (lps/100m)

e = the base of a natural logrithm

b = a number which changes for each watercourse

Δd = the change in water depth above or below the normal depth (cm)

For the 150 watercourses measured, the average value of b was 0.15. This means that the water loss rate increased or decreased by 15% every time the depth increased or decreased by one centimeter, or that the water loss rate will double if the depth increases by 5 cm, and triple if it increases by 8 centimeters. Likewise, a 5 cm drop in the water level should cause losses to decrease by one-half.

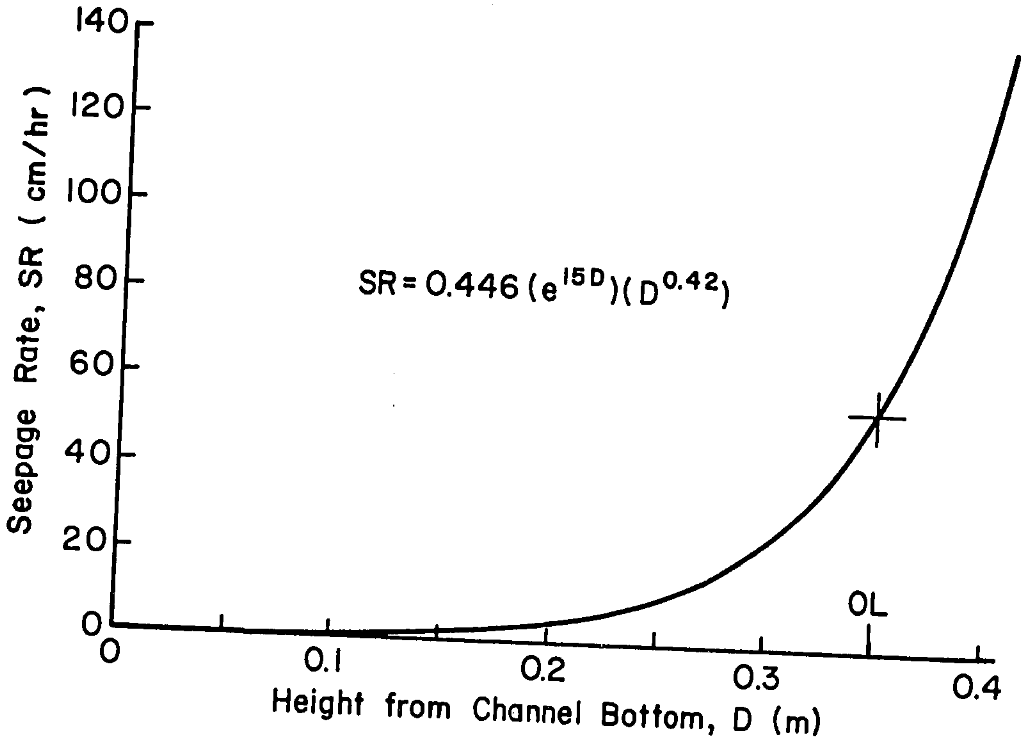


Figure 2. The variability of seepage or infiltration rates of watercourse banks as you move up the bank from the channel bottom.

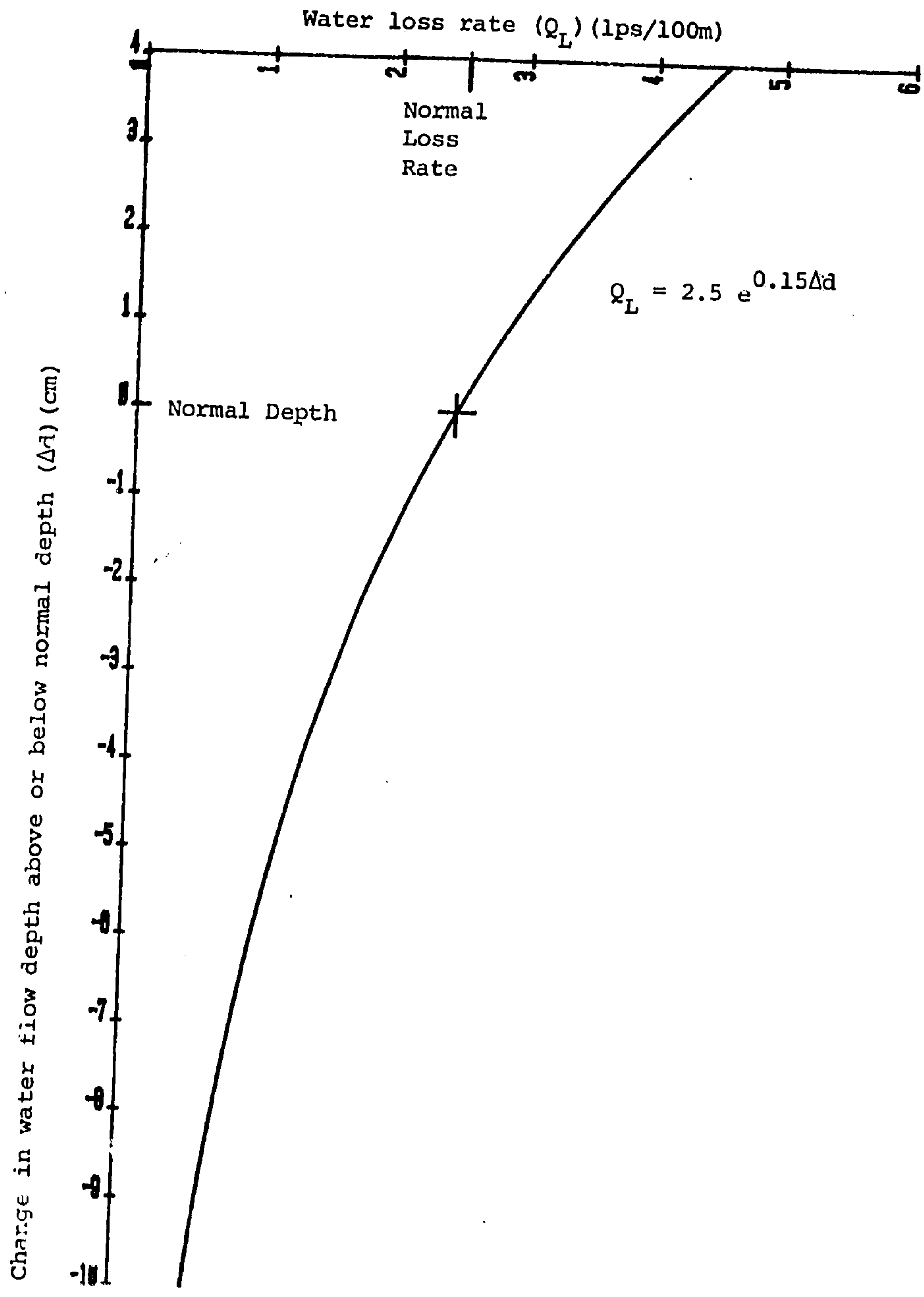


Figure 3. Water loss rate as a function of changing flow depths.

This finding is very important, because it implies that anything which causes the water depth to increase will cause water losses to increase very rapidly. Things which cause water flow depths to increase include:

1. irrigating a high field
2. more water than usual flowing in a watercourse
3. only partially opened naccas
4. logs or buffalo or other things lying in the watercourse blocking the flow
5. a very irregular watercourse
6. excessive silt deposition on a watercourse bed
7. grasses and weeds growing in the watercourse

Of these causes, little can be done about the first one, although leveling the high field can sometimes help. Also, fluctuations in mogha inflows cannot be changed but mixing private tubewell water with the mogha flow causes the depth and losses to increase. The next two causes, 3 and 4, should certainly be remedied by the farmer who is irrigating by keeping his channels free of obstructions.

The last three problems, and especially the last one, that of grasses and weeds growing in the watercourse, are very important. It can be observed that when a watercourse becomes grassy and weedy, the water flows more slowly. If water flows more slowly, to carry the same amount of water, a channel must flow with a larger cross sectional area or at a deeper depth. The only other alternative is that the mogha has been submerged and less water is entering the watercourse.

Manning's Equation can be used to predict the depth of flow in a channel if the cross sectional shape, inflow, slope, and roughness of the bed and banks are known. The roughness coefficient of watercourses vary depending upon the uniformity, the amount and length of grasses, and the amount and size of regular and anchored floating aquatic weeds. For Pakistan watercourses, measured values of Manning's roughness coefficient is given in Table 1.

TABLE 1. Values of Manning's roughness coefficient for Pakistan watercourses.

Description of Vegetation in the Watercourse	Roughness Coefficient
Clean, no vegetation, uniform	.025
Clean, no vegetation, irregular and winding	.030
Short grasses	.035
Medium grasses	.045
Long thick grasses	.055
Long thick grasses with extensive aquatic weeds	.100

The affect of changing roughness coefficients, or vegetation, on flow depths is shown in Figure 4 for a typical watercourse channel cross section. The figure shows cases where the depth change is relatively large, moderate, and relatively small. Most real cases will fall between the outside lines. The figure indicates that flow depth will increase about 5 to 14 cm in a channel with moderate grasses, or conversely, that by cleaning a watercourse with long grasses, the water surface level will drop from 7 to 20 cm.

As was said before, if the flow depth increases by only 5 cm, the loss rate will double. By combining the results of Figures 3 and 4, the relationship between changes in channel roughness and losses can be determined. This is shown in Figure 5. The great importance of vegetation and cleaning and maintenance on water losses is shown by the graph, which indicates that even minor vegetation can cause water losses to double.

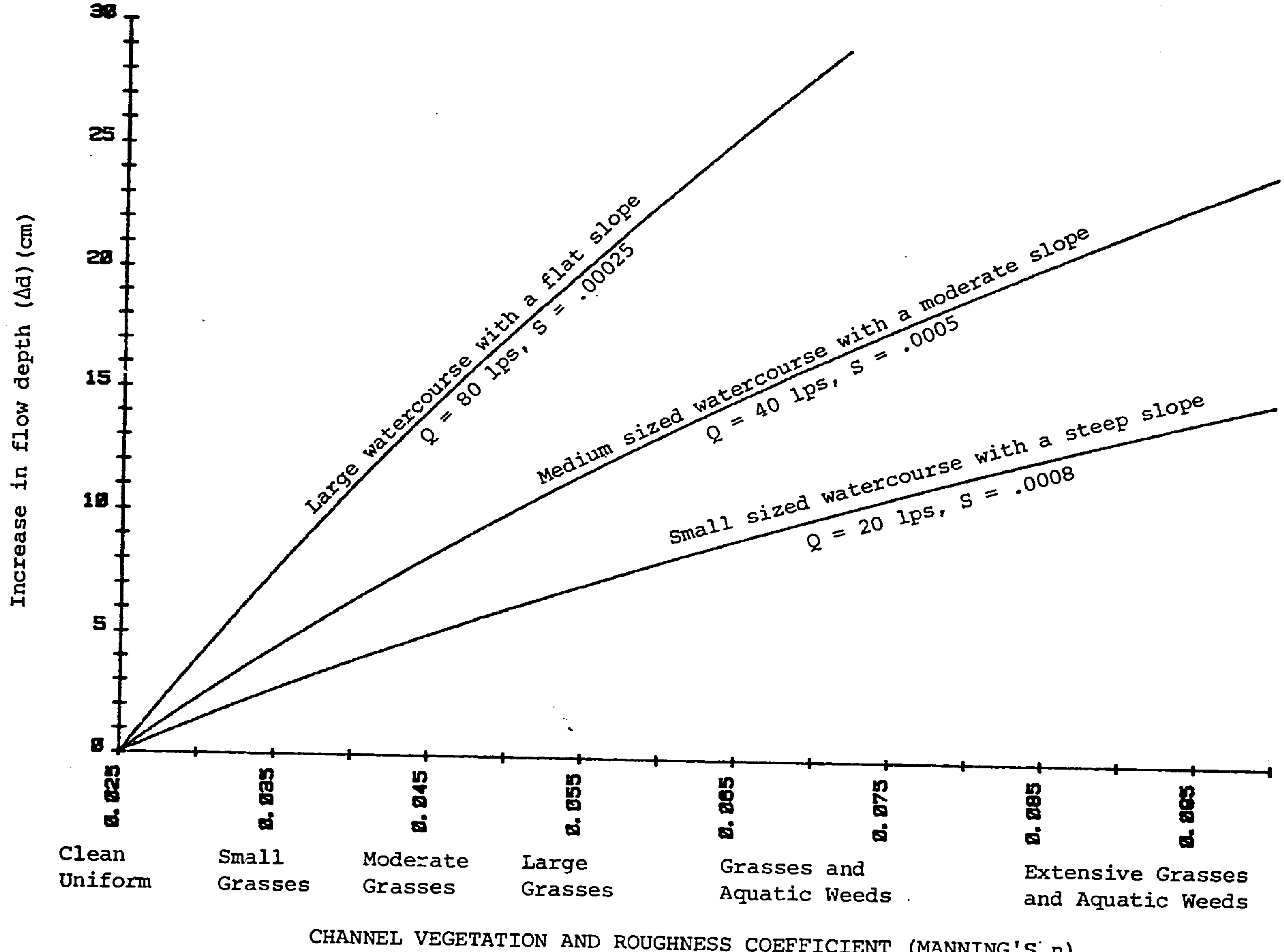
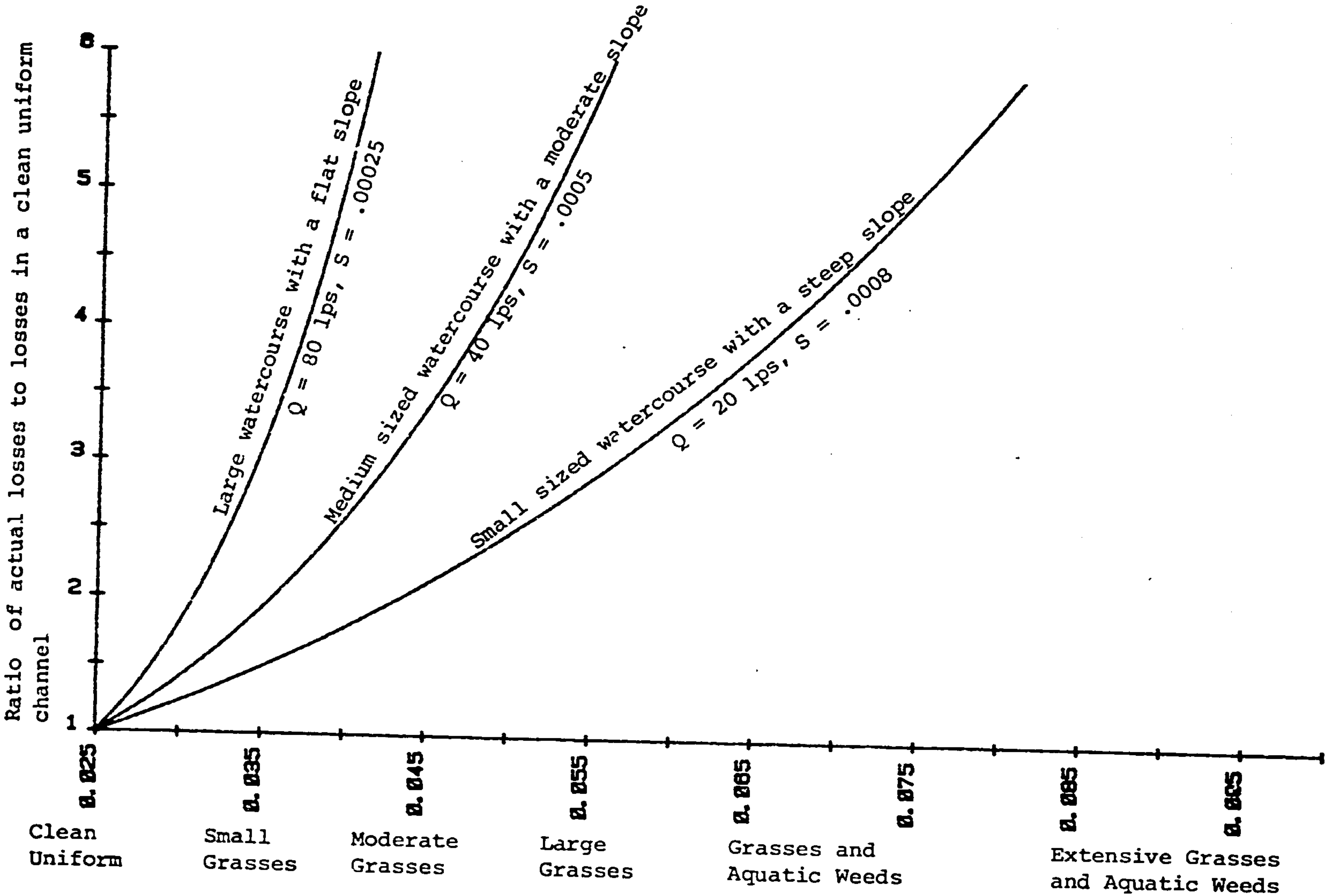


Figure 4. Affect of vegetation and roughness coefficient on flow depths in watercourses.



CHANNEL VEGETATION AND ROUGHNESS COEFFICIENTS (MANNING's n)

Figure 5. Affect of vegetation and roughness coefficient on watercourse losses.

A water loss study was conducted on six sections of two watercourses before and after complete cleaning of the vegetation. Cross sections of one of the channels before and after cleaning (Figure 6) shows that cleaning caused the water flow depth to decrease by 10 cm. Although the seepage rates into the bed and banks tended to increase slightly after cleaning, as indicated by Figure 7, probably due to the removal of the silt, the loss rates at the new lower water surface levels were greatly reduced. Table 2 lists the measured loss rates in all six sections before and after cleaning the vegetation.

TABLE 2. Watercourse Loss Rates at Full Supply Operating Level as Affected by Cleaning.

	Branch I, T.W. 78 (Previously improved)		Private Branch, T.W. 56	
Sect. #	Before Cleaning	After Cleaning	Before Cleaning	After Cleaning
1	3.4 liters/sec/100m	0.65	3.6	1.10
2	2.7 liters/sec/100m	0.50	3.5	1.55
3	1.2 liters/sec/100m	0.37	5.7	0.50
Average	2.4	0.51	4.3	1.05

The measured data supports the predicted results of Figure 5, by indicating that the uncleaned channels had loss rates 4 to 5 times greater than loss rates in the same sections after cleaning.

Figure 8 shows how water losses might vary on a watercourse with three different cleaning schedules. The first assumes watercourse cleaning twice a year, the second, cleaning four times each year and the third cleaning each month. In the example, Schedule 1, cleaning twice a year, results in about three times as much water loss as cleaning monthly, while cleaning four times

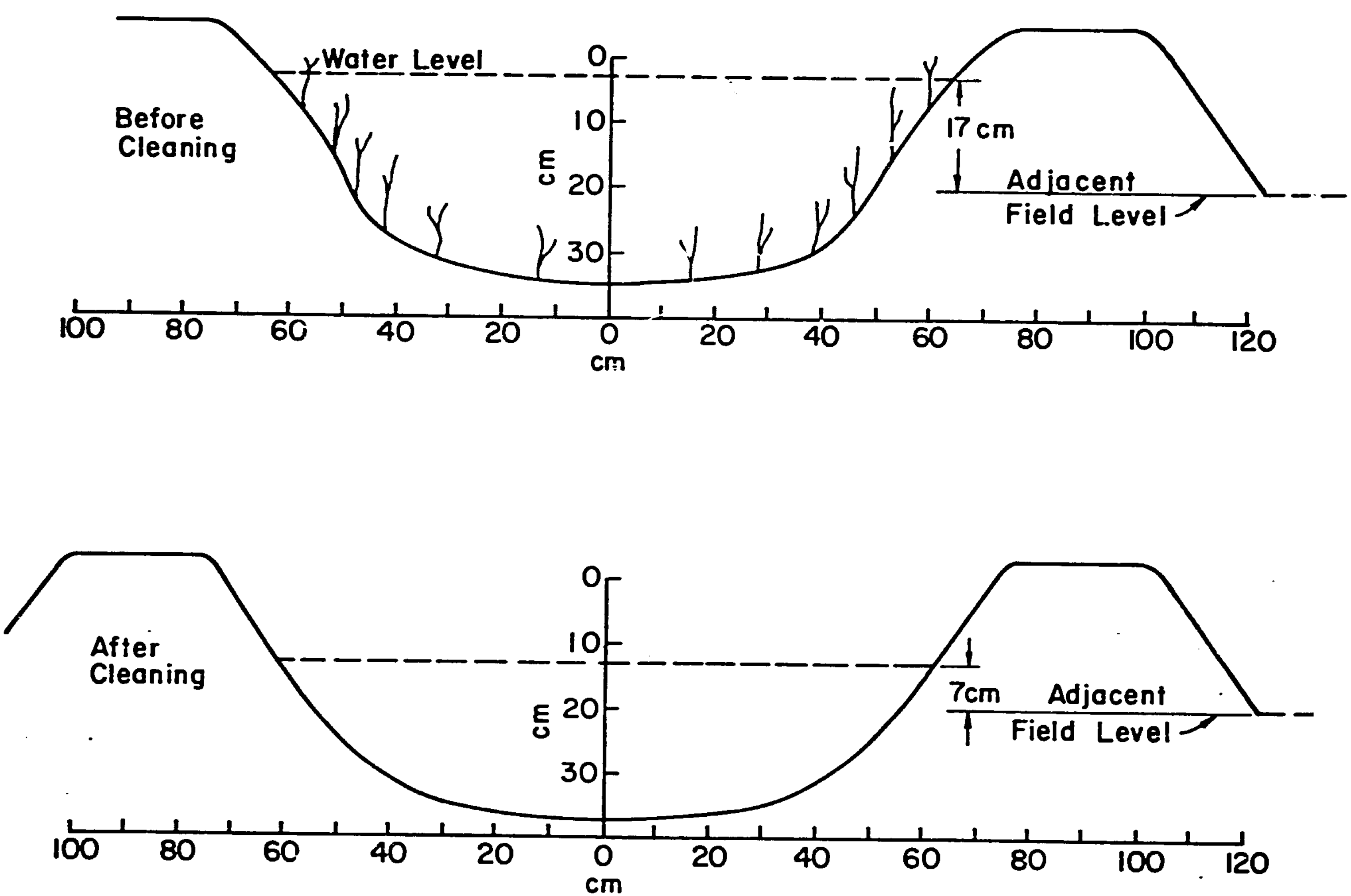


Figure 6. Average conditions at Tubewell 78 Watercourse before and after cleaning.

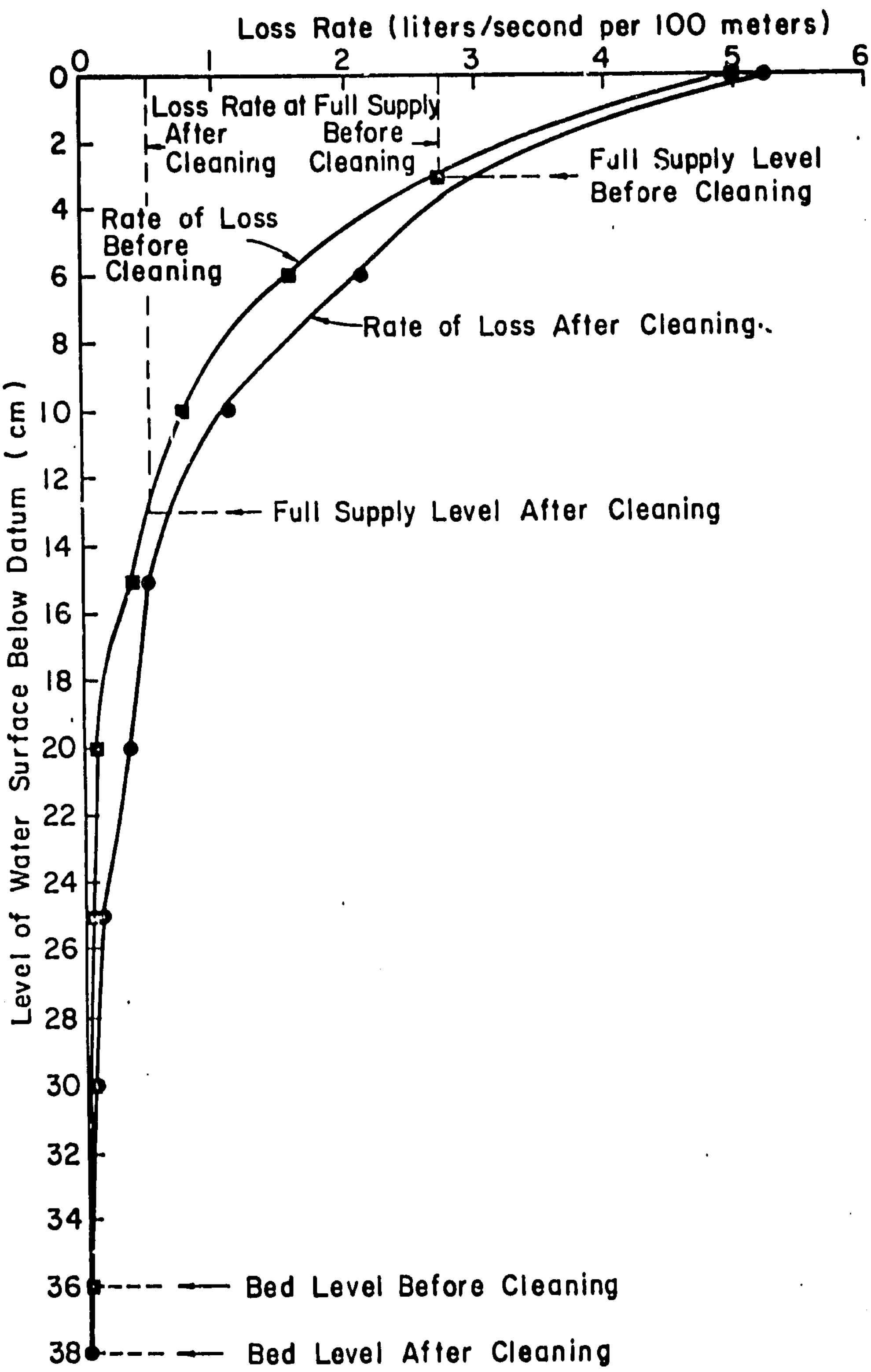


Figure 7. Water surface elevations and loss rates on Section No. 2 (Tubewell 78) before and after cleaning.

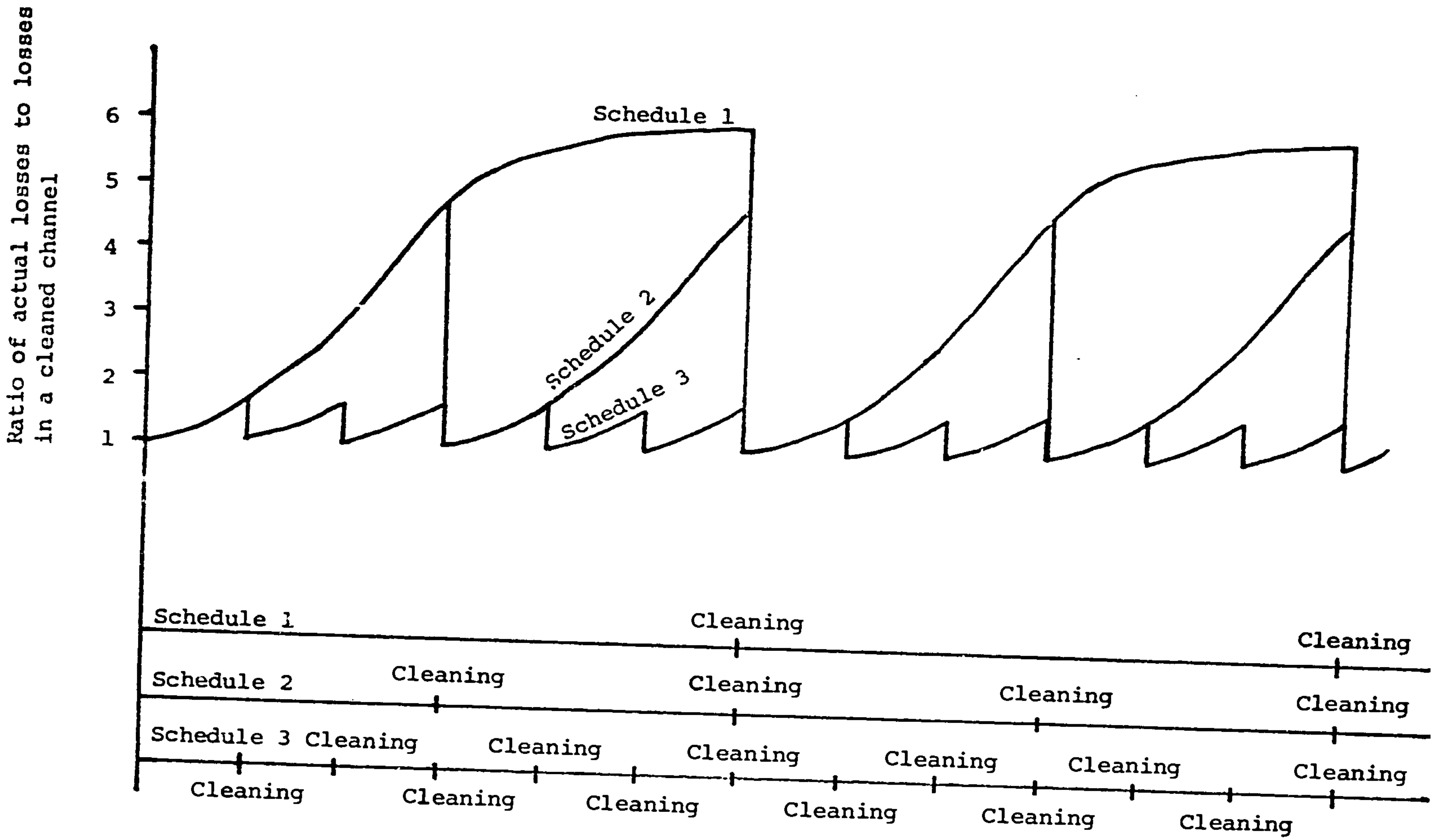


Figure 8. Water loss rates as a ratio of loss rates in a clean watercourse for three cleaning schedules.

a year results in double the losses experienced with monthly cleaning. According to the estimates farmers on the watercourse which clean twice a year and lose 50% of their water, could deliver 40% more water to their fields if they would clean their channels twice as often and 70% more with monthly cleaning.

When to clean a watercourse depends upon the value of or demand for the water, the amount of vegetation in the channels, the amount of water losses, and how many hours the section is used each week. Main channels generally should be cleaned whenever the grasses get more than 4 or 5 cm long. Seldom used branches need not be cleaned so often, perhaps twice each season. All channels should be cleaned before periods of water shortage.

The projected loss of inflow per year above that of a permanently cleaned watercourse is shown in Figure 9 as a function of the above three cleaning and maintenance schedules. Under schedule 3, very little extra loss occurs over the years (less than 3%) while with schedule 1 about 22% more loss will occur as compared to a permanently clean watercourse. This very vividly points out the benefits of a regular, timely cleaning and maintenance program.

One method of monitoring a watercourse for needed cleaning is to install a permament staff gauge in the main sections. The gauge, an example of which is shown in Figure 10, should have three sections. The first section, about 5 cm in width indicates the safe operating depth. The second, also about 5 cm in width, indicates a caution depth when water losses are beginning to increase rapidly. The farmers should clean their watercourse when the water level is in the "caution" section of the gauge. If the water level reaches the third section, the water losses are very high and the channels should be cleaned immediately. Changes in flow rates also affect flow depths, so the gauge should always be checked when the mogha and/or tubewell is flowing naturally.

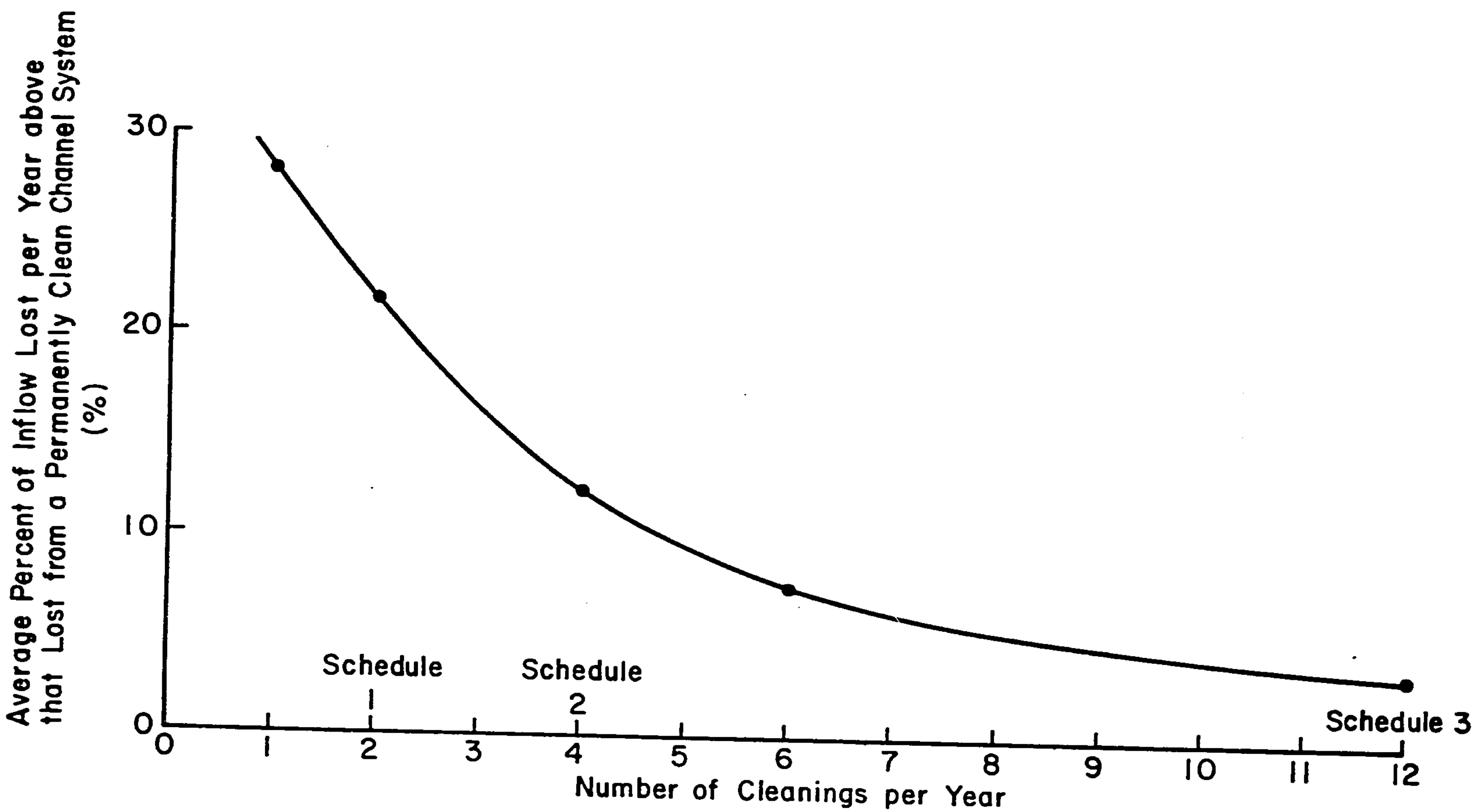


Figure 9. The projected loss of inflow in a watercourse over the years, as compared to a permanently cleaned watercourse, as influenced by the cleaning and maintenance schedules that are presented in Figure 8.

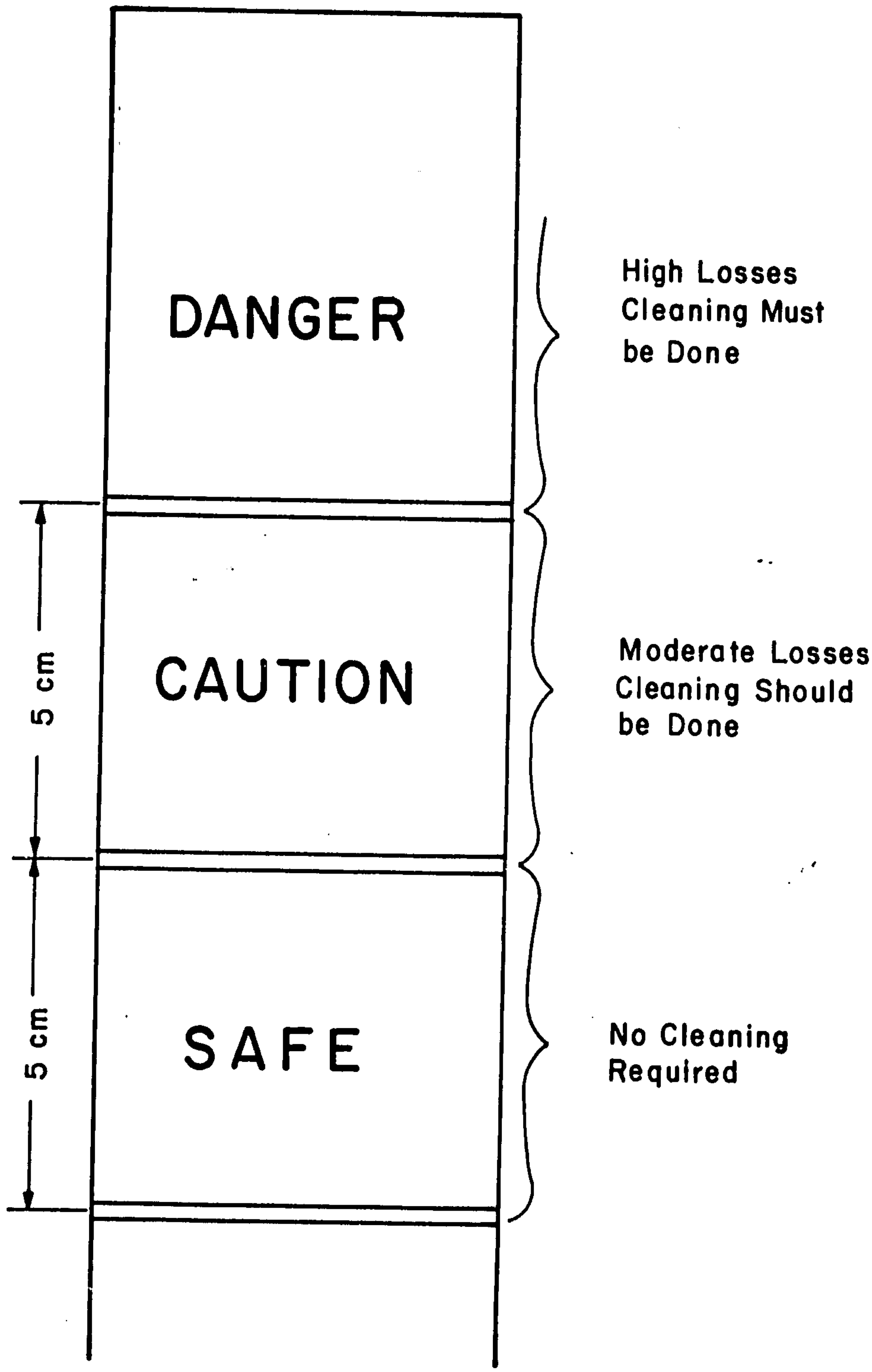


Figure 10. Staff Gauge for Monitoring Increases in Water Surface Levels and Subsequent Required Cleaning and Maintenance.

The gauges should be installed in the watercourse after a complete and thorough cleaning and maintenance has taken place and with the water flowing normally to a field at least 500 meters downstream. The bottom of the "safe" section of the gauge should be installed at the water surface level.

Instruct the farmers that when the water level is in the second "caution" section, they could save 50% of their water losses by cleaning the channels and when the water level reaches the third "danger" section, their losses of water are at least four times higher than they should be.

IV. Techniques of Cleaning and Maintenance

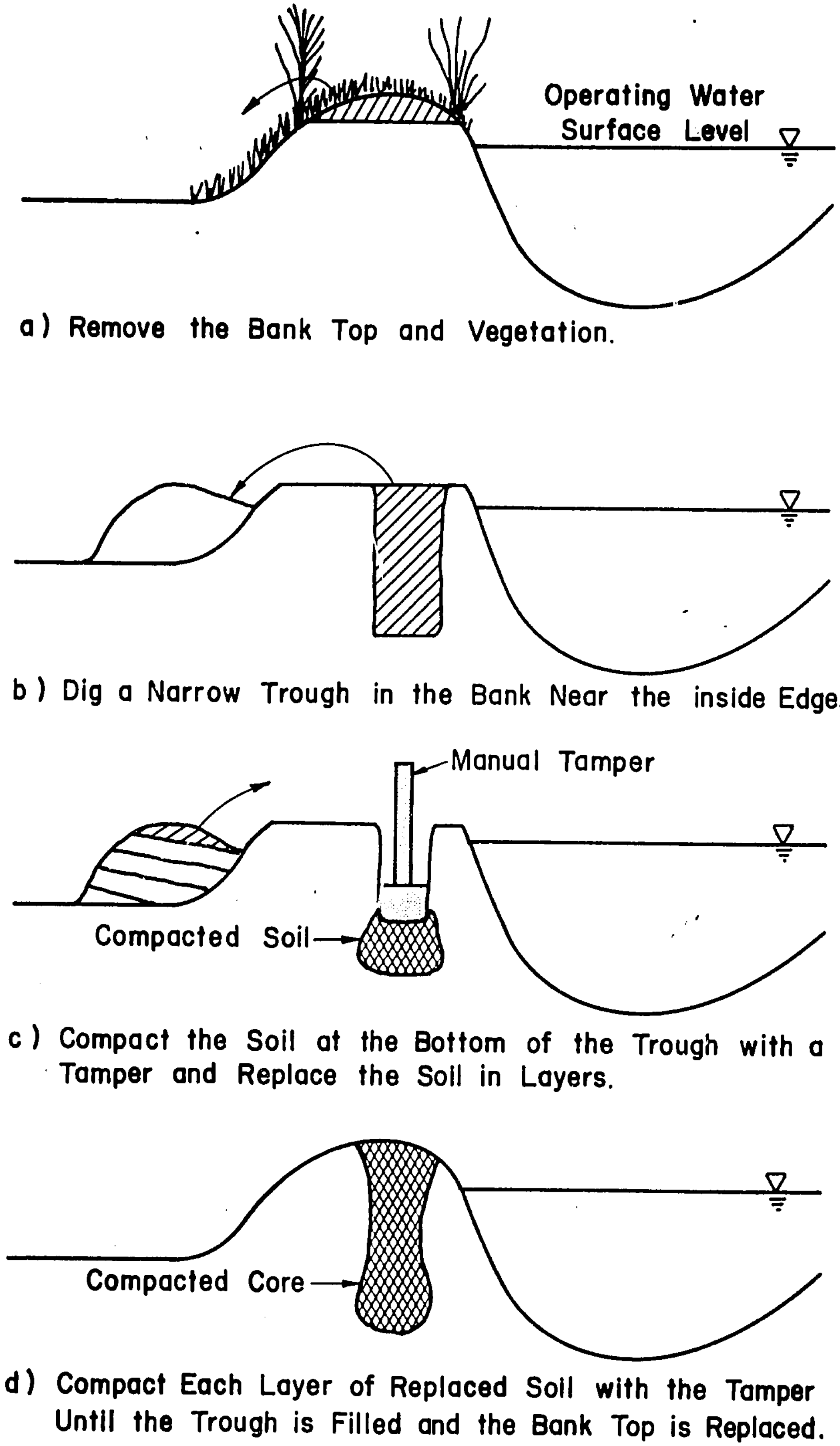
The techniques involved in the proper cleaning and maintenance are not much different than those presently used by farmers. The main difference is the degree to which the cleaning and maintenance is accomplished. Farmers have to be encouraged to clean the watercourse adequately. Some of the points of particular importance are listed below:

A. Removal of vegetation

Since chemical weed killers are not available to the average farmer, the only other method of removing the vegetation from the bottom and banks of the watercourse is with the kussey. Enough soil should also be removed so that the weeds are cut below the crown so they don't regrow. Care should be taken so the original cross section of the watercourse isn't altered.

B. Plug holes

Rats, insects, etc. will burrow into the banks and cause leakage. These holes should be completely plugged by compaction or by tearing down the old bank and rebuilding. Core compaction (Figure 11) will help in retarding insect and rat activity. Plugging the holes from the outside of the bank will not last long. The hole channel must be completely destroyed.



a) Remove the Bank Top and Vegetation.

b) Dig a Narrow Trough in the Bank Near the inside Edge.

c) Compact the Soil at the Bottom of the Trough with a Tamper and Replace the Soil in Layers.

d) Compact Each Layer of Replaced Soil with the Tamper Until the Trough is Filled and the Bank Top is Replaced.

Figure 11. The procedure used to compact a core in the watercourse bank.

C. Strengthening and Raising Banks

If seepage is occurring along the watercourse it is either due to insect or rat holes or seepage through the banks because they are too thin. Thin banks should be strengthened. This can be done by using the silt that is removed from the watercourse during cleaning or, if this isn't enough, soil will have to be brought in from the surrounding area.

If overtopping has occurred during irrigation or more freeboard is needed, the banks should be raised during cleaning and maintenance. Adequate freeboard must be maintained in order that the banks will hold up under foot traffic, if the watercourse is used as a pathway.

D. Junctions and Structures

If the farmers have been using their concrete nakkas properly, no soil borrowing and erosion should have occurred at the junctions. If it is evident that the farmers have been using mud dams or have been borrowing soil from the banks at the junctions, the reason must be determined. The farmer should be convinced to use the nakka properly.

Any broken structures, i.e. culverts, checks, nakka lids, etc., should be repaired or replaced. The OFWM field team will assist the farmers in acquiring the replacement. Generally, the farmers will have to purchase any replacements. Details on this can be worked out with OFWM.

APPLICATION

During the two days in the field, the trainees should learn how to approach the farmers to organize a cleaning and maintenance program, what to look for while walking the watercourse with the farmers and how to convince them to undertake a cleaning and maintenance program. When the trainees commit themselves to the farmers to help them perform a cleaning and maintenance program, they must carry through with the committment. This cleaning and maintenance is to be accomplished during the 6 day lesson block entitled, "Implementation of a Cleaning and Maintenance Program on an Improved Watercourse." The Irrigation and Drainage Dept. is to have the major responsibility but Agricultural Extension and Rural Sociology Depts. should participate. The trainers from these two departments should also accompany the trainees during the 2 days in the field in this training exercise.

QUESTIONS

1. What is the key to the life of an improved watercourse?
2. How often should a watercourse be cleaned and maintained?
3. What is the rate of seepage into the upper parts of the banks of a watercourse as compared to the bed?

Subject: CONVINCING FARMERS TO UNDERTAKE A WATERCOURSE CLEANING AND MAINTENANCE PROGRAM AND TO USE THE INCREASED WATER SUPPLY

Trainer Agricultural Extension
Class Room 4 hours
Field 1 Days

OBJECTIVES

1 - To develop confidence in the trainees in convincing farmers to undertake watercourse cleaning and maintenance programs.

2 - To provide the trainees with the basic training, and experience which will enable him to assist the farmer in using the increased water supply more efficiently.

MATERIALS NEEDED

Graph paper, Cutthroat flume or orifice plates, meter tape, plastic tube for measuring head loss and centimeter scale.

TRAINING AIDS

1 - Data from previously evaluated watercourses before and after improvement.

2 - "Watercourse Improvement" that is attached to this lesson plan.

3 - Flip charts for use in farmers meetings.

INTRODUCTION

In any extension endeavor, the first consideration is to know where farmers are in relation to the problem. An inquiry about the following aspects can help in gaining some insight about the cleaning and maintenance program that exists and how farmers view their relationship and responsibility to cleaning and maintenance.

1. Existing arrangements of cleaning and maintenance.
2. Awareness of the farmers about the importance of this job.
3. Attitude of the farmers.
4. Appraisal of the difficulties for not having satisfactory arrangements for cleaning and maintenance.

The farmers view of what they can do with more water is also important. An assessment of their views of irrigation problems should also be made.

PRESENTATION

The thought process that a farmer goes through when he realizes he doesn't have enough water to meet his needs and the Agricultural Officer's (Extension Agent) role is depicted in the attached publication "Watercourse Improvement". Although this depicts the improvement program, the function of an agent in cleaning and maintenance is very similar. As can be seen, the Extension Agent can play a major part in helping the farmer realize what his problem is and how to correct it.

The process and techniques involved in making a tour of the watercourse, measurements and demonstrating the need for cleaning and maintenance has been discussed at length in the Irrigation and Drainage Department lesson. "The need for watercourse cleaning and maintenance" and does not have to be discussed again. This lesson will be mainly devoted to the trainee's contact with farmers to convince them of the benefit and need of cleaning and properly maintaining their watercourse and what they can do to improve their irrigation practices efficiency.

1. Water Users Meeting

A. Farmers Meeting

When the leading farmers have taken the initiative and set the appointed time and place for the meeting, the agent must be sure to be at the appointed place at the appointed time. Quite often, not all of the farmers will be there when the meeting begins. If this is the case, the extra time can be utilized by the agent to explain benefits of cleaning and maintenance programs on other watercourses to the farmers who are present.

When the word spreads that the agent is present and that he has things of general interest to show, more of the farmers will assemble. When representatives of most of the families are there, the agent should begin the presentation of those items that all farmers should be informed of.

Presentations should include flip-chart pictures and illustrations which can be seen clearly from a distance of ten to fifteen feet.

The objective of this presentation and of the visual aids should be:

1. to inform the farmers about the rates of loss from their watercourse.
2. to let them know that similar losses have been experienced by other farmers.
3. to show them that in cases where these other farmers have conducted a good cleaning and maintenance program, they have appreciably increased their water supply.

B. Diagnosing Watercourse Problems with the Farmers

The agent will construct a graph on a large piece of paper on which the ordinate (vertical axis) will show the acres of land irrigated per hour and the abscissa (horizontal axis) will indicate the distance of the fields being irrigated from the mogha. . .as indicated in Figure 1.

Each of the farmers, in turn, should indicate the distance of their fields from the mogha and the amount of land they are able to irrigate per hour. . .during regular irrigation turns (irrigations other than the first irrigation following a cultivation).

This will normally develop the type of figure indicated in Figure 1, in which the number of acres irrigated per hour decreases as the farmer is more

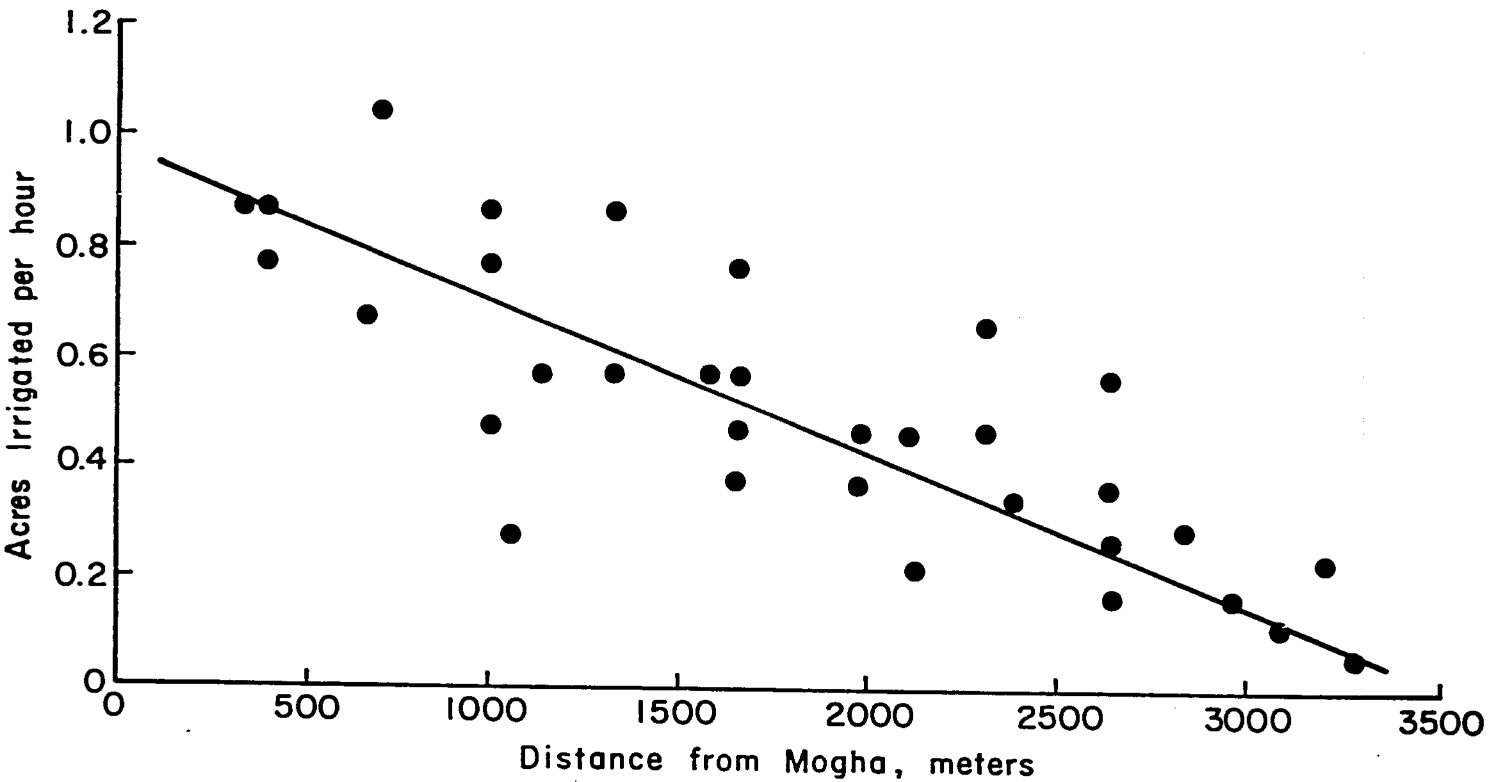


Figure 1. Area Irrigated/Hour as a Function of Distance from the Mogha on a Poorly Cleaned and Maintained Watercourse.

distant from the mogha. There will be a great deal of scatter due to other factors, but an estimate of the effect of distance from the mogha on losses from the watercourse can generally be obtained from the best fit line drawn through these data points. The best fit line should be used along with the estimates of loss taken along the watercourse to estimate how much water is being lost. A graph from the results of another watercourse that has been properly cleaned and maintained should be shown (Fig. 2). The dashed line shows how much improvement in acres irrigated per hour was achieved by cleaning and maintenance. This should convince the farmers of the benefits of cleaning and maintenance.

The approximate number of man-hours needed to properly clean and maintain the watercourse in a manner which will allow it to provide efficient water delivery should be estimated. . .and understood by the farmers. The investment of time and the organization needed to assure an adequate cleaning and maintenance program should be discussed with them in detail. If the farmers do not wish to organize for this purpose or to commit themselves to provide the needed man power, the agent should excuse himself from their meeting with the explanation that other farmers need his assistance. Cooperative farmers should be provided copies of the data from their watercourse. These farmers should be assured that should they wish to proceed with their program, as planned, he will be glad to arrange another appointment and to help them proceed. He is ready, then, to begin a preliminary assessment on another watercourse.

C. Performance of a Cleaning and Maintenance Program

This subject has been discussed at considerable length by the Irrigation and Drainage Department trainers and needs not be considered here. The trainees are well versed in the techniques involved.

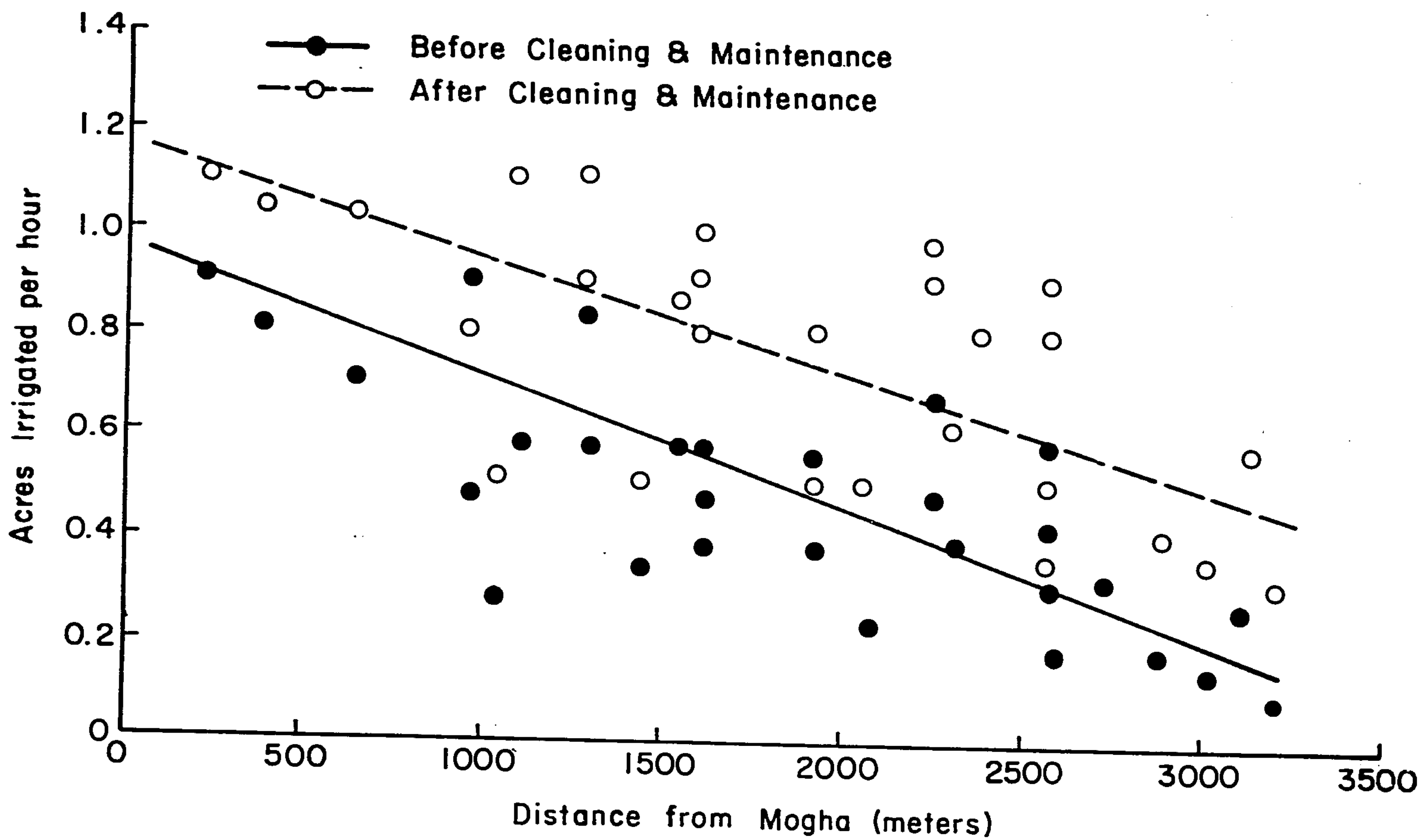


Figure 2. Comparison of Acres Irrigated Before and After Cleaning and Maintenance.

D. Meeting to Review Improvement and Identify Farmers with the Most Potential for Irrigation Efficiency Improvement.

After the farmers have had the chance to irrigate their fields again following the cleaning and maintenance operation, the agent should hold another meeting with the assembled farmers to assess the results of their efforts.

Before he holds such a meeting, he should have walked the watercourse with the farm leaders and made the measurements of inflow and outflow which will allow him to estimate the water delivery efficiency.

1. Evaluation of cleaning and maintenance program.

One of the first agenda items of this meeting should be to construct the new relationship of the amount of land (acres or killas) irrigated per hour and the correlation of that figure with distance from the mogha as was done in Figure 2. This should be compared with the relationship which existed prior to the cleaning and maintenance program. The estimate of average improvements should be discussed with the farmers and they should be complimented for their foresight in implementing the program and for their energy in carrying it out. Use of the increased water supply should be discussed in terms of additional acres to be irrigated, potential increases in crop production, cost of equivalent alternative supplies such as wells, etc.

2. Identify farmers with the most potential for improving their irrigation efficiency.

Those fields in which the number of acres irrigated per hour is appreciably below average should be identified. The agent should let the farmers know that he is interested and available to help farmers with problem fields, assist in diagnosing problems, and help develop solutions for them. As he addresses all of the farmers, he should describe diagnostic techniques which are available to them, the causes of their problems, as he sees them, and some of the general solutions which, when applied, will result in better irrigation efficiency. He should allow the discussion to continue while he singles out those individuals who own the fields which have been indicated to offer the greatest potential for improvement. Next, he must determine whether or not those farmers wish to work with him in diagnosing and developing solutions for the specific problems which the fields represent.

Since the diagnosis is much more effectively done when the water is flowing to the fields, appointments should be made with these farmers to join them in their diagnostic efforts when they will be irrigating the selected fields. The agent should try to respond to all of the farmers who make requests, but if that number is too large, he should give priority attention to the first five or six farmers who apply. Others should be invited to join in the diagnostic sessions with the advisor and any of their neighbors whose fields are included and whose problems and solutions are similar to those on their own fields.

3. Field diagnoses of irrigation efficiency problems with farmers.

1. The farmer should be asked to state the problems which he perceives in the irrigation of his field. (Is it not level? Is it high so that the water level in the watercourse must be raised? Etc.) Particular attention should be paid to the farmer's leads.

2. Measurements. In general, the following measurements should be taken. The attached "Information Sheet for the Farmer's System" (Table 1) indicates a set of information which should generally be obtained. However, other special problems should also be evaluated. Those which seem to present the greatest limitation to water management efficiency should be noted.

Table 1. INFORMATION SHEET FOR FARMERS SYSTEM

1. Farmers name: ______________________. Village ____________
2. Legal description of field. Square No. __________ Acre No. ________
3. Size of field ______m long _____m wide. Area ______m, _______ acres.
4. Approximate distance from ____outlet (mogha) ______m, _________ feet.
5. Distance from sarkari khal (length of farmers branch _______m, ___feet.
6. Problem perceived by farmer: ______________________________
____
____
7. If the farmer believes unlevelness of land is a problem and there is a crop on the field, stand counts should be made on areas which the farmer believes to be the highest, lowest, and average elevations within the field. Then stake the field and use the procedure indicated in HB 10 to determine elevations, estimate earth moving needed and estimate water that could be saved, etc. If the farmer does not believe that unlevelness of his basin is a problem, check water depth at lowest point in the field following irrigation. ________cm
8. Farmers estimate of how long it takes to irrigate this field. ________ minutes.
9. Time when irrigation turn begins. _______Time when irrigation turn ends. _______ Time when water reaches the field. ________ Time when outlet is closed _______ Actual irrigation time __________ minutes.
10. Infiltration rate (ponding and recession measurements) in field.

Time	Water Level	Time	Water Level	Time	Water Level

11. Inlet and associated data as follows:

	After 10 min.	Near end of Irrigation
Width of inlet (toke)	________cm	________cm
Water depth in field near inlet	________cm	________cm
Headloss through inlet (toke)=H	________cm	________cm
Flow rate near the inlet to field	________lps	________lps

Table 1 (continued)

12. Width of watercourse __________cm and depths at: midpoint ______cm, and halfway to the left bank _______cm, and right bank _________cm.

13. Head loss in farmers channel = ΔH_h______+ ΔH_{f-} _______ + ΔH_1________ + ΔH_2______ + ΔH_3_______, etc.

    a. Operational level - static ponded level at top of farmers branch = ΔH_h = _______cm.

    b. Operational level - static ponded level near outlet into field = ΔH_f = ________cm.

14. Farmer estimate of irrigation frequency during crop season. Number of irrigations.____________ Approximate duration of each. ____________

15. Farmers estimate of whether current flow rate is less or more than the average and if so, how much less _________% or more __________%.

16. Watercourse losses in sections suspected of high losses (ponding and recession). Distance of section head from the sarkari khal _______m. Length of section ______m. Height of initial reading above observed operational level _________cm.

Time	Level (cm)*	Width	Time	Level (cm)*	Width	Time	Level (cm)*	Width

17. Head differences between these successive basins which are the differences ΔH_1_____, ΔH_2 _______, ΔH_3________, ΔH_4__________, etc. across the dams built in the channel. These head differences should be measured at the same time that ΔH_h and ΔH_f are measured, when forward movement of the water has ceased. See HB 11 for further details.

*Elevation with respect to observed operational level.

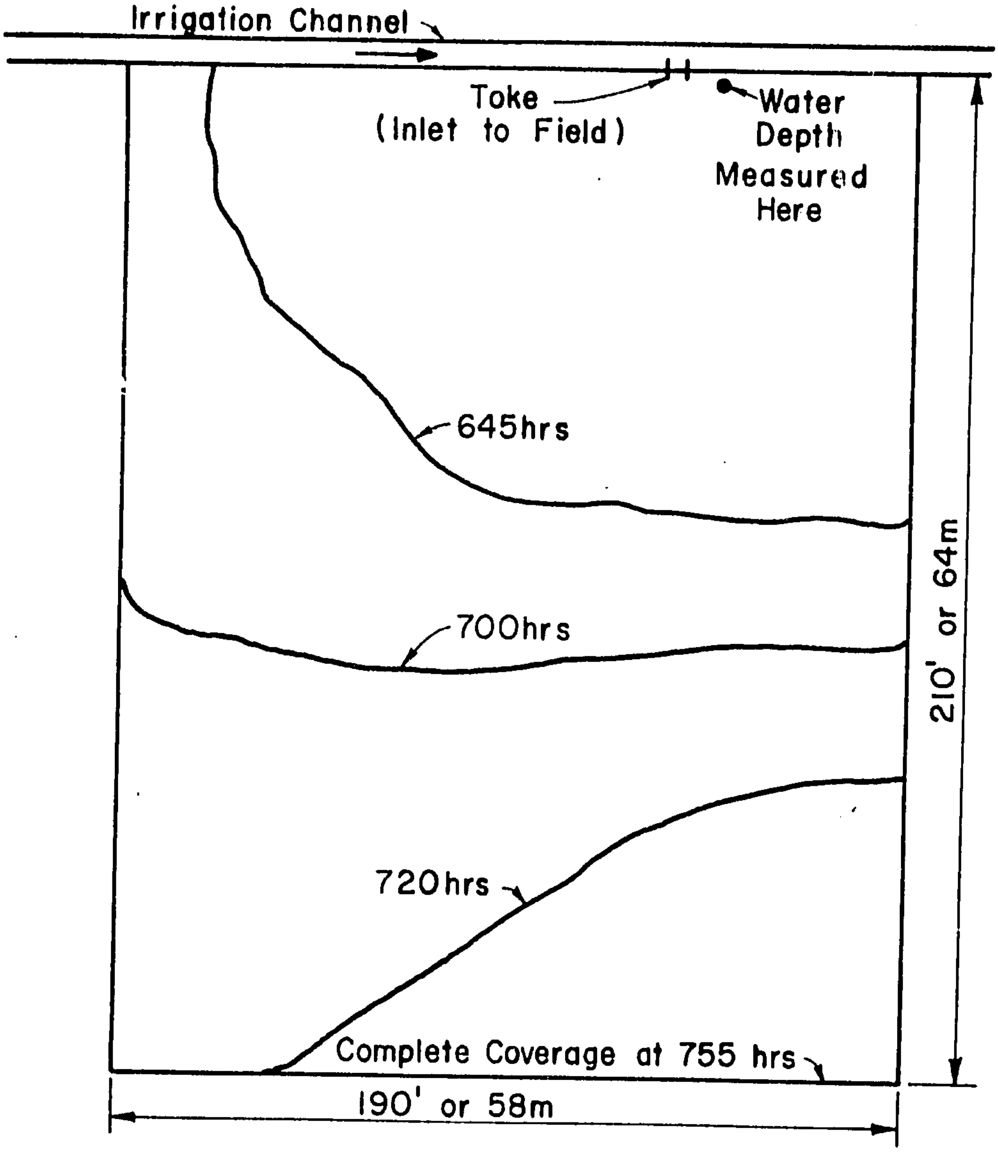
Cross-sectional areas of flow should be measured in at least two apparently representative sections of the farmer's branch channel. When the farmer has irrigated the field to his satisfaction, have him close the inlet to the field, allow the watercourse to fill about 3 cm above operational level and then build dams across the watercourse enclosing the sections in which measures of loss rates are desired. Determine and record recession rates widths and loss rates in these sections. Determine head loss along the farmers branch by measuring the elevation differences between the operating levels and the ponding levels at the top and bottom ends of the farmer's branch (i.e., ΔH_h and ΔH_f). If dams have been formed between these ends, the elevation difference across each of these dams must be measured and added to ΔH_h and ΔH_f to obtain the total head loss along the farmers branch.

The size of the field should be determined and the field should be mapped on a sheet of notebook size graph paper as indicated in Figure 3. Size and location of tokes and any cross bunds or partial bunds should be indicated.

Time for the coverage of the field should be recorded and the pattern of coverage should be sketched at about 1/4, 1/2, and 3/4 coverage.

If the farmer believes that unlevelness is his problem, use stakes in the field to determine the water depth at the end of his irrigation turn. The time the farmer begins to use the water, time required to fill the watercourse section leading to the fields and the time at which the water is diverted to another field. Water recession rates in the whole field or in small bunded portions thereof. Water depth in the field near the inlet and head loss through the inlet (toke), and across other structures that may exist in the farmer's branch channel.

Toke Opened at 625 hrs	Time 630 hrs	750 hrs
Width of Inlet (Toke)	60 cm	72 cm
Head Loss through Toke	9 cm	4 cm
Depth of Water Near Toke	2 cm	10 cm



Area = 190 × 210 = 39,900 square feet
= 58 × 64 = 3,712 square meters

Figure 3. Field Dimensions and Inlet Data

The rate of flow in a section of the watercourse near the toke should be measured (using orifices, if possible). Operating levels in the sarkari khal near the head of the farmer's branch and near where the farmer's branch is supplying water to the field should be determined and marked by stakes set firmly into the side of the watercourse for later reference in determining the head loss in this watercourse. Operating levels at midpoints of sections suspected of high leakage should be similarly marked to be used as datum levels for ponding and recession measurements.

Observable leaks should be pointed out to the farmer and if there is time the rate of water loss from these leaks should be measured.

3. Analysis. Head loss and water loss in watercourses and potential for their reduction. Cleaning can reduce the roughness coefficient to decrease head loss and reduce the water level in the watercourse. Compute the average slope of the watercourse. Using this slope, the cross-sectional area and the flow rate of water in the watercourse, and assuming that a good cleaning job could reduce the roughness coefficient to less than 0.04, evaluate the reductions in head loss, operating water levels and water loss that could be achieved in this branch watercourse and the sarkari khal, by cleaning this branch.

Optimizing the number and size of tokes and culverts to reduce water level in the watercourse. The head loss measured at the tokes provides an estimate of the reduction in head loss that can be achieved in general. For instance, since head loss is approximately proportional to the amount of water flowing opening two tokes (or doubling the width of the toke) will reduce the head loss to about one half of what it will be if only one toke of the same size is open. Effect of this lowering of water level in the watercourse on water loss should be estimated. If appreciable head loss (i.e., more than a few centimeters) is measured at any of the culverts or control structures existing on the watercourse, methods of replacing or modifying these structures should be evaluated.

Reducing observable leaks and seepage faces - if the loss through these observable leaks is appreciable, methods of reducing leakage should be discussed with the farmer to make sure that he understands that even the hard to find holes can be closed and that the loss of water and seepage damage to his crops can be avoided.

Estimating wastage of water due to unlevelness of field and the amount of earth moving necessary to eliminate this wastage. If the condition of the crop indicates that the farmer is irrigating adequately on the highest point, assume that when the elevation of water in the field has reached the high points, the depth of water covering the rest of the soil is excess to the needs of the crop, is nonbeneficial and may be damageing because it is leaching nitrate out of the reach of the roots.

4. Recommend Specific Steps for Improvements. The trainee should then help the farmer draw up the improvement plan that is adapted to his land, water, labor, equipment, power and capital resources and his specific needs. The trainee should provide him with the specifications and, where purchased items are necessary, contacts with manufacturers, distributors or On-Farm Water Management team personnel who can help him make his investments most effectively. The plan should include a schedule and time for each of the improvement activities.

If the farmer will need additional consultation from the agents or other members of the On-Farm Water Management Team, the time and place for this consultation will be defined and specific appointments will be made.

5. Assess Improvements, Recommend Touch-Ups and Publicize Results to Other Farmers. An appointment should be made with the farmer to return and help him evaluate his improvements as follows:

a. If excessive head losses in his branch watercourse were part of his loss problem, the operating levels of the watercourse while in use and the losses therefrom should be measured following the cleaning, repair and maintenance.

b. If land leveling was the problem the unlevelness of the land followed leveling should be determined after it has been irrigated a few times and the soil has settled. The amount of water required to irrigate the land after this leveling operation should be compared to the amount required prior to that leveling. If further leveling would be beneficial it should be recommended

c. If the attempt to achieve improved uniformity of application involved the installation of furrows or borders, or compacted furrows, the uniformity of the application should be determined.

d. These and all other aspects of the recommended program should be reviewed both in terms of physically measurable changes and in terms of the farmers conclusions as to the benefits and soundness of the improvement. His suggestions for improving and adapting the procedures should be requested and seriously considered.

6. Encouraging the participants to tell other farmers of their success and continuing the advisory role. A field day should be organized, involving the participant farmers, in which they tell the other farmers of the improvements which they made and the benefits derived. These meetings will help establish the wisdom and ambitiousness of the participant farmers. However, they will indirectly help establish the credibility of the agent with the farmers on

this and other surrounding watercourses. The agent should take advantage of this opportunity to suggest additional improved water management techniques such as: procedures for applying the amount of water needed by the crop, and when it is needed, crop planning to utilize available water, land and other resources most effectively and in general, give them further information which will help them improve their water management and crop production.

APPLICATION

The field work in this exercise is only scheduled for one day and obviously follow-up will be required after the cleaning and maintenance has been accomplished. This can be done with the next group of trainees if the first group graduates before the watercourse is ready for the follow up or the OFWM Agricultural officeer can be asked to assist in the follow up. Regardless of the situation, each trainee should go through the process of assisting a farmer in improving their irrigation practices and efficiency. Only after the farmer has been taught how to use his increased water supply to produce more will the country realize the benefit of the watercourse improvement program.

QUESTIONS

1 - What was the major obstical you encountered in working with the farmers on this project?

2 - How was it overcome? Was your method the best one or are there other solutions that are better?

Subject: EXTENSION PROGRAMS--METHODS

Trainer Agricultural Extension
Class Room 3 hours
Field 0 Days

OBJECTIVES

To develop within the trainees:

a. the ability and the desire to be of assistance in improving the lot of the small farmer,

b. the capability to apply research information in a manner which results in improved practices becoming a part of the "traditional" management of the small farm,

c. the ability to use his training in a manner understood and accepted by his clientele in the development of the single family commercial farm*, and

MATERIALS NEEDED

1 - Flip chart

2 - Slides showing extension activities in the field

TRAINING AIDS

1 - Examples of successful extension experiences.

2 - Research data to be discussed, interpreted, reorganized for farmer-use.

3 - Simplified demonstration plans for use in setting up a field demonstration of various kinds.

4 - Farmer publications.

* One which produces more than it uses and which contributes to the welfare of both the farm family and the community.

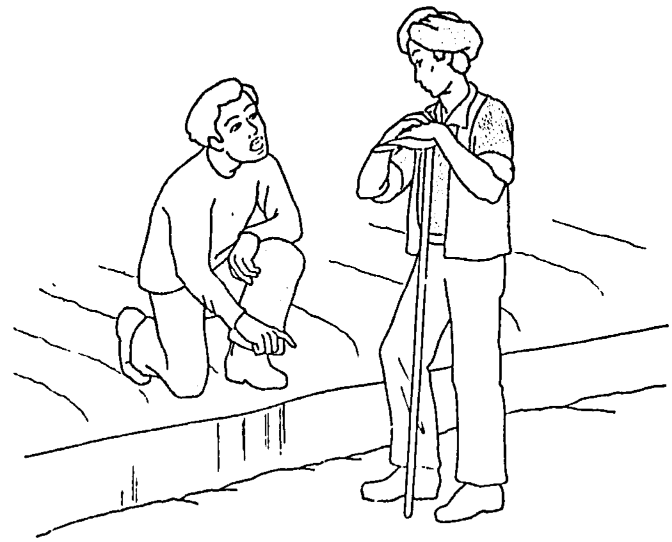
INTRODUCTION

Extension is the connecting link which ties research to the farm, presents it to the farmer on his own ground and in terms he understands, and seeks to collect, evaluate and interpret new information for the farmer as it becomes available. Extension personnel in many countries represent departments (ministries) of agriculture and the universities as well as the farmers themselves. In addition to transmitting information to the farm, they have the responsibility for gathering facts from the country and transmitting them to research agencies so that the research effort can be directed toward solving the primary problems of the people.

The extension worker must be aware of and in position to assist farm people in locating the necessary inputs required by developing farms, and in using them in a manner which is profitable for the farmer. He may be required to assist in the development of the necessary agribusiness enterprises and markets as developmental activities progress. Most certainly, he will be called upon to help the small farmer recognize and utilize his resources.

THE EXTENSION WORKER SELLS IDEAS.

In order to accomplish this multiple responsibility, extension must use every tool at it's disposal. Every educational method at his disposal is utilized. The "life blood" of extension, however, is <u>people</u>. Extension workers must be <u>people-oriented</u>. The most effective tool which extension has, in the developing country, is "people to people communication". There is no substitute for the satisfied client. Rapid development programs in many countries have proved this to be true . . .and particularly so where high percentages of the small farmer population are not able to take advantage of the printed word, mass media, and maybe not even personal letters or the telephone.



It is for this reason that, in order to accomplish the goals of a rapid development program in a developing country, many personable, energetic, interested young people must be selected and trained to do extension work. They must want to help the people help themselves. They, in turn, must carry the program to the people. They should be familiar with the people and with their customs and they must certainly be familiar with the kinds and types of agriculture with which they will be working and with the general conditions represented within the area.

As the extension worker makes his contacts and meets the people, he will be selecting his cooperators and the sites for his demonstrations. From his cooperators, leaders will emerge who are both representative of the people and able to influence others. The time is well-spent by the extension worker as he trains these people to spread beneficial information to their friends and neighbors. . .and to others in the community who might be of help. No other extension method is as effective, in the beginning, in the dissemination of information among farm people.

PRESENTATION

Program Development

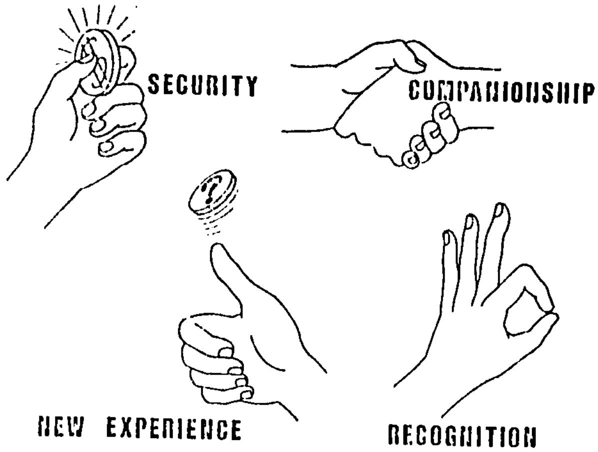
In terms of program development, the situation in which the extension service in the developing countries finds itself is very similar in some ways to the situation which existed in the United States when the Federal Extension Service was first created. Since there is no (or very little) direct knowledge of what extension work is or what it does, most contacts must be on a person-to-person basis. New methods must be proven to be sound under the conditions under which the farmer uses them and they must be profitable on the average farm. The Demonstration proved to be the most effective teaching device at that time. Combined with other direct educational tools, it still provides greater impact than do other less direct methods. "The Demonstration Way" became the slogan of the Federal Extension Service in America at that time. Program developers in the undeveloped nations might do well to emulate that philosophy.

More recent worldwide programs which have been successful have shown that farmer acceptance of new technology requires four basic prerequisites. all of which must be fulfilled if any program is to succeed.

1. Productive and profitable technology must be available.
2. The farmer must be instructed in it's use.
3. Necessary inputs (seed, fertilizer, feed, equipment) and credit must be available to him, and he must be able to use them at a profit.
4. Markets must be available for the products he produces.

If any one of these is lacking or ignored, the small farmer cannot utilize recommended improvements.

Another very important contributor to a successful program is that it be designed to fit the needs of the small, often poverty striken, farmer. Improvements which these people can use will also aid the larger, more affluent, farmer. They usually adopt new practices first because they can more easily afford them. Many generations of inheritance and land division have resulted in the formation of many small farms and traditional subsistance farming. It is toward this problem that the extension-research team must direct it's major thrust, if major improvements are to result.



PEOPLE ARE MOTIVATED TO LEARN IF THEY CAN SATISFY A BASIC NEED

Trainees who have been selected to accept the extension responsibility should receive instruction in:

1. Approaching the people -- gaining acceptance and cooperation.
2. Problem identification -- what are the greatest needs?
3. Result demonstrations -- simplified plans that can be explained to small farmers and which can provide needed necessary information.
4. Training methods for farmer leaders.
5. Method demonstrations -- show and tell (how to do it).
6. Evaluation -- for clients
   -- for agencies, Universities, sponsors.

7. Use of teaching aids

--New media (if available and useable)

--Radio (if available and useable)

--TV (if available to people who need to be contacted)

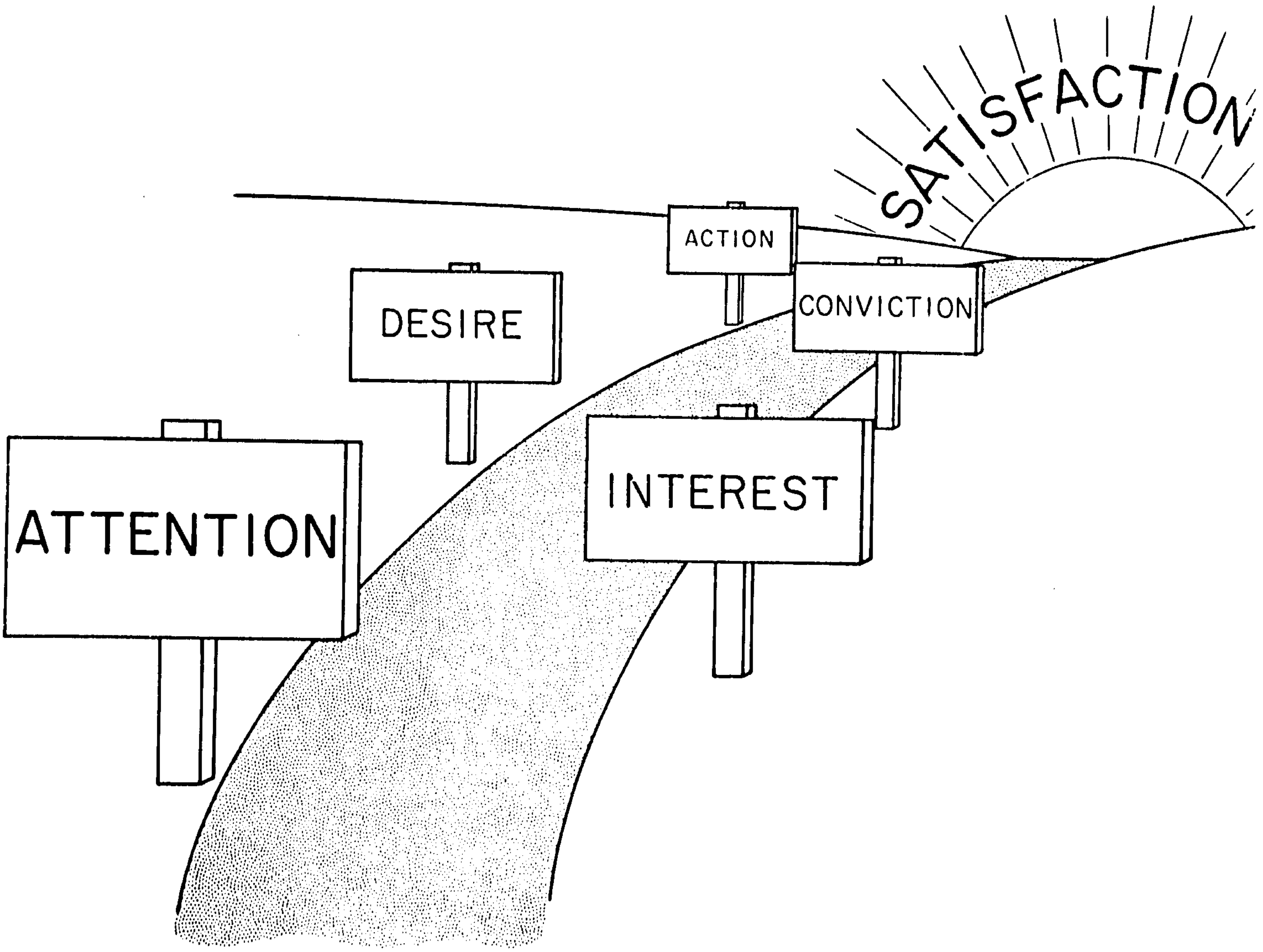
--Making and using charts, posters, slides, etc.

--Preparing and using leaflets, handouts, circulars, etc.

--Organicing and conducting field days, tours, institutes, etc.

--Conducting farmer-meetings

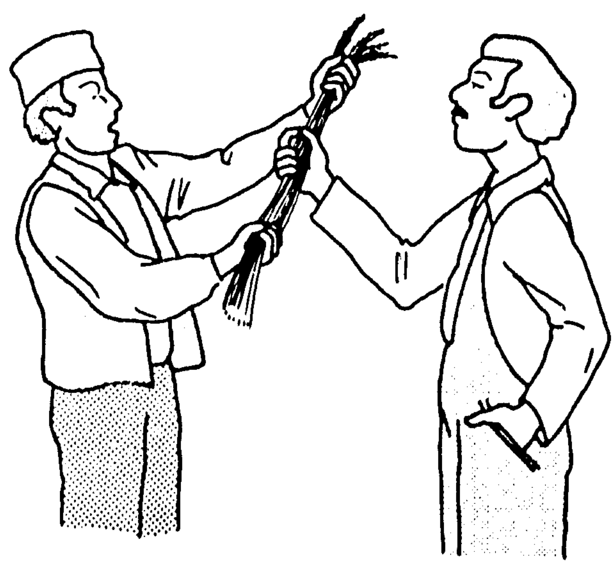
--Organizational methodology



Leadership Training

It has been said that good extension workers are expected by their clientele to do ten men's work. . .and by themselves to do even more than that. Thus, the continuous training of farmer-leaders is not just a satisfying experience for the agent and for his farmers. It provides interested, experienced leadership which can be utilized for program expansion. Extension experience shows that the rate of early adoption of new ideas is directly proportional to the numbers of personal contacts between the agent and his cooperating farmers. Likewise, it has been proven that farmer-to-farmer discussion is the most effective tool for dissemination of information. Many agents have found that informed farmers can reach other farmers more effectively than can the agents themselves. Thus, the agent must continually engage in leadership development if his program is to progress beyond the one-on-one stage of development. His work as a teacher is continuous. Every cooperator and every demonstrator is a potential leader. It is extension's job to see to it that this resource is not underdeveloped, and that the experiences of these people are constructive and enlightening.

Once the farmer-leadership becomes active, cooperators are extremely effective proponents of the program. They are by far the most respected contributors to farmer meetings, tours, field days and other extension activities.



INDIRECT INFLUENCE

Extension influence has been classified as direct and indirect. Direct --that which results from direct contact between extension agents and their client, and indirect--that which results from contacts between informed farmers and their friends and neighbors. Time and energy limit direct influence. Like the ripple on the pond, however, indirect influence, stimulated by informed constituents can reach far beyond the bounds of individual effort.

Evaluation and Reorientation

The evaluation of extension activities and results are continuous. Every day's experiences are reviewed with the idea in mind being improvement. There should be no such thing as "stereotyped" extension programs. Each activity must be geared to the particular need, the location, and the people or individuals involved.

Longer term evaluations of projects and activities must by necessity involve the people for whom those projects were initiated. Questions must be answered, such as:

What was done. . .what wasn't. . .why?

Who was benefitted. . .how. .who was missed. . .why?

How can the project be improved. . .or where do we go from here?

Were the right people involved?

What changes should be made. . .how should they be initiated?

Extension people and their leadership should be prepared, if necessary, to extend their activities beyond their own conceptions of the normal confines of their responsibilities. For instance, a land leveling project may require custom or cooperative ownership of equipment; a grain improvement program may increase production to a degree which requires market-agribusiness development; production intensification may require greater inputs into fertilizer-chemical and water control devices, which in turn will require credit for operational budgets. The establishment of contacts with people who can provide these inputs and services becomes a highly necessary activity. Farmers may be required to organize in order to be eligible collectively for goods and services not available for the individual and to form water users associations. Again, extension's responsibility is to get people together and to help them to accomplish things collectively which they could not have done individually.

As various programs become part of the ordinary farming system, some problems will, no doubt, be solved. As this happens, new needs and new concerns will surface. Program planning, therefore, is a continuous part of the everyday activity of every extension worker. The initiation of new, expanded programs will involve more people and provide greater leadership potential. The ongoing extension program for any given area may include projects in all stages of the developmental cycle.

Training Needs

Assuming that potential extension agents have the basic training in the agricultural and engineering sciences, they should understand the basic skills for which they will be held accountable. Perhaps some exposure to the social sciences might also be in their backgrounds. Very few curricula, however, as generally developed within the scientific universities will have included training which provides an understanding of the extension type activities. They should be provided with some supervised indoctrination before they are sent to the field.

To begin with, they will need some help in:

1. General characteristics of small farmers and of the areas where they will be working.
2. Refresher. . .interpretation of research results.

A GENERAL CLASSIFICATION

I. Classification according to use

Individual Contacts	Group Contacts	Mass Contacts
Farm visits	Meetings Demonstrations Training Discussion Planning	Radio
Work with individuals	Tours	TV
Establishing Demonstrations	Field days	Newspapers
Other individual contacts	Conferences	Magazines
		Exhibits
		Posters
		Leaflets
		Circular letters

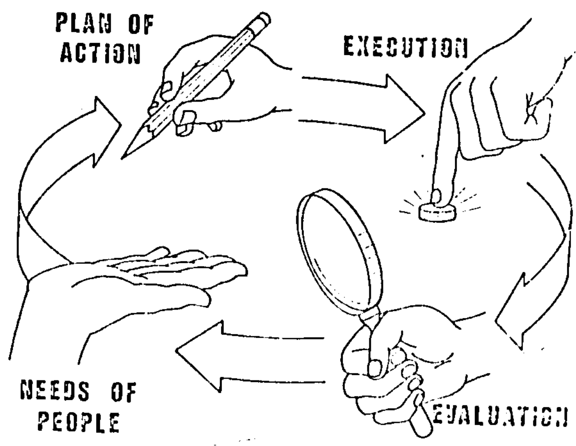
II. Classification according to form

Written	Spoken	Visual
Bulletins	Meetings	Demonstrations
Leaflets	Farm Visits	Exhibits
News articles	Calls	Posters
Letters	Radio	Charts
Reports	TV	Pictures-Slides
	Tours	Tours
	Field Days	Field Days

3. Preparation of demonstration plans.
4. Compiling demonstration results.
5. Explaining demonstrations to farmers.
6. Organizing and conducting field days, tours, farmer meetings.
7. Program planning and execution.

Supervised field trips, farm visits and orientation tours as part of a training program can provide invaluable experience. "Feel" for the job to be done is a training aid that cannot be overemphasized.

Training of this kind will help build confidence in the extension staff. It will instill in them the idea that they are not alone when they to go the field.



THE CONDUCT OF EXTENSION INVOLVES FOUR DISTINCT, YET CLOSELY INTEGRATED STAGES

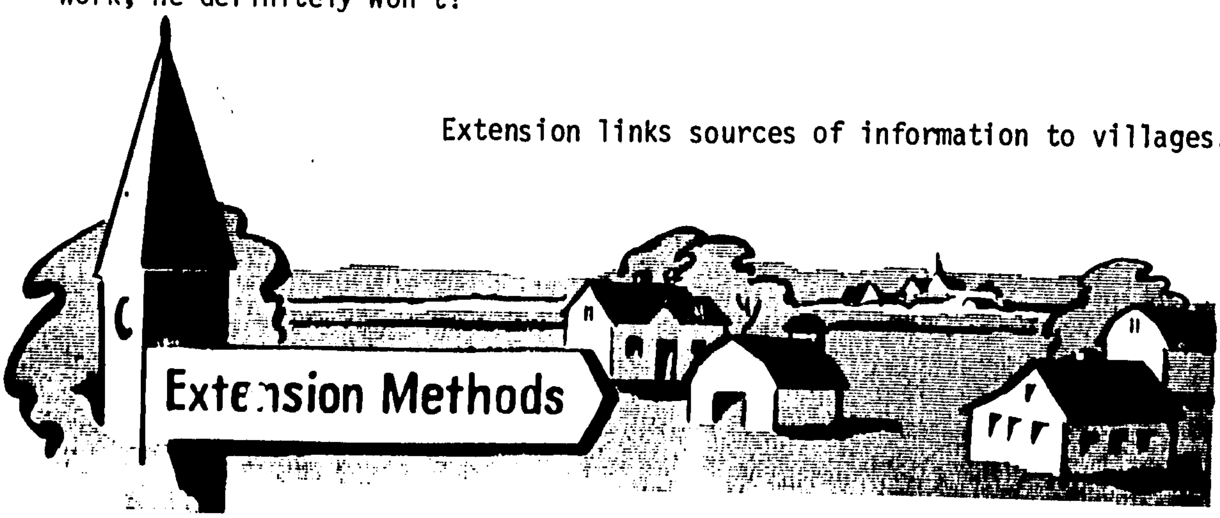
Later on, as programs reach the stage where organizational training is needed, it should be provided. Regu-arly scheduled short-course and con-ference type sessions, which expose the agents to training improvements, geared to solving current problems, and provide the opportunity for them to learn of the successful work of others are also help-ful training media for extension people.

CONCLUSION

Properly oriented extension programs, carried to the people by capable, young extension agents can contribute a great deal of favorable impact to rapid development programs in the developing nations.

Extension is a governmental function--only favorable government commitment and support can provide the necessary inputs required for the creation of the program. Since extension's delegated responsibility is to carry research to the farm and to assist in it's adoption, it is imperative that extension and research agencies work very closely together. When this condition exists, and when extension agents receive the necessary cooperation from the farm people, research is transferred to the man on the land in the shortest possible length of time. Likewise, farm problems are brought to the research agencies for consideration and disposal. . .the program becomes "that of the people".

In final conclusion, it should be remembered that the extension agent is often the final link between the project, his organization, or his sponsor and the man on the land. It is of utmost importance that he be instilled with confidence and with full knowledge that capable people are behind him when needed. The confident, enthusiastic agent can transmit that same spirit to his farmers. When he knows that his organization selected him especially because of his ability to do his job well, he will work hard to succeed. If, however, he is sent to the field without the proper training and orientation, and if the people with whom he works reflect a negative connotation to his work, he definitely won't!



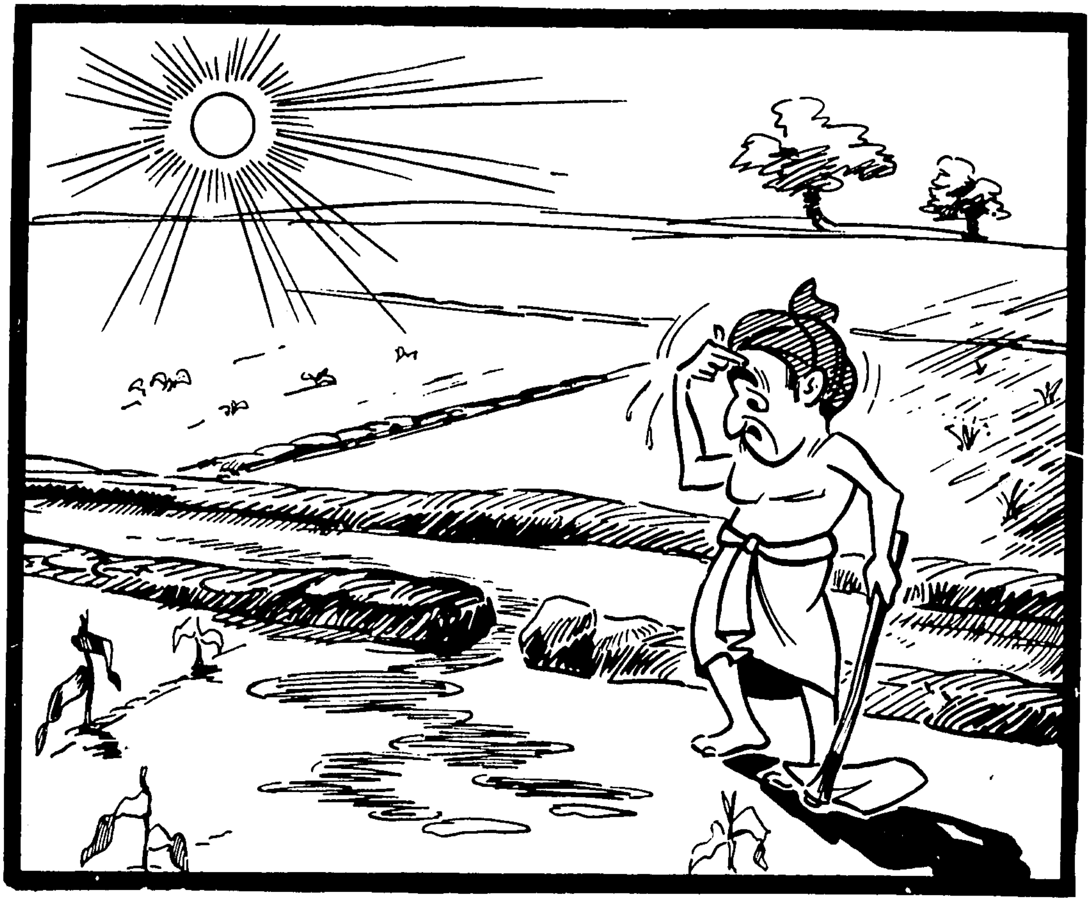
Extension links sources of information to villages.

کھال کی دیکھ بھال اور صفائی

WATER COURSE IMPROVEMENT

ڪرڙئي جي سنڀال ۽ صفائي

WATER MANAGEMENT



۱۔ میرے کھیت میں پانی کیوں نہیں آرہا ہے ......؟ اتنے کم پانی سے یہ کھیت کیسے سیراب ہو سکتا ہے۔ اس طرح تو میری
ساری فصل تباہ ہو جائے گی

Why isn't water coming to my field? How can I irrigate with this little water? My whole crop will be lost!

١. منهن جي پنيءَ تي پاڻي ڇو نه ٿو چڙهي....؟ ايتري ٿوري پاڻيءَ سان
پني ڪيئن آباد ٿيندي. ايئن ته منهن جو سارو فصل سڙي ويندو.

۲۔ مجھے پیچھے جا کر دیکھنا چاہیئے کہ میرے کھیت کو پورا پانی کیوں نہیں پہنچ رہا ہے۔ شاید کسی اور جگہ سے پانی بہہ رہا ہو یا کوئی اور آدمی تو میرا پانی نہیں لے رہا......؟

I must go back and see why the water isn't reaching my field. Maybe water is going somewhere else or maybe someone is stealing my water.

٢. مون کي پوئتي وڃي ڏسڻ گهرجي ته منهنجي ٻنيءَ تي پورو پاڻي ڇو نه ٿو پهچي. پاڻي ڪٿان ٻئي پيو آهي يا ڪو ٻيو ماڻهو منهنجو پاڻي وٺي رهيو آهي.

۳- لو دیکھو! پانی تو کھال کے اِس کنارے سے اُچھل کر بہہ رہا ہے۔ مَیں تو حیران ہوں کہ ایسا تو پچھلے ہفتے تو نہیں تھا۔ اب اس جگہ سے پانی کیوں بہہ رہا ہے......؟

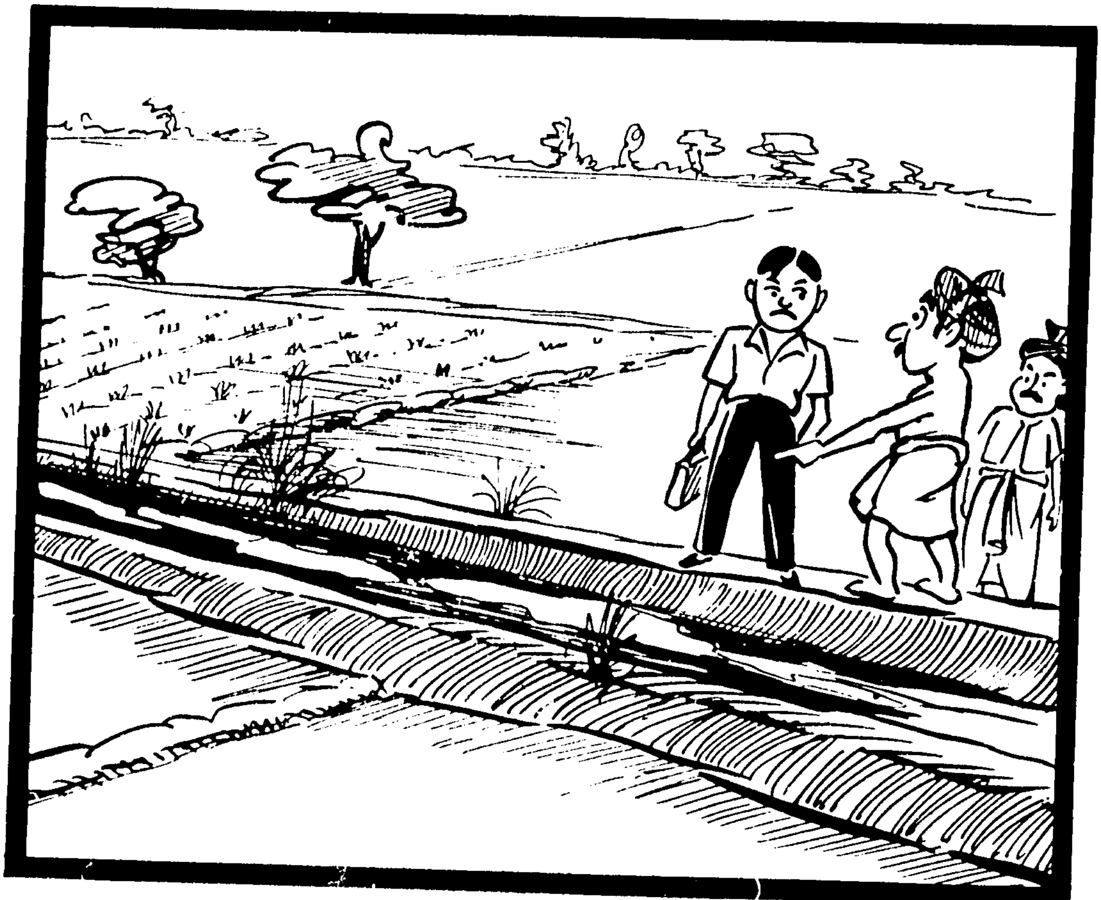
Look! The water is flowing over this bank. Last week it wasn't doing that. Why is it flowing over now?

۳. اوھو! پاڻي ته ڪڙيءَ جي ڪنڌن مٿان وهي رهيو آهي
آءُ ته حيران آهيان. اڳئين واري تي ته ائين ڪونه هو. هاڻي ان جاءِ
تان پاڻي ڇو وهي رهيو آهي.

۶۔ اسلام علیکم! مجھے اطہر احمد کہتے ہیں۔ میں آپ کے علاقے میں زمیندار بھائیوں کے مسائل حل کرنے آیا ہوں۔ اگر آپ کو کوئی مشکل
ہو تو مجھے بتائیں تاکہ میں آپ کی مدد کر سکوں

Hello. My name is Athar Ahmed. I am here to help you farmers with your problems.

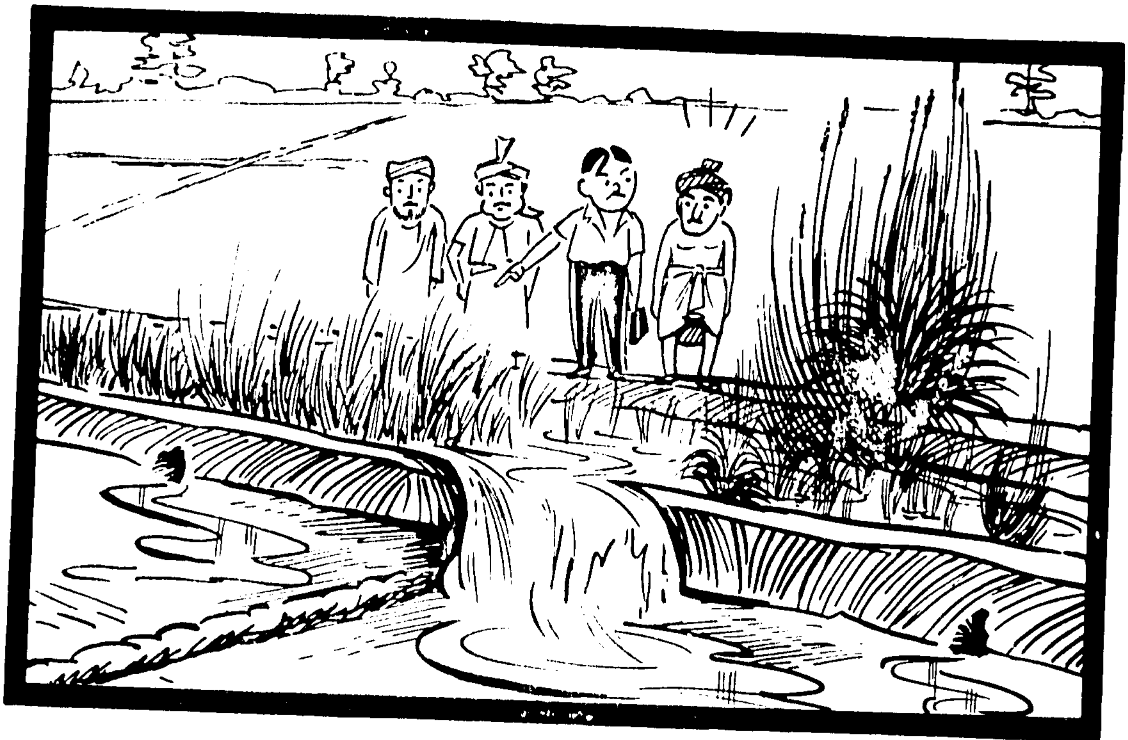
٦. اسلام عليڪم! منهن جو نالو اطهر احمد آهي. آءٌ اوهان جي علائقي ۾
زميندار ڀائرن جا مسئلا حل ڪرڻ آيو آهيان. اوهان کي ڪا تڪليف هجي ته
ٻڌايو ته جيئن آءٌ اوهان جي مدد ڪري سگهان.



۷۔ جناب۔ مجھے تو سب سے بڑا یہی مسئلہ ہے کہ میں پانی کی اس مقدار سے اپنے کھیتوں کو سیراب نہیں کرسکتا۔ مجھے تو کچھ سمجھ نہیں آتا کہ میں کیا کروں.....؟ کیا آپ اس مسئلے کو حل کرنے میں میری مدد کرسکتے ہیں.....؟

My biggest problem is that I cannot irrigate my fields with this quantity of water. Can you help me?

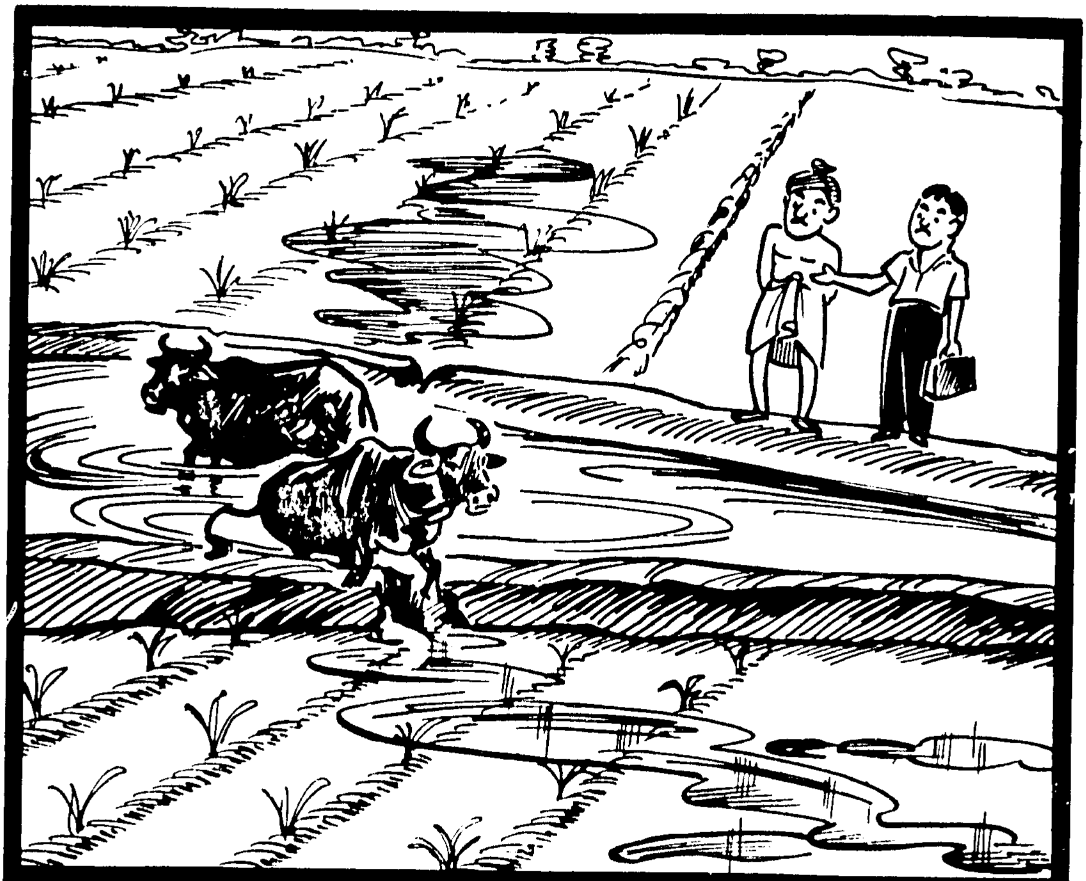
۷. جناب! منهنجو ته سڀ کان وڏو مسئلو اهو آهي ته هن پاڻيءَ مان منهنجي ٻني نٿي پرجي. منهنجي سمجهه ۾ نٿو اچي ته ڇا ڪريان؟ اوهان هن مسئلي کي حل ڪرڻ ۾ منهنجي مدد ڪري سگهو ٿا؟



۸۔ کیوں نہیں —— آیئے میں آپ کو بتاؤں کہ آپ کے پانی کے کھیتوں تک نہ پہنچنے کی کیا وجوہات ہیں۔ یہ کھال میں جو جڑی بوٹیاں آپ دیکھ رہے ہیں ان کی وجہ سے پانی کی سطح اتنی بڑھ جاتی ہے کہ وہ کھال کے کناروں سے باہر بہنے لگتا ہے اور پانی کی رفتار میں کمی آجاتی ہے۔ انہی جڑی بوٹیوں کی وجہ سے کھال کے کناروں میں مختلف سوراخ ہو جاتے ہیں جن میں کیڑے مکوڑے اور چوہے وغیرہ اپنا گھر بنا لیتے ہیں۔ اور اس طرح کناروں کے کمزور ہونے کی وجہ سے سوراخوں میں سے پانی رستا رہتا ہے اور بعض دفعہ ان سوراخوں کی وجہ سے پانی کھال سے باہر نکلنے لگ جاتا ہے

Why Not! Come with me and I'll tell you why water isn't reaching your field. The weeds you see raising the water level and causing it to overflow the banks and so water flow is reduced. Because of weeds, insects and rats build their nests in these banks and make them more porous. These porous banks cause seepage and sometimes large leaks.

۸. ڇو نه — اچو ته آءٌ اوهان کي ٻڌايان ته توهان جي پنيءَ تائين پاڻي نه پهچڻ جا ڪهڙا سبب آهن. ڪڙئي ۾ اوهان جيڪي گاهه ٻوٽا ڏسي رهيا آهيو انهن جي ڪري پاڻيءَ جي سطح ايتري وڌي وڃي ٿي جو پاڻي ڪنارن تان ٻاهر وهڻ لڳي ٿو ۽ پاڻيءَ جي رفتار گهٽجي وڃي ٿي. انهن ٻوٽن جي ڪري ڪنارن ۾ سوراخ ٿين ٿا جن ۾ ڪيڙا ۽ ڪوئا پنهنجا گهر ٿا جوڙين ۽ اهڙيءَ طرح ڪنارن جي ڪمزور ٿي وڃڻ سبب، پاڻي سمندو رهي ٿو ۽ اڪثر انهن سوراخن مان ڪڙئي کان ٻاهر وهڻ شروع ڪري.



۹۔ ان بھینسوں کی وجہ سے کھال کے کنارے ٹوٹ جاتے ہیں اور پانی ان سے باہر بہنے لگ جاتا ہے اور کھال میں ان کے بیٹھنے سے پانی کے بہاؤ میں کافی کمی آجاتی ہے۔ اِس طرح یہ بھینسیں کھال کے ٹوٹنے کا سبب بنتیں ہیں۔

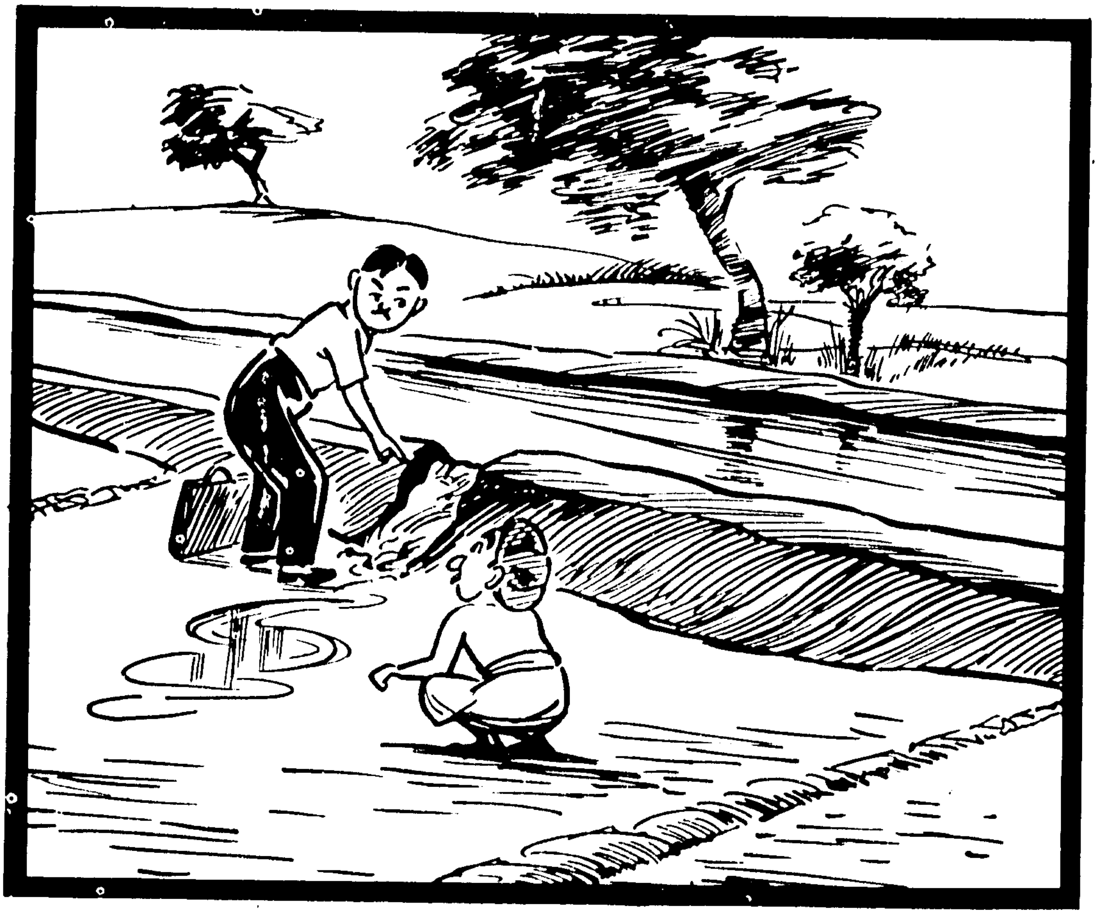
These water buffalo break the watercourse banks which allows water to flow out. When buffalo bathe in the watercourse flow is retarded.

۹. مال جي ڪري ڪسيءَ جا ڪنارا ٽٽي پون ٿا ۽ پاڻي انهن کان ٻاهر وهڻ شروع ٿو ڪري ۽ ڪسيءَ ۾ انهن جي ويهڻ ڪري پاڻيءَ جي وهڪري ۾ ڪافي ڪمي ٿي اچي وڃي. اهڙيءَ طرح مال ڪسيءَ جي ڪنارن جي ٽٽڻ جو سبب ٿو ٿئي.

۱۰۔ اَب دیکھو۔۔۔۔ یہاں سے پانی رِس رِس کے اِس کھیت کے کافی حصے کو نقصان پہنچا رہا ہے کیونکہ یہاں سے کھال کے کنارے
کی موٹائی بہت کم ہے۔ یہ صرف اِس وجہ سے ہے کہ ہل چلانے والے۔ نے کھال کے کنارے پر بھی ہل چلا دیا ہے۔ جس سے کنارا
کمزور ہو گیا ہے۔

Now look! Water is seeping and damaging a large part of the field because bank width is too thin. This happened when the farmer shaved the bank too closely while plowing.

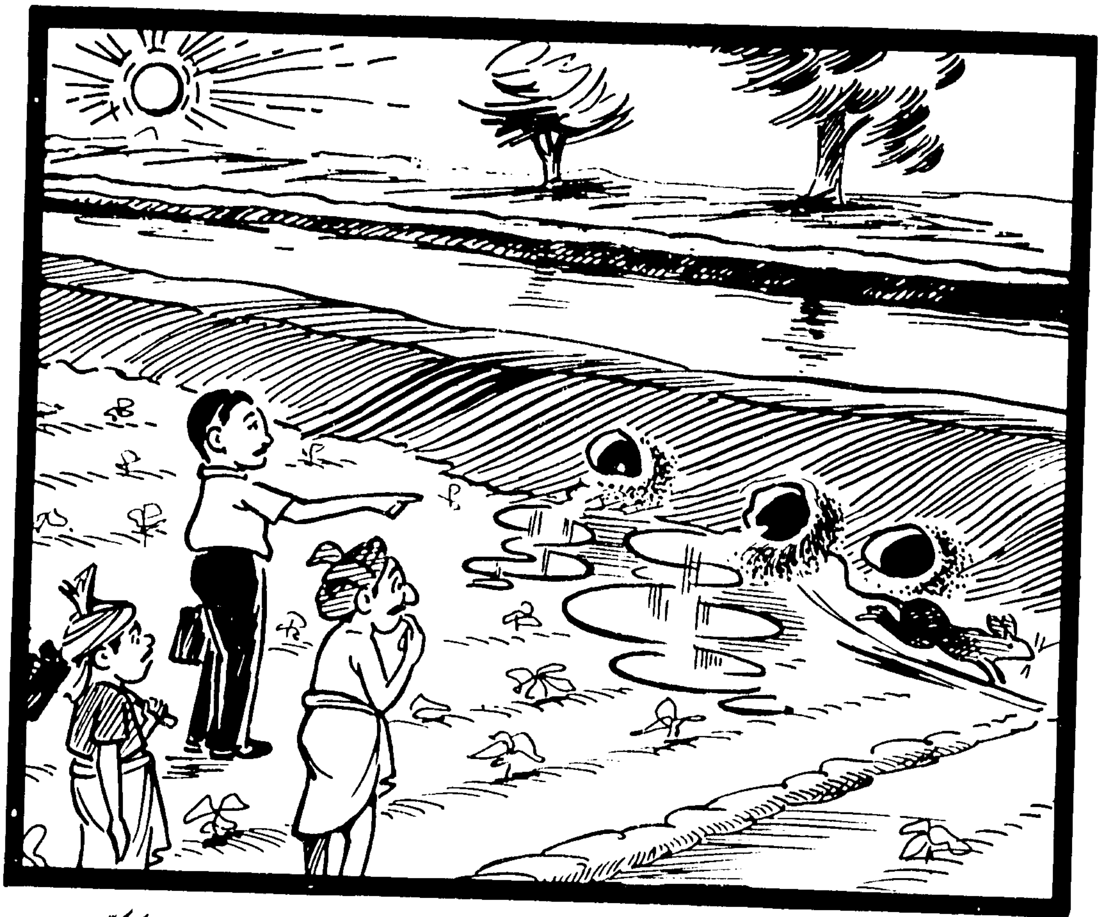
١٠. هاڻي ڏسو... هنجاء تان پاڻي سيمو ڪري ٻنيءَ جي ڪافي حصي کي
نقصان پهچائي رهيو آهي ڇو ته هتان ڪسيءَ جو ڪنارو ڪمزور آهي. اهو انهيءَ ڪري ٿيو
آهي جو هر هلائڻ جي دوران ڪسيءَ جي ڪناري تي به هر ڪاٽو ويو آهي، جنهن ڪري
ڪنارو ڪمزور ٿي ويو آهي.



۱۱۔ اب اِسی موگھے کو بھی دیکھو۔ اِس کو صحیح طریقے سے بند نہیں کیا گیا ہے۔ اور اِسی طرح کی بہت سی مثالیں آپ کو پیچھے ملیں گی۔

Look at this turn out. It was not properly closed. There are many more like this further on.

١١. هاڻي هن اهوانديءَ کي ٿي ڏسو. ان کي چڱيءَ طرح بند نہ ڪيو ويو آهي.
اهڙا ڪيئن مثال اوهان کي پوئتي به ملندا.



۱۲- ایسی ہی مثال ان چوہوں کے سوراخوں کی ہے جن سے پانی باہر بہتا رہتا ہے اور بہت سا پانی ضائع ہو جاتا ہے - ان سوراخوں کو مکمل طور پر بند کرنا چاہیئے۔

The same is true from these rat holes from which water is flowing: this wastes a lot of water. These holes should be completely closed.

۱۲. اهڙوئي مثال ڪوئن جي هنن سوراخن جو آهي جن مان پاڻي وهندو رهي ٿو ۽
ڪيترو پاڻي زيان ٿي وڃي ٿو. انهن سوراخن کي چڱي طرح بند ڪرڻ گهرجي.

۱۳- آیئے ہم سب مل کر اس کھال کی مرمت اور صفائی کا کام شروع کریں۔

Let us all begin to clean and maintain this watercourse.

۱۳ . اچو ته اسين سڀئي ملي هن کڙيءَ جي مرمت ۽ صفائي جو ڪم ڪريون

۱۱۴- ان بوٹیوں کو جڑ سے اکھاڑ دیں۔ سوراخوں کو مٹی سے اچھی طرح سے بھر دیں۔ کھال کی تہہ پر جو زائد مٹی ہے اس کو نکال دیں اور
ٹوکوں کو اچھی طرح سے بند کریں۔

Remove all these weeds! Fill the holes properly. Remove the sediments and close the turnouts correctly.

۱۱۴. هنن ٻوٽن کي پاڙئون پٽيو. سوراخن کي چڱيءَ طرح مٽيءَ سان ڀريو
کڙ جي تري ۾ جيڪو لٽ آهي سو ڪڍي ڇڏيو ۽ اهوڙاڏن کي چڱيءَ طرح بند ڪريو.

۱۵۔ اپنے مویشیوں کو کھال سے دُور رکھیں۔ اور جو کھال کے کنارے اِن کی وجہ سے ٹوٹ پھُوٹ گئے ہیں انہیں اچھی طرح سے مرمّت کریں۔ آپ کے کھال کا کنارا چوڑا اور مضبوط ہونا چاہیئے

Your animals should be kept out of the watercourse. The banks broken by them should also be repaired. The watercourse bank should be wider and stronger.

۱۵. مال مويشيءَ کي پري رکو. ۽ کتڙيءَ جا ڪنارا جيڪي مال جي ڪري ٽٽي ويا آهن تن کي چڱيءَ طرح مرمت ڪريو. کتڙيءَ جا ڪنارا ويڪرا ۽ مضبوط هئڻ گهرجن.

۱۶ . اگر آپ باقاعدگی سے اپنے کھال کی صفائی اور دیکھ بھال اسی طرح کرتے رہیں تو اس طرح آپ کو پانی کی زیادہ مقدار ملے گی جس سے آپ اچھی فصل حاصل کر سکتے ہیں۔ اگر آپ کو اپنی کھال کی صفائی اور دیکھ بھال کی ضرورت محسوس ہو تو آپ ہر وقت میری مدد لے سکتے ہیں آپ اپنے دوسرے بھائیوں کو بھی بتائیں کہ میں اُن کی مدد کے لئے بھی ہر وقت تیار ہوں۔ آپ اپنے دوسرے ساتھیوں کو بھی بتائیں کہ کھال کی صفائی اور دیکھ بھال سے کتنا فائدہ پہنچتا ہے۔ تاکہ وہ بھی اپنے کھال اسی طرح سے بنا سکیں۔

If you maintain your watercourse continually just like I have told you you will get more water and better crops. You can call on me anytime you need advice in maintaining the watercourse. You should tell the others I'm always ready to help. You should also tell your friends of the benefits of cleaning and maintenance so they will make their watercourses like this.

۱۶. جيڪڏهن اوهان باقاعدگيءَ سان ڪتڙيءَ جي سنڀال ۽ صفائي، اهڙيءَ طرح ڪندا رهندا ته اوهان کي وڌيڪ پاڻي پهچندو، جنهن جي ڪري اوهان سٺو فصل حاصل ڪندا. جيڪڏهن اوهان کي پنهنجي ڪتڙيءَ جي سنڀال ۽ صفائيءَ لاءِ مون جي ضرورت هجي ته توهان هر وقت مون جي مدد وٺي سگهو ٿا. پنهنجي ٻين ڀائرن کي ٻڌايو ته آءٌ انهن جي مدد ڪرڻ لاءِ هر وقت تيار آهيان. توهان پنهنجي ٻين ساٿين کي ٻڌايو ته ڪتڙيءَ جي صفائي ۽ سنڀال مان ڪيترو فائدو ٿو پهچي ته جيئن اهي به پنهنجا ڪتڙا اهڙي طرح بنائين.

Barqsons Printers Ltd., Islamabad   Phone: 22811

Subject: PLANNING AND ORGANIZING A WATERCOURSE COMMITTEE TO ACCOMPLISH A WATERCOURSE IMPROVEMENT OR CLEANING AND MAINTENANCE PROGRAM

Trainer Agricultural Extension
Class Room 0 hours
Field 1 Days

OBJECTIVES

1 - Introduce trainees to a village situation so they will become more confident in their ability to convince farmers of benefits of OFWM Project.

2 - Organize a watercourse committee in a village.

MATERIALS NEEDED

Transporation to field. Village should be chosen before date of field trip and initial visit made by trainer to determine if farmers have need or are interested in watercourse cleaning and maintenance.

TRAINING AIDS

Charts and handouts showing benefits of cleaning and maintenance of watercourse.

INTRODUCTION

As soon as the benefits of the watercourse management program are disseminated to the farmers and the consensus is obtained that the farmers are interested in the watercourse program, a committee is proposed to be organized which shall allow the members of the community to plan and execute programs for watercourse management and improvement.

Heavy emphasis has been placed on the proper approach to farmers, potential problems encountered and the sociological implications in contacting farmers during the Rural Sociology Training. This field exercise is conducted in cooperation with the Rural Sociology Department. This will give the trainees the opportunity to put into practical use the training they have received. Each trainer should always be present to assess the results of the farmer contacts.

PRESENTATION

The following steps should be followed:

1. Explain the program to farmers.
2. Satisfy the needs of the farmers as much as possible.
3. Choosing leaders and other members of the committee.
4. Induce the farmers in the decision of the basic design of watercourse.
5. Impress on the farmer their roles and the government responsibility towards the development, improvement and management of watercourse.
6. Deal with opposition and obstructionists as they arise.
7. Impress on farmers need for continued work of committee in the field.

APPLICATION

This watercourse should be selected for improvement and the work should start immediately. If the watercourse has been improved previously, a cleaning and maintenance program should be undertaken by the trainees. This should take about five days in the field.

Subject: IMPLEMENTATION OF A CLEANING AND MAINTENANCE ON AN IMPROVED WATERCOURSE

Trainer Agricultural Engineer
Agricultural Extension
Rural Sociology
Class Room 3 hours
Field 6 Days

OBJECTIVES

To provide trainees with practical experience in organizing farmers for cleaning and maintenance of watercourses.

MATERIALS NEEDED

Surveying instruments, tapes, field notebooks, plans of improved watercourses that are to be cleaned and maintained.

TRAINING AIDS

Charts and graphs showing effects of cleaning and maintenance of watercourse for use in farmers meetings, chart outlining procedures and work hours required in cleaning and maintenance of a watercourse.

INTRODUCTION

Since one of your major duties in the OFWM Project will be encouraging farmers to maintain their watercourses, it is appropriate to spend a week accomplishing a cleaning and maintenance project. This facet of the OFWM Project has not been given sufficient emphasis in the past but insuring that farmers regularly clean and maintain their watercourse is essential to the success of the OFWM Project. It is in the farmers' interest to maintain their watercourses because only then will they obtain the benefits of more irrigation water over the long run. Under existing social conditions, farmers are often unable to organize themselves adequately to maintain their watercourse. They need your help.

PRESENTATION

This lecture period will be devoted to trainees discussing their experiences and problems faced in organizing watercourse committees. They will exchange suggestions, identify problems and explain their proposed strategies for dealing with the problems and seeing that a cleaning program is carried out. The trainers from Rural Sociology, Irrigation and Drainage and Extension Departments should be present at this class.

APPLICATION

The trainers from the three departments of Irrigation and Drainage, Extension, and Sociology together will coordinate and supervise the cleaning and maintenance of the watercourses. The Irrigation and Drainage Department will have major responsibility in conducting the actual field work of cleaning and maintenance. All trainers should be present during all the field days to give on-the-spot guidance and suggestions to the trainees.

The trainees will be divided into groups of 4-6. A Group Leader will be designated for each day, the leadership rotating through all the trainees. The Group Leader will have major responsibility for the days activities. Each group of 4-6 will be taken to a watercourse that has previously been improved by the OFWM field team and organize the farmers and accomplish a cleaning and maintenance program of the entire length of the improved watercourse. If there are damaged structures, they should be repaired. If funds are needed to accomplish this, the farmer should contribute. Coordination with the OFWM area

Director should be made and his assistance sought in replacing and repairing structures. A member of the OFWM field team should be present during all phases of the cleaning and maintenance project. He will already have a knowledge of village organization, cooperative spirit, etc. and his assistance should be sought.

Throughout this exercise, it should be the objective of the trainees to instill in the farmers the feeling that this is their project and they will benefit from the cleaning and maintenance project by receiving more water. This should be substantiated by making watercourse loss measurements before and after improvement and sharing the information with the farmers.

QUESTIONS

After the cleaning and maintenance of the selected watercourses is complete, each team will write a report on the experience, discussing problems encountered, mistakes made, lessons learned, and suggestions for improving the effectiveness of such a program. These reports will be discussed at a meeting of the trainers and trainees and the OFWM Area Director.

Subject: METHODS AND RESULTS DEMONSTRATIONS AS RELATED TO OFWM

Trainer Agricultural Extension
Class Room 1 hour
Field ______ Day

OBJECTIVES

To develop an understanding of method and result demonstrations and under what circumstances the field member should use them.

MATERIALS NEEDED

Blackboard

TRAINING AIDS

Slides of demonstration plots and OFWM team member and farmer setting out a demonstration. Handouts of plans and results of OFWM demonstrations carried out in past.

INTRODUCTION

Human beings have a peculiar habit of accepting scome of the marvelous things without question, while they doubt and require proof for things which are quite simple and clear. Formal extension work grew out of early efforts to teach new farm practices by showing farmers how to do new practices in their farm conditions (Method Demonstration) and make them believe and convince them about the merits of the new practices by showing them the results (Results Demonstration). The above mentioned way of teaching is called "Demonstration Way of Teaching". The demonstrations are classified into two types.

1. Method Demonstration

When a person is taught how to accomplish a new practice, it is named a method demonstration. For example, how to make beds or ridges for cotton growing, how to do precise land leveling, how to compact watercourse banks, how to apply fertilizer or insecticides, how to make a silt tank, etc. The main emphasis during a method demonstration remains on teaching the way of doing some new technique.

A demonstration must be distinguished from an experiment. A demonstration proposes to show a known truth. An experiment is a search for truth. A practice which is not approved through necessary experimentation should never be demonstrated.

Advantages of Method Demonstrations

1. They are highly acceptable in proportion to teaching costs.
2. They have high publicity value.
3. They are adaptable to many teaching situations.
4. They teach skills that cannot be learned other ways.
5. They motivate and stimulate action because seeing, hearing, discussing and doing are employed.
6. They provide opportunity for developing leadership.
7. They build confidence in the demonstrator.
8. They promote personal acquaintances between demonstrator and other farmers.
9. They provide some opportunity for gaining insight with other problems of learning by farmers.

Limitations of Method Demonstration

1. They are not well adapted to all subject matter.
2. They require careful preliminary preparation and practice and thorough understanding by team member.

3. They necessitate considerable skill.

4. They involve greater expense than verbal presentations.

2. Result Demonstration

The demonstration conducted by a farmer under the direct supervision of a team member to prove the advantages of a recommended practice is calle "Result Demonstration".

Advantages of Result Demonstration

1. They furnish local proof of the desirability of establishing a recommended practice.
2. They are an effective method of introducing a new project.
3. They furnish cost data and other basic information.
4. They provide a good source of information for meetings, news items, pictures, radio talks, etc.
5. They aid in developing local leadership.
6. They establish confidence of the agent in the extension work.

Limitations

1. In agriculture, they are affected by many uncontrollable factors such as weather. They might not always be successful.
2. They lessen the effectiveness of other extension methods when successful. Farmers may lose confidence in team member if it is not successful.
3. The influence will be limited to a few people unless the team member organizes a farmers day to show demonstration to other farmers on the watercourse and neighboring villages.
4. They require considerable time to complete and to make results available after completion.

5. They require a relatively large expenditure.

PRESENTATION

The trainees should be left with a thorough understanding of different kinds of demonstrations and how each should be used. Personal "success" experiences of demonstrations should be integrated into the lecture as the problems encountered with farmers and how they were overcome.

APPLICATION

1. After explaining the concepts of method and result demonstrations, slides will be shown to clarify the concepts.

2. The advantages and limitations of both the methods will be discussed with the class in detail to emphasize the advantages and limitations of demonstrations.

QUESTIONS

1. Differentiate between the method and result demonstrations.
2. Explain the advantages and limitations of the result demonstrations.
3. Explain the advantages and limitations of the method demonstrations.

Subject: CONDUCTING A METHOD AND RESULT DEMONSTRATION RELATED TO AGRONOMIC AND IRRIGATION IMPROVEMENT

Trainer Agricultural Extension
Class Room 2 hours
Field 2 Days

OBJECTIVES

1. To give a detailed analysis of various steps to be taken for planning and conducting a demonstration.

2. To teach the trainees how to establish a demonstration by doing it in the field.

MATERIALS NEEDED

Black board, transportation to field and necessary field equipment depending on season and demonstration to be conducted.

TRAINING AIDS

Necessary equipment to set out a demonstration. Plans of previous OFWM demonstrations with farmers. If it is not possible to set out a demonstration in farmers field due to wrong season, a "dummy" demonstration should be conducted on University land. All operations should be performed, i.e. preparation of land, planting, fertilizing, measurement of water, etc. It can be abandoned and/or destroyed once the trainees have physically accomplished each operation. The accomplishment of each operation will build the trainees confidence in their own ability.

INTRODUCTION

Good demonstrations do not just happen. They are the result of careful planning, preparation, practice and presentation.

1. Planning of Demonstrations.

Written plans for demonstrations should be developed well in advance of the starting date. The plans should be as clear and simple as possible. Decide on the records needed, especially in the case of result demonstration.

2. Selection of the Demonstrator.

The demonstrator may be selected by the field team member, watercourse program committee or through consultation with farmers. Individuals may volunteer to serve as demonstrators. Demonstrators selected by local people, in cooperation with the field team, are likely to be more successful because of their responsibility to the community. People who volunteer to conduct a demonstration and who have the confidence and respect of their neighbors often prove to be the best demonstrators. Demonstrators should be friendly, well liked and good managers, public spirited and located within easy reach of as large a number of farmers as possible. The demonstrator should have farm conditions that are similar to that of the farmers to whom the demonstration is directed. If the demonstration is designed to show "small" farmers how to accomplish a certain technique, the demonstration should not be set up in a "big" farmers field.

If the prospective demonstrator meets the requirements for carrying on the demonstration, the complete procedure including the time and costs involved should be explained to him. The important items to be outlined are why, how and when the work is to be done. Thus, the demonstrator knows definitely what he is to demonstrate or prove.

3. Preparation for the Demonstration.

After initial planning, necessary preparations should be made as follows:

a. If the demonstration involves the use of some skill which needs to be taught to the demonstrator, the field team member should arrange to teach the needed skill.

b. List the steps to be shown in order in which you will follow and decide how you are going to do each step.

c. Grouping the steps into sections helps to break a long program.

d. List the supplies needed and plan their orderly and efficient arrangement to avoid clutter and keep supplies away from the front of the demonstration area.

e. Before the demonstration starts, prepare for and do the steps that need not be shown, thus, keeping the demonstration moving (e.g. measuring of ingredients).

f. Decide what you are going to say. Plan a discussion for the longer steps of the process.

g. Know the topic so well that the explanation need not be memorized. You should be an "expert" on the subject before you go to the field.

4. Presentation of Results to Farmers.

a. Show the results of the demonstration to the farmers very clearly. Have charts, graphs, handout material prepared before hand.

b. Give the audience opportunity to ask questions.

c. Restate the main points and tell why they are important and the advantages to the farmers.

d. Have some one repeat, if possible.

e. Never insult or talk down to farmers regardless of their attitude towards you.

f. Always leave the farmers a handout pointing out the value of the new practice to him as an individual farmer.

5. Several Other Considerations are Important in Conducting Effective Demonstrations.

a. The elements of good public speaking are fundamental in demonstratic These include voice control, eye contact or relaxed attitude, a friendly smile enthusiastic manner, good posture, neatness and good training.

b. As with a good speech, the language of the demonstration should be in terms the audience can understand. New terms should be defined in a language common to all. Do not use technical terminology.

c. Good demonstrations usually result when principles of education are combined with principles of good showmanship and skill. These require preparation and practice.

d. If the individuals can be stimulated to participate in the demonstation, there is greater acceptance of ideas.

e. Where the group is small and the process long, it is frequently desirable for all members to perform a few steps as the demonstration progresses.

PRESENTATION

It should be stressed that if a demonstration is to be effective, the team member should know his subject matter well. He should be thoroughly familiar and confident in his ability to conduct the demonstration. After the lecture, the trainees should go to the OFWM Demonstration Farm and set up a demonstration. The demonstrations need not be appropriate for the season and can be destroyed shortly after trainees set it up. It's purpose is to teach trainees how to conduct a demonstration only.

APPLICATION

After explaining the process of organizing demonstrations, trainees will be asked to plan a demonstration. They should be taken to the field and asked to establish a "dummy" demonstration. This need not be done with the intent of carrying the demonstration to harvest, but just done to give trainees confidence in their ability.

QUESTIONS

1. What considerations should be kept in view while selecting a demonstrator?

2. What principles should be kept in view while presenting the demonstration?

3. Why common language should be used during conversation?

Subject: PACKAGING EXTENSION TEACHING METHODS TO MEET A SINGLE PROGRAM OBJECTIVE AND EVALUATION OF THESE OBJECTIVES

Trainer Agricultural Extension
Class Room 2 hours
Field 0 Days

OBJECTIVES

1. To develop an understanding of the principles used in applying a combination of extension teaching methods to eduate farmers.

2. To explain the need and important of evaluating objectives.

MATERIALS NEEDED

Black board.

TRAINING AIDS

Handouts of various extension programs that are presently being used by Dept. of Agriculture and showing success. Examples of various farmer publications.

INTRODUCTION

Agriculture research results must be extended and adopted by the farmers to get their potential benefits. This extension activity is your responsibility. There are several extension methods which are used in extension work. As every extension method has its peculiar uses and limitations, the selection of a package of extension methods is critical to the success of the program. For example, radio can reach the greatest number of audience in the shortest possible time due to is wider geographic coverage. It lacks in visual aspect and its teaching efficiency is very much reduced in cases where the visual aspect is essential. Television has the advantage of the visual aspect over the radio but its limited coverage to most farmers limits its usefulness. In the case of printed matter, length and frequency of exposure to printed matter depends upon the choice of the reader. Printed matter is durable, can be kept in record and may be referred to over as long a period as you may require. Apart from being more accessible, its length can be adopted to the form demanded by the nature of the material presented. The need for absolute care to ensure the accuracy of information presented through all media is very important. People remember if you made an error many times longer than they remember you correct information.

Radio and T.V. teach even the illiterate but the printed work has the limitation of having use only to the literate ones. All the mass media have the common disadvantages of lacking in full feed back which is possible through personal and group contacts. The personal element of face to face interaction is partially approximated in television but no feed back occurs. This is the advantage of the best method, personal contact. One of the elementary lessons of extension is that in the process of adoption of new farming practices, people go through a series of distinguishable stages. These are:

1. Awareness
2. Interest
3. Evaluation
4. Trial
5. Adoption

Awareness--It is the first knowledge about the new idea, product or practice.

Interest--During this stage, one is active in seeking detailed information about an idea in order to determine its possible usefulness and applicability.

Evaluation--The evaluation stage involves weighing and shifting of the acquired information in the light of existing conditions to determine if the practice would fit into a farming operation.

Trial--At this stage, one tentatively tries out the practice or idea. This is a very important stage and the program will succeed or fail based on the guidance provided to the farmer.

Adoption--Finally, comes the stage of adoption, where full scale integration of the practice into the on going operations is made.

At each of these five stages, communicative effectiveness of different media varies. For example, in creating awareness and arousing interest about a particular idea, mass-media, especially the radio and T.V. can be ranked at the top. However, in practical application, we must find out which channel is suitable for which information and for what kind of audience.

We can safely conclude that radio, T.V. and even newspapers can be used with great advantage in matters like weather and pest forecast; or the initial initiation of PLL or watercourse improvement programs where the objective is to inform the farmer of the existence of a program. At the stages of evaluation and trial, when the farmer is in need of more detailed information, we may use fully illustrated printed materials. But, the best source of information would be the actual demonstrations and personal contacts made by the team members.

Definition of Evaluation

It is the process of determining the change in behavior of people, resulting from extension educational programs, evaluation is an integral part of the process. Extension objectives are also always educational; aimed at producing behavioral changes in farmers. In evaluating extension objectives, the following questions are generally asked.

1. Who was helped to move toward an objective?
    a. What were they like?
    b. What problems did they have?
    c. What did they learn?
2. Did these behavior changes seem to help improve the situation?
3. What resources did they lack?
4. What were their motivations?

These questions are then asked:

1. How were these people helped to move toward an objective?
    a. What teaching methods were most effective? Why? With whom? When? By whom? Least effective? Why? With whom? When? By whom?
    b. Which subject matter was most useful? Why? With whom? When was it taught? By whom?
    c. What changes are not implied for future extension programs?

There are many other questions that a person might ask in the evaluation process. But it is noteworthy here that Extension programs cannot be planned without evaluation of the situation. If a change in people is planned for, it is necessary to know from what place -- the bench mark. Each change that occurs in people brings about a change in the situation. Unless teachers know and take into account this basic change -- causing -- change process, they do not know the kind of program to plan.

Therefore, evaluation is part of the never-ending, circular process of program planning, program evaluation, and application of results to the situation. The process of evaluation has the following direct bearings on good program building.

1. Evaluation helps to establish a "bench mark". The first principle in program building is to get the facts about a situation and the first measurement in evaluation must be taken at the point where people start or just before the teaching process begins.

2. Evaluation shows how far our plans have progressed.

3. Evaluation shows whether we are proceeding in the right direction. It helps to test our objectives and to recommend changes where needed. By its systematic approach, it may point out omissions or suggest entirely new directions of effort. It helps to focus work directly on needs, interests and desires of the people.

4. Evaluation indicates the effectiveness of a program.

5. Evaluation helps locate strong and weak points in any program or plan. Improvements can be made only when we locate the weak points. This applies to both planning and evaluation.

6. Evaluation improves our skill in working with people.

7. Evaluation helps to determine priorities for activities in the plan of work. As extension becomes more complex, one of its greatest problems is determining what to do, how much to do, and what to omit.

8. Evaluation brings confidence and satisfaction to our work.

PRESENTATION

Step 1. Need for the use of a combination of extension methods.

Step 2. Criteria for the selection of appropriate extension methods.

APPLICATION

Principles, need and importance of packaging extension methods and evaluation of objectives will be explained and then questions will be invited from the trainees to clarify the concepts.

QUESTIONS

1. What considerations should be kept in view while selecting extension methods for a single extension program?

2. What is evaluation and how is it important in evaluating extension objectives.

3. What things should be kept in view while selecting the use of printed materials for educating the farmers?

4. What is the best method to use to convince a farmer to adopt a water management practice?

Subject: MACHINERY FOR AGRICULTURE AND OPERATION ASPECTS UNDER FIELD CONDITIONS

Trainer Farm Power & Machinery
Class Room 6 hours
Field 7½ Days

OBJECTIVES

To familiarize the trainees first with the proper operation of tractors and machinery and second, with what this machinery can do for the farmers.

MATERIALS NEEDED

1 - Tractors, 2, 35 to 45 hp

2 - Bullocks, 2 pair

3 - Scrapers, 1

4 - Land plane, 1

5 - Chissel plows, 1

6 - Mold board plows, 2 (2 bottom 1, one-way and 1 two-way)

7 - Disk plow, 1

8 - Disk harrow, 2 (1 offset, 1 double)

9 - Spike tooth harrow, 1

10 - Grain drill, 1

11 - Trollies, 2 (1-2 wheel, 2-4 wheel)

12 - Bed Shaper, 1

13 - Corn/cotton planter, 1

14 - Sprayer, 1

15 - Dessi plow, 1

16 - Karah, 1

17 - Tarfahli drill, 1

18 - Shop tools and equipment suitable for periodic servicing

19 - Fuel - 100 gal.

Oil - 24 qts.

Transmission oil - 10 qts.

Grease - 25 lbs.

Filters - 1 set per tractor

Service manuals on all equipment - 1 per trainee

TRAINING AIDS

Diagrams and flow charts of how tractors operate and transfer power to the wheels.

INTRODUCTION

Crop yields in irrigated areas of Pakistan are lower per acre than in other countries with similar climatic and soil conditions. Further, in many areas, the annual yields are decreasing in spite of government and private efforts to raise outputs.

There are many reasons for this painful trend and some of them relate to problems that can be relieved with better use of mechanization.

Accurately leveled fields are necessary for proper flood irrigation. If fields are not level, part of the crop is overirrigated and drowned, while other parts are underirrigated and do not mature properly. In addition, the excess water on the overirrigated portions of the field washes away expensive fertilizers, and finally causes the ground water table to rise resulting in eventual waterlogging of the land. Accurate leveling requires machinery.

Poor soil structure, such as hard, caked, soil layers, can reduce root growth, and limit the air and nutrients available to the roots. This will reduce crop yields. This is corrected by mechanical chiseling.

Poor seedbed preparation which leaves the soil either in large chunks or too powdery, will reduce crop yields by causing poor germination in chunky soils, or erosion, crusting, and excessive evaporation with powdery seedbeds. Good seedbed preparation often requires deep tillage followed by harrowing, both of which require machinery.

Some crops grow better on beds or ridges which are best made by machines. Many crops, such as small grains, yield better when planted and harvested mechanically.

Several cultural practices can only by carried out by machines, such as spraying, cultivating, and ridging.

Many of our farmers are either unaware of what machines can do for them, or do not understand enough about the machines to be able to use them effectively.

It is the responsibility, and also a valuable opportunity, for agriculture officers, such as yourselves, to learn about what machinery can do for farmers and help them take better advantage of mechanization.

SOURCES OF POWER

Machinery requires power to operate. This power can come from man, animals, or mechanical sources, such as engines or electric motors.

When considering mechanizing some farming operation, the first point to consider is the amount of power required. Plowing takes about 5 psi of furrow profile, and mowing takes about 1 hp per foot of cutter bar.

A man can deliver about 0.1 hp continuously. This means that if the work to be done is greater than lifting 55 lbs. a height of one foot in one second, one average man is not able to do this work continuously.

A team of two average bullocks can deliver between one and one and one half horsepower. In other words, a bullock can delivery about five times the power of a man.

By comparison, the smallest common tractors delivery 35 hp.

There are many field operations, such as land leveling or chisel plowing, that require at least this much available power and therefore, can not be done with animals or human power. Tractor power must be available for the farmer to obtain the benefits of these operations.

At the rate tractors are being bought in Pakistan, as agricultural officers, you are bound to be working with farmers who either own or hire tractors and implements to do much of their tillage and other field work.

You will need a reasonable understanding of how tractors and machines work and some of the "do's and don'ts" of equipment operation and service.

I. MAN AND MACHINE

A machine is like a living person. It can work or lie idle. If you "talk" to it nicely and treat it gently, it will be your best friend and do very good work for you. If you watch it and listen to it, it will usually tell you when you are doing the wrong thing or asking it to do what it is not designed to do.

If you beat it and abuse it, it will quit, or perhaps kick you, or even kill you. So, treat machinery like a friend. Whenever working around machinery, always, "Look, Listen, and Feel".

A. Whenever you approach a tractor or machine, don't just look at it, study it. Do you see lines in the dust on the machine where parts join together like the joint of the transmission to the clutch housing? A line in the dust usually is caused by the parts moving on each other which means they are coming loose. Similarly, oil seeping out from under a cover could mean that the cover is loose. If taken care of early enough, usually no damage has been done. But if neglected, serious breakdowns may occur. Look for loose or missing bolts, broken wires, soft tires, or radiators full of leaves and chaff. Remember, machinery that is taken care of gives the longest service for the least investment.

B. You all have heard tractors running and know that they are noisy. That noise comes from the moving parts in the tractor. As long as all of the parts are in proper operating condition, these noises are normal. But when something is too loose, or tight, or worn, or needing lubrication, it will often make a different or unusual noise. That is one of the tractor's ways of telling you that it needs attention. If you listen and look, and find problems while they are still minor, you can frequently prevent serious breakdowns and expenses. The same "communication" applies to other equipment.

C. Feel the machine. When you are driving a tractor, do you feel any unusual vibrations? If you have left the hydraulic control valve in the "UP" position, with the ram fully extended, this will cause the pump to continue to work against the pressure relief valve and can eventually over heat and damage the hydraulic system. The relief valve makes a vibrating noise that you should be able to both heat, and feel through the steering wheel.

As we are working in the field and at the shop, we will point out and discuss many parts on machinery that may need repair or have been repaired. These will give you an idea of what things to look for.

As we are using the machinery we will try to detect various noises that are normal, as well as any abnormal ones that occur, and point out their sources.

Because most power for farm machinery comes from tractors, we will begin by getting an understanding of how a tractor works.

II. TRACTORS

Definition: A tractor is sometimes called an "Iron Horse". You feed it fuel and it does work for you. Because the engine is the most important part of the tractor, we will cover it first and in detail.

A. Engines

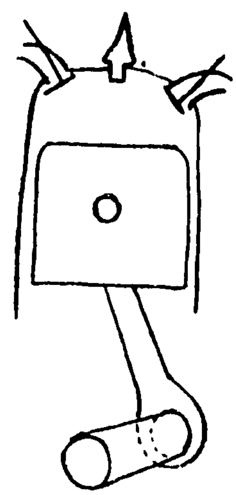
1. The engine converts the chemical energy stored in fuel into mechanical energy that can do useful work for the farmer. The fuel burning in the combustion chamber causes an increase in pressure which forces the piston down. The piston pushes on the connecting rod which in turn rotates the crankshaft. Through the flywheel, clutch, gears and axles, the energy released in the combustion chamber moves the tractor. (Diagram 1)*

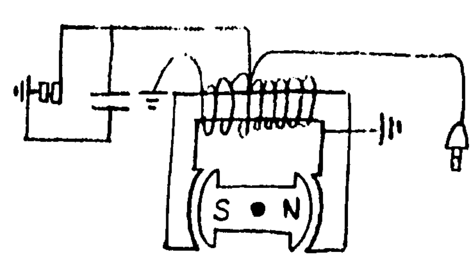
2. Engines are classified in two ways: The first is spark ignition or diesel which defines whether the fuel is ignited by a spark, or by the high temperature from compression. The second is two stroke or four stroke which describes how many strokes the piston must make to complete one running cycle.

    a. The spark ignition engines are characterized by:

        1. high voltage ignition
            a. magneto system (diagram 2)
            b. coil system (diagram 3)
        2. low compression ratio
            a. less than 10:1
        3. carburetor to mix fuel with air
            a. some modern engines use fuel injection
        4. low cost per horsepower
        5. low weight per horsepower
        6. high operating r.p.m.

*Diagrams indicate blackboard drawings.





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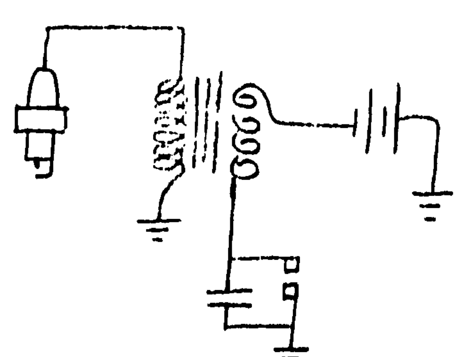

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7. inexpensive to repair, but needing repair more often than diesel

8. usually used for small power requirements such as cars and motocycles

b. The diesel engines are characterized by:

1. high compression ratio, 20:1

2. high pressure fuel injection system

3. fuel system extremely sensitive to dirt and contamination

4. expensive to repair, particularly the fuel system

5. economical to operate

6. long service life

7. usually used on larger equipment

c. The two stroke cycle exhausts the burned gases and intakes the fresh air or mixture when the piston is at the lower portion of its travel (see diagram 4). This is accomplished with:

1. ports and sometimes values

2. crankcase compression or blower

3. sometimes rotary or reed valves

d. The 4-stroke cycle uses 2 extra strokes, one to push out the burned gases and the second to draw in fresh air or mixture. This system uses valves that are either:

1. overhead

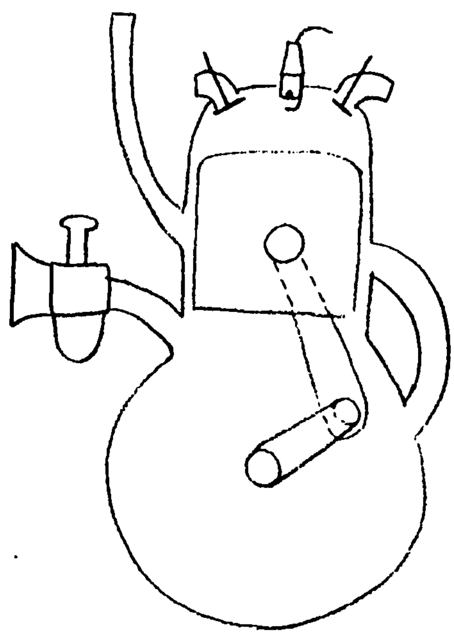
2. side valve

3. "F" head

They are operated by either:

1. pushrods and rockers

2. overhead cams or cam and rockers



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3. Most tractors today are diesel, 4-stroke, overhead valve with pushrods and rockers.

Without going into too much detail, there is certain information about tractor engines that you will need.

a.) Fuel system: "Use clean fuel, keep it clean" is written on the fuel tank cap of every Caterpillar tractor.

1. Always fill the fuel tank in the evening when work is finished. This prevents condensation of water in the tank when it cools off at night.
2. Always drain off sediment in the morning before starting up.
3. Use only clean drums for fuel.
4. Use a fuel pump, not a bucket.
5. If in doubt, run the fuel through a strainer. Chamois is best.
6. Maintain clean filters.
7. Never disassemble any part of the fuel system unless you are positive it is faulty.
8. Be sure that fuel system parts, as well as the surrounding engine parts are clean before disassembling any part of the fuel system.
9. Do not work on a fuel system in dusty locations.

b.) <u>Air system</u>: A new tractor run without an air filter for only one day can be complete worn out.

1. Check air cleaners regularly.
2. Check hoses and pipes for holes and loose joints.
3. Check oil bath filters for proper oil level and sediment load.
4. Check paper filters for tears and leaks as well as need for cleaning or replacement.

c.) Cooling system: Less than ½ of the heat energy in the fuel a tractor burns is actually converted to work. The rest of the heat must be carried away by the cooling system.

1. Keep the cooling system clean to prevent "hot spots".
2. Use only clean water which is free of salt lime, or other material that may cause deposits inside the engine.
3. If possible, use a rust inhibitor in the system.
4. Do not OVER FILL the radiator, leave some air space for expansion. Check the owners manual.
5. Be sure the surface of the radiator is not filled with trash. Air must flow through it in order to carry off the heat.
6. Check the water pump for leaks and worn bearings.
7. Be sure the temperature gauge is working properly. A 50 Rs. instrument may prevent a 5000 Rs. repair bill.

d.) Lubriaation system: This serves three functions: it reduces friction and wear; it cleans the inside of the engine; and it carries away heat.

1. Change the oil and filters at recommended intervals; and use only the recommended oils.
2. When starting an engine, let it warm up at low power settings.
3. Check the soil level regularly.
4. Be sure the oil pressure warning system is working properly.

e.) Electrical system: On diesel tractors, this is used only for starting and lights. It is convenient and will give long service if given a little care.

1. A good battery will last four years or more if given just a little service.

a. check the water level frequently, particularly in hot weather

b. add only distilled water

c. if terminals are corroded, clean them with soda water and coat them with grease

d. remember, the ground connection is just as important as the "hot" connection

e. be sure all electrical connections are tight. Twisted wire joints and loose screws frequently have high resistance and can arc or burn.

B. Driving a tractor is different from driving a car, truck, or motorcycle. We shall discuss some of these differences and practice them in the field.

1). For safety sake, follow these suggestions whenever possible.

a. keep the brake peddles locked together except when needed for turning.

b. keep the brakes adjusted equally

c. when pulling, to prevent flipping over backwards, never hitch higher than the rear axle

d. always shift to neutral, engage the clutch, idle the engine and lower equipment to the ground when someone comes up to talk with you.

2). To increase the life of the tractor, follow these suggestions:

a. start in the gear you are going to work in. The possible exception is when pulling a heavy trailer on the road.

b. start with the engine set at low speed. Then accelerate after the clutch is engaged.

c. do not use the clutch and brake peddles as foot rests. This wears the clutch bearing and brakes.

d. when turning, always lift plows, chissels, harrows, discs, etc. out of the ground.

e. use water balast in the tires for better traction when doing field work.

f. always cool an engine down after hard work by letting it run a few minutes at high idle.

III. Land Preparation Machinery: Land preparation begins with brush clearing and finishes with a prepared seed bed ready for planting.

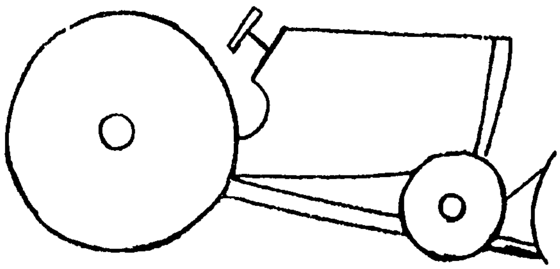
A. Land clearing and earth moving machinery is used on land that has never been cultivated before, or is going into a radically different type of cultivation. One example of such a change is when large sugar cane beds are leveled to make paddy rice fields.

A second example would be when several small fields that are at different elevations are combined into one large field of a constant elevation.

There are three basic machines that are used for this kind of earth moving.

1. The front mounted blade or "bulldozer" is the most common implement used for clearing trees, stumps and brush (Diagram 5). It is also very good for filling ditches and holes, or removing small ridges.

The advantage of the bulldozer is that it is fast, maneuverable, and easy to operate. The tractor driver does not have to turn his head to see what he is doing. In filling operations, the tractor does not have to drive through the hole or ditch that is being filled.



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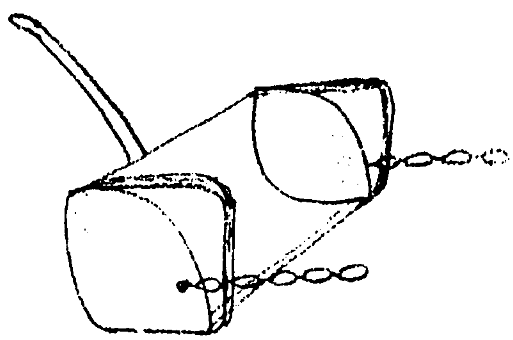
The shortcomings of the bulldozer are that it is only efficient over the short distance, generally not more than a few tractor lengths, or about fifty meters maximum haul length. It is also very difficult to accurately control the depth of cut of the blade. This makes it impossible to do an accurate job of land leveling and smoothing with the bulldozer (though it is often tried).

2. The roll over scraper (Diagram 6), sometimes referred to as a "Fresno" scraper is pulled by a tractor or draft animals. It is designed for moving soil from one location to another. Usually these have a control handle on the rear so that the operator can tip the front cutting edge up or down to control the amount of cut when filling the bucket, and then raise the cutting edge above the ground so that the bucket slides on the ground for transport. When the operator wishes to dump the bucket, he simply lifts the handle so that the cutting edge digs in and the bucket flips over forward.

   It is a good implement for moving small quantities of soil from one location to another. It can be used for building up road beds or canal beds, or leveling small fields. It is cheap to build and simple to operate.

   The roll over scraper is usually a small implement, limited in capacity and accuracy, and requiring a fair amount of energy for dragging over the ground when transporting.

3. Wheel type scrapers are the most common implement used in land leveling operations. The range in size and complexity from one



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cubic yard roll over buckets to hydraulically operated machines that can carry thirty yards or more. (Diagram 7)

For most farm land leveling operations, the simple small scraper of one or two yard capacity will be used.

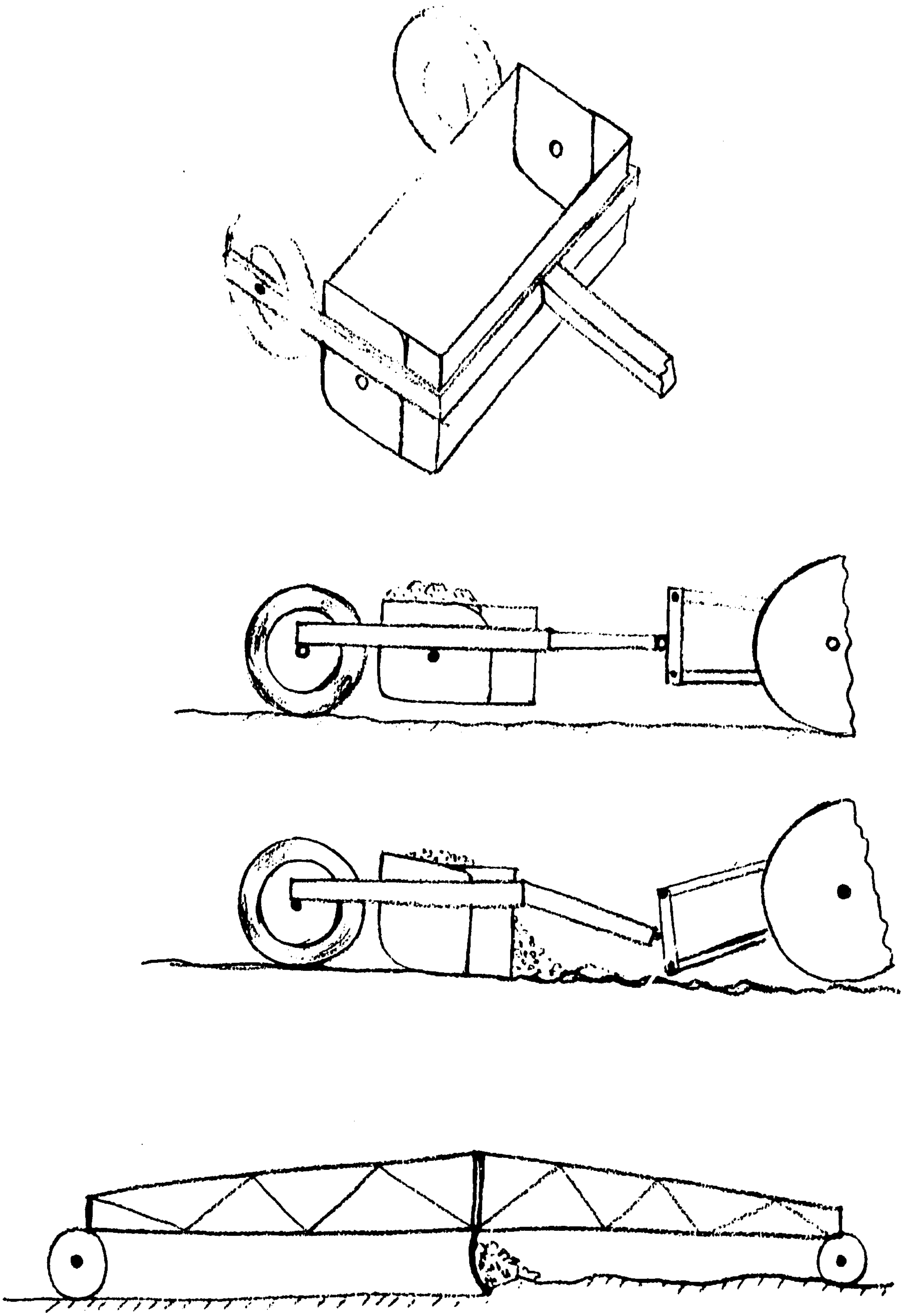
The depth of cut is controlled by the three point hitch of the tractor so that accurate cutting can be maintained. To transport the soil, the bucket can be raised completely off the ground, and

Diagram 8, 9 the load carried on the wheels with minimal energy requirement, or the bucket can be raised just enough to stop cutting, yet pushing a "super load" in front of the bucket. This moves more soil per haul, but takes more energy per haul. Which method is more efficient on a job basis is dependent on field conditions which vary from job to job.

These small scrapers usually unload by tripping a release that allows the front of the bucket to drop down and dig into the ground and then the forward motion of the machine rolls the bucket over forward to dump and spread the load. The unloading of the bucket may also be controlled by a hydraulic cylinder, but this requires more expensive hydraulic equipment and is always a source of possible mechanical breakdowns.

B. Once the bulk of the soil is moved to its desired location the next operation for land preparation is land planing or land smoothing. Ideally, this is done with a very long machine with a blade mounted

Diagram 10 at the middle. Effective machines will range from 30' to 80' in length. Obviously, these require large fields to manuever around in. The length is needed to span long unevenness and give the planing action desired. Some implements make use of the three point



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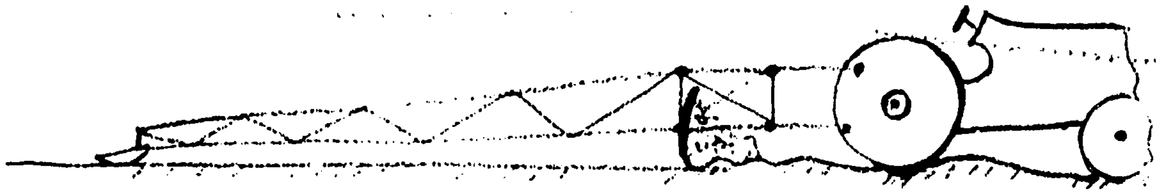
hitch of the tractor to give added length of the land plane. By using the three point hitch properly, the front wheels of the tractor become the front wheels of a direct coupled land plane blade. (Diagram

IV. Tillage equipment: Tillage equipment can be described as implements that modify the condition of the soil. This will include such actions as: breaking up clods to give a finer texture; loosening the soil to allow air and moisture to penetrate more easily, and allow easier root penetration; turning under organic matter, fertilizer or other materials which should be mixed into the soil, inverting weeds to kill their roots; and to control some insects.

Tillage equipment can be catagorized into moldboard, disc, and chissel type implements.

A. Moldboards and disc plows perform two main functions. They turn over a slice of soil so that whatever was on the surface becomes buried. Second, they break up the soil into smaller chunks. (Diagram 12 and 13)

1. A 14-inch moldboard plow working in average soil conditions will require from 600 to 800 lbs. draft. If the plow is not sharp or adjusted properly, this figure can easily be over 1000 lbs. Among the common draft animals, only horses and mules are capable of delivering this much force. A very small moldboard plow of about 6 inch cut can be drawn by bullocks. Plows pulled by animals are going to work at the speed the animal walks and this cannot be changed. However, the speed of a tractor can be varied, and this will effect the action and efficiency of the plot.



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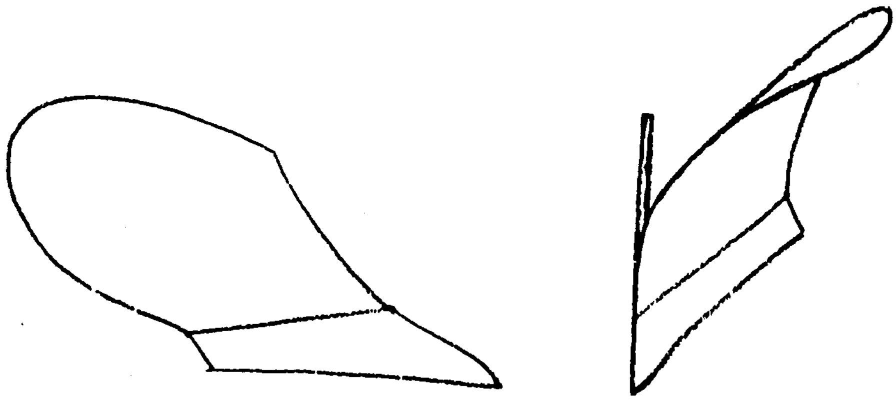

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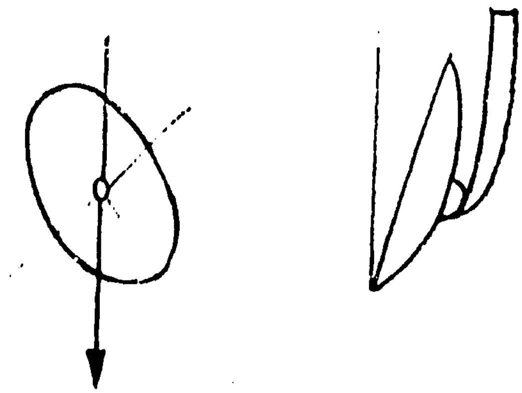


a. Plow speed will effect how much the soil is broken up by the plowing. The faster the plow moves, the finer the soil is broken up.

b. Speed and power input are not directly proportional as one might suspect. The force required to cut the furrow slice remains relatively constant regardless of speed. This force is about 50% of the force needed for plowing at a speed of 2½ miles per hour. The rest of the force is used in lifting and throwing the furrow. The lifting and throwing force will increase with speed increase, but by combining the forces, higher speeds give generally more efficient plowing.

c. The depth of cut is similarly not proportional to the power requirements of plowing. Again, the force required to make the furrow cut remains relatively constant regardless of the depth of cut. That portion of the power required to lift and throw the furrow will be proportional to the depth of cut.

2. Many local attempts have been made to produce successful animal drawn moldboard plows. Four very basic points should be looked for in the design of such a plow.

a. The angle of the share (the blade part of the plow that cuts the bottom of the furrow) should be no greater than 50° with the direction of travel of the plow, and best not greater than 40° so that there is a slicing rather than a shearing action. (You can cut meat easily by drawing the knife across it in a slicing action, but you can not cut meat by simply pushing the knife down through it. The same principal applies to cutting soil.)

b. The plow share must be well sharpened and preferably made of hardened steel so that it maintains a sharp edge.

c. All of the surfaces of the plow that the soil must slide over must be not only smooth, but polished. Friction is critical.

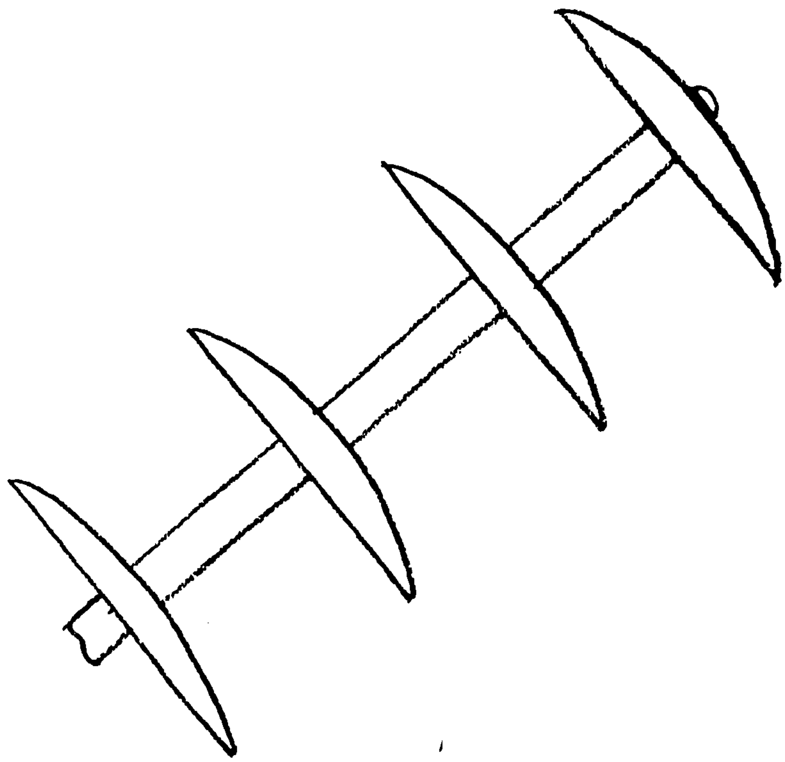
d. The curviture of the plow must be gentle enough that the soil is not excessively compressed while rolling over along the moldboard. Do not make the mistake of thinking that a small plow with a short radius of curviture will pull easier than a larger, more gentle curved plow.

3. Disc tillage implements begins with the disc plow. It does a very similar job to the moldboard plow. It loosens and inverts the soil. Because of its rotating action, it will work in certain conditions that are difficult for moldboard plows. (Diagram 14)

   a. A disc plow will penetrate hard soils better than a moldboard plow.

   b. A disc plow will handle sticky soils that will not scour cleanly on a moldboard plow.

   c. When hard pan is a problem, a disc plot does not leave a flat surface at the bottom of its furrow as moldboard plows do.



d. Usually disc plows can penetrate deeper than moldboard plows.

e. A disc plow does not cover trash as well as the moldboard.

f. A disc plow does not pulverize the soil as finely as a moldboard.

g. Disc plows are larger, more complicated, and must be pulled by tractors.

Discs operate at a horizontal angle of from 42° to 45° from the direction of travel of the implement. They are tilted back from the vertical about 15° to 25°.

4. The disc tiller is similar to the disc plow. It is a series of discs mounted on one common axle so that all discs rotate together. It is designed for minimum tillage with only three or four inches of penetration. The draft is much less than for the deeper plows (150-300 lbs per ft of width) and therefore a given tractor can cover more acres per hour with this implement. Sandy loam soils have draft requirements of from 3 to 7 psi for moldboard plows and 6.5 to 8.5 psi for disc plows.

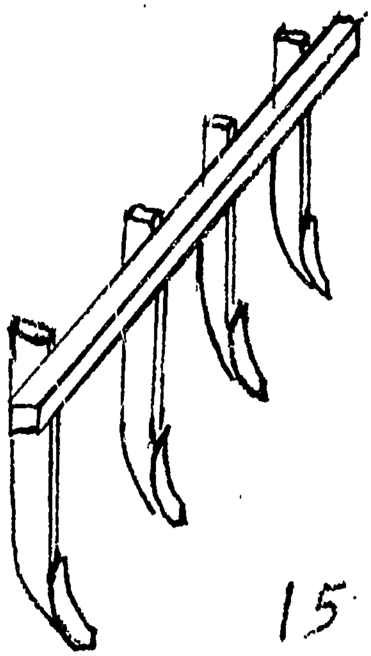
B. Chissel implements do not do any turning or inverting of the soil. They break up the soil which allows air and moisture to penetrate better and offers less resistance to root penetration through the soil. (Diagram 15)

For the cross section of soil penetrated (width of implement and depth of penetration) they require far less energy input than any of the plows.

1. Chissels should be used where minimum tillage is desirable.

   a. no need for turning under trash, fertilizer or organic matter.

   b. the soil is fine textured and should not be broken up any further.



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2. Chissels penetrate deeper than plows and are very good for breaking up pan layers left by plows.

3. Chissels are also used in land leveling to break up the soil so the scrapers can load more easily.

4. Chissels can be fitted with sweeps, or horizontal blades. These blades will loosen the soil and also cut any top roots of weeds.

5. Chissels, as with plows, must be lifted completely out of ground when turning the tractor. They are designed to take a forward draft, but not a side draft. Continual turning while in the ground will bend and break both the tractor hitch and the implement.

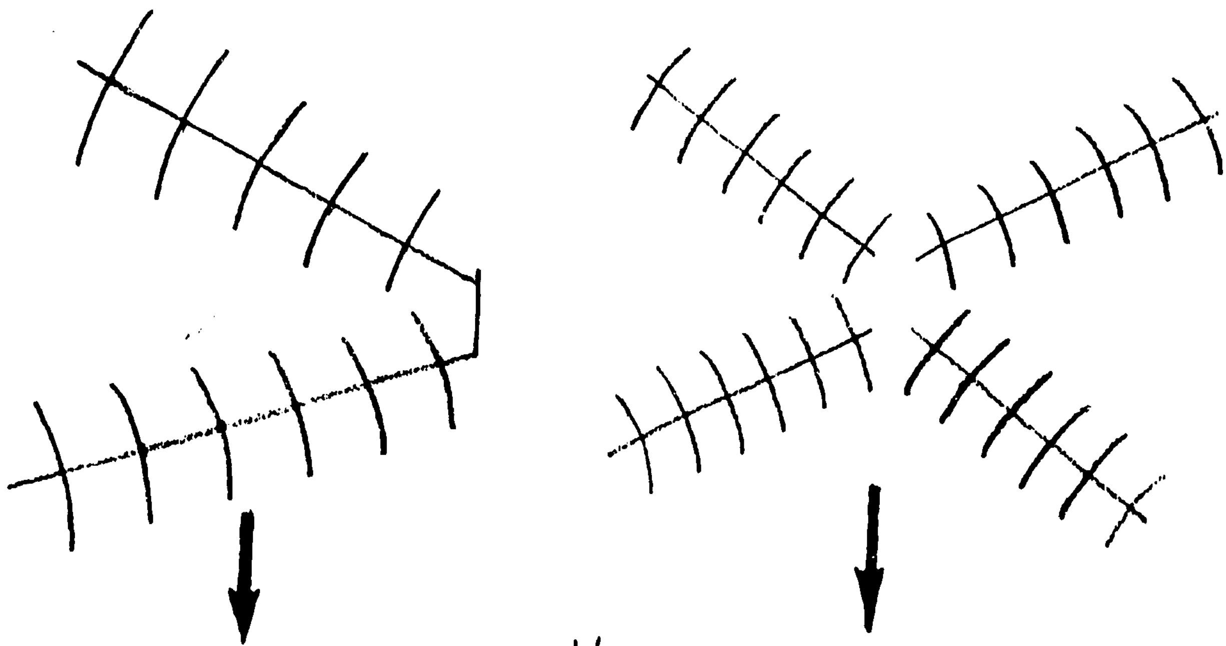
V. Seed bed preparation usually involves only finer pulverization of the top few inches of soil. It may also include: smoothing the surface, removing trash that might interfere with planters, establishing ditches for irrigation or ridges for some plants.

A. Disc cultivators are similar to the disc tillers. The differences are that the cultivator uses smaller blades that are spaced closer together, and uses two sets of blades in tandem and cutting or throwing in opposite directions. (Diagram 16)

1. The tandem disc uses four sets of blades, the two front sets throwing soil outwards, and the two rear sets throwing toward the center.

2. The offset disc uses two sets of blades in tandem. A right hand offset will throw the soil first to the right and then bring it back to the left.

3. A tandem disc must either be closed or raised when turning. An offset will turn in one direction only while in the



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ground if it is being towed, and not mounted on a 3 point hitch (All 3 point hitch implements must be lifted for turning.)

4. A tandem disc leaves small furrows at the outer end of the rear discs. The offset disc only leaves a furrow on one side, the other side being smooth from the thrown soil. With a right hand offset, the left side is smooth. Therefore, if the tractor goes around the field in a counterslockwise direction, each pass moving one position further to the right, the field will be left smooth.

5. Tandem discs, and some offset discs are adjustable. When they are closed so that the sets of blades are parallel, they do not penetrate, and can be rolled easily over the ground. As the angle is increased between the sets of blades, the penetration will increase.

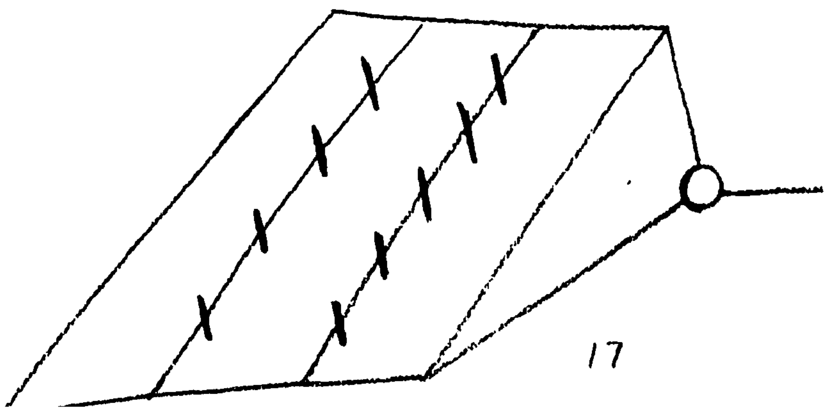
6. Disc bearings must be kept well lubricated and the axle bolts must be continually check for tightness, particularly on new machines.

B. The spike tooth harrow is probably as old historically as the plow. Its function is to break up clods of soil and further smooth the seedbed surface. (Diagram 17)

1. It is frequently pulled directly behind a plow or disc so that it is working on moist soil and can break clods better.

2. The angle of the spike is sometimes adjustable to control depth of penetration.

C. The spring tooth harrow is similar in principal and function to the spike tooth harrow. However, its adjustable, curved blades allow it to penetrate the soil deeper. The spring tooth blades are



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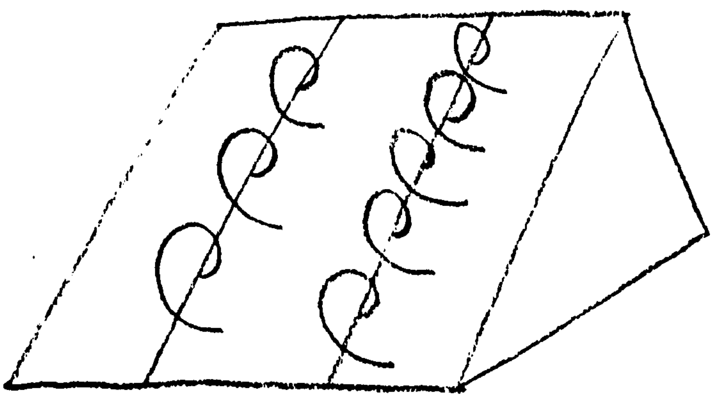

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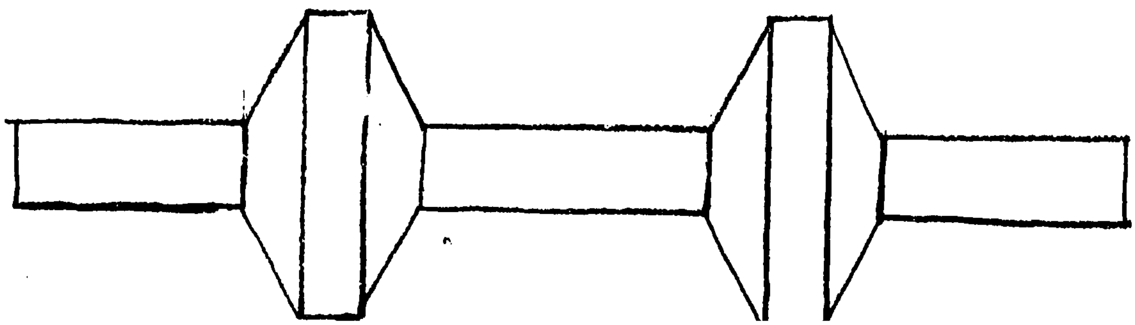
broader than the spikes, and finally, if the tip of the spring tooth strikes something hard, the tip bends backwards reducing its penetration angle, and lifting the implement, which reduces the draft momentarily. (Diagram 18)

D. Bed shapers do not condition the soil but rather shape its surface. Typically, a bed shaper will make one or more beds between ½ meters and 1½ meters wide with irrigation furrows in between. The furrows (Diagram 19) are about 15 cm deep. The surface of the bed is very smooth and ideal for precision planting. Beds are advantageous where crops can be grown in rows and surface irrigation is used. The advantages over level basin flood irrigation may include:

1. No crust is formed from water standing on the surface of the field.
2. The field does not have to be as precisely leveled to be able to irrigate the higher portions of the field without over-irrigating the lower portions.
3. Higher salinity conditions can be tolerated because the salt will move to the center of the bed leaving the edges of the bed where the crop is growing relatively free of salt.
4. The center of the bed never becomes saturated, so it can be walked on during, or very soon after, irrigation to be weeding, spraying or other field work.
5. The furrows will store considerable runoff in case of a heavy rain storm. This can prevent drowning of the crops.

E. The rotary hoe is used to break crust and remove small weeds in an established crop (Diagram 20).



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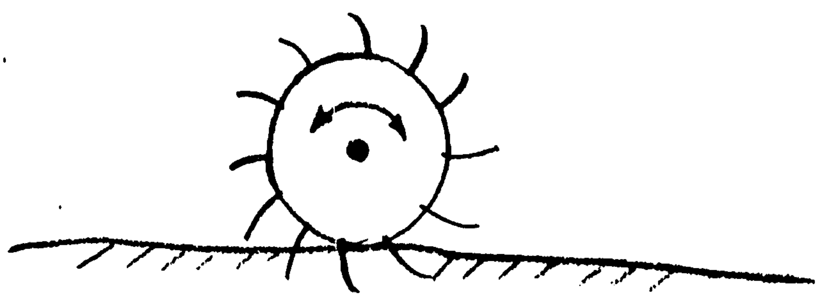

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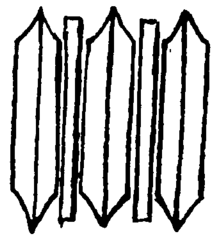
1. It is a long (about 2 meters) axle with spiked wheels spaced about 15 cm apart. The spikes are curved with their tips about 10 cm apart.
2. When rolling on one direction, the spikes barely penetrate due to their curve. In the opposite direction, they penetrate much deeper to flip out weeds.
3. The rotary hoe works best at fairly high speeds (5-6 mph)
4. Sometimes two sets of rotary hoes are used in tandem with the wheels staggered to give closer spacing on the field.
5. A variation of the rotary hoe uses two or three wheels on a short axle mounted at an angle to the direction of travel. A pair of these can be mounted on a tool carrier so that they straddle a row of crops and remove the weeds on either side.

F. Several kinds of rollers are used in seedbed preparation.
   1. A large, solid roller will smoothen and pack the soil as well as break up clods.
   2. Corrugated rollers use a row of flanged or knotched rollers that fit loosely on an axle. They pack the soil, break clods and crust, but leave the surface in little ridges and furrows which reduce wind erosion and help flood irrigation. (Diagram 21)

VI. Cultivators are implements which are used after the crop is growing and there is need for weed control or some soil conditioning such as mulching.

A. Most cultivators are mounted on a tool bar or carrier. They usually are a shank that has some type of single sided or double sided sweep on the bottom. The shanks and sweeps are spaced so that the rows of crop are straddled and any weeds in between the rows are eliminated. (Diagram 22)



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B. A cultivator may include some other activity besides weeding and mulching.

1. Special sweeps or rotary hoes may be used that throw soil up against the crop forming a ridge along the row.

2. Fertilizer attachments can be used to side dress the crops.

VII. Ideally, seeds should be placed at the proper depth and spacing in soil that is at the proper moisture content with the soil properly compacted after seed placement.

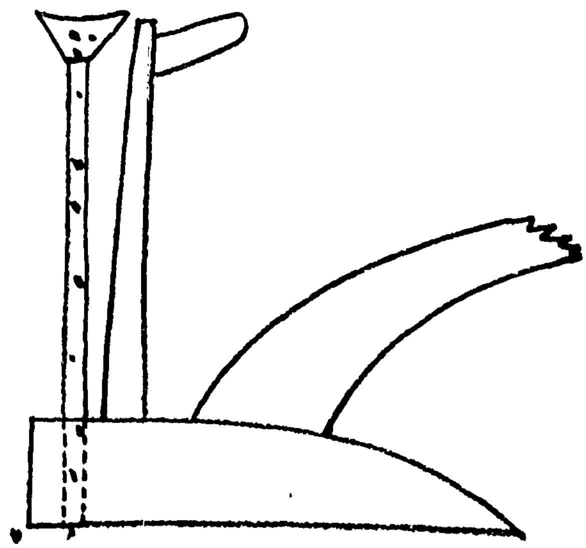
A. The oldest method of spreading seed is by hand broadcasting. And this is still in common practice.

B. An improvement on hand broadcasting is the hand broadcasting machines which use a crank operated spinning plate to broadcast either seed or fertilizer. The advantage of this over straight hand braadcasting is that it requires less skill, and gives a much more uniform coverage of the material being broadcast. Most broadcasters have some means of metering the material being broadcast.

C. A drill is an implement that places the seed in the ground rather than on the surface.

1. The simplest drill is a pipe mounted on the heel of a wooden plow. A funnel is mounted on the top end of the pipe so that when seed is hand dropped into the funnel, it drops down the pipe to the bottom of the furrow. The seed is metered by how fast the operator drops the seeds into the funnel. (Diagram 23)

2. Multi-row seed drills do a better job of planting small grains than broadcasters do. Less seed is used and is placed at the proper depth in rows that are the proper spacing. Seed spacing



2 3

within the row is not controlled from seed to seed, but the amount deposited per acre or per 100 meters of row is fairly well controlled.

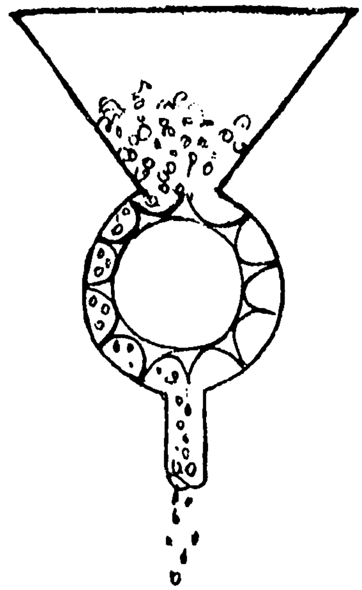
a. Very small and simple drills are made to be pulled by animals. They may drill only four or six rows with a one meter wide machine. The seed metering mechanism is driven by one of the ground wheels. The metering device is usually a rotating fluted shaft that controls the flow of seed into an adjustable opening in a drop tube (Diagram 24). At the bottom of the drop tube, the seed will fall into a furrow made by an opener. Openers can be of the hoe type, runner type, or rotating disc type (Diagram 25). Field conditions dictate which type of opener should be used.

(1) The hoe type penetrates best, but will collect trash and roots which cause it to make a very wide furrow.

(2) The runner (sometimes called a knife) makes a narrower furrow but requires more force to hold it in the ground. With too much trash or hard clods, the runners tend to lift out of the ground and leave the seed at too shallow a depth.

(3) Disc openers leave a narrow furrow and can cut through trash which makes them generally the best for planting. However, they require hard steel discs and proper bearings, and cannot be made without sophisticated manufacturing equipment. This makes them expensive and harder to maintain.

3. Grain drills frequently have additional attachments on them that allow the drills to do more than just planting seed. Many of



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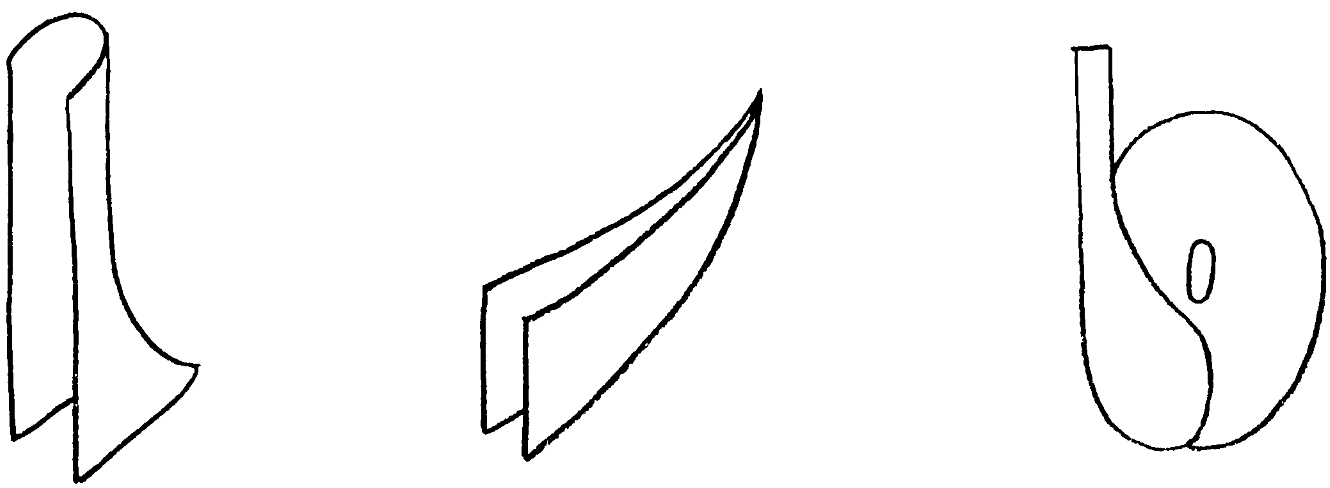

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them have fertilizer attachments on them that place fertilizer in rows very near the seed, yet not close enough to damage the young plants. The mechanism for placing the fertilizer is very similar to that for placing the seed.

4. Some grain drills are very simple with all of the parts, including openers mounted rigidly on one frame. With this design, if the field is not even, some openers will be digging deeper furrows and placing the seed deeper in the ground than other openers. More complicated drills will have the openers individually mounted on sub frames so that they follow the ground and all of them plant at their adjusted depth.

D. Planters serve the same function as drills, but differ in that they usually have more accurate control of the spacing of the seed in rows. This is more important for such crops as corn, sugar beets, and cotton. Also, the category of "planter" includes such machines as potato planters, and sugar cane planters, while drills refer principally to grain planters.

1. Probably the first two crops to be mechanically planted in Pakistan will be cotton and corn. A few farmers and some of the research stations are using mechanical planters now, but with limited success. There are three problems involved with precision mechanical planting.

a. The seeds themselves must be very uniform in both size and shape. This will require seed processing plants that are equipped to clean and grade, and in the case of cotton, delint, the various seeds. The farmers will then have to get their seed from these plants.

b. The seed bed must be uniform enough that there are no clods or other material that will interfere with the smooth movement of the planting unit.

c. The planters themselves are complicated machines with intricate parts that must be properly adjusted. Usually there are special plates or other attachments required for each specific type and size of seed. These machines are expensive to purchase and must be carefully operated and maintained. They will do the best job of planting and undoubtedly will be in common use in Pakistan in the near future.

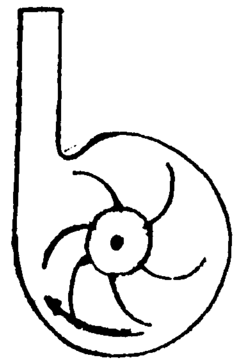
VIII Pest and weed control are frequently done with mechanical chemical applicators. These can be hand operated, power operated, hand carried, or tractor-mounted units.

A. Of these three, the only category we will be concerned with will be the tractor mounted units. These have a storage tank for the chemical, a pressure pump, and a spray boom with nozzles.

1. The storage tank must be made of a material that will not be attached or corroded by the chemical being used. Most modern tanks are made of plastics. A good tank will have some kind of agitation system to keep the chemicals in suspension in the water. The tank should also have a filter to prevent larger solid particles from entering the pump.

Diagram 26, 27, 28 and 29.

2. The pumps are usaully of the centrifugal, roler, vane, or piston type. The piston type develops the highest pressure and is the most susceptible to wear, and most expensive to build. It is uslaly based on orchard high pressure sprayers. The centifugal pump is cheapest, least susceptible to wear and capable of deliverying the pressre (100 psi) for needed spraying. Centrigfugal pumps are not positive displacement



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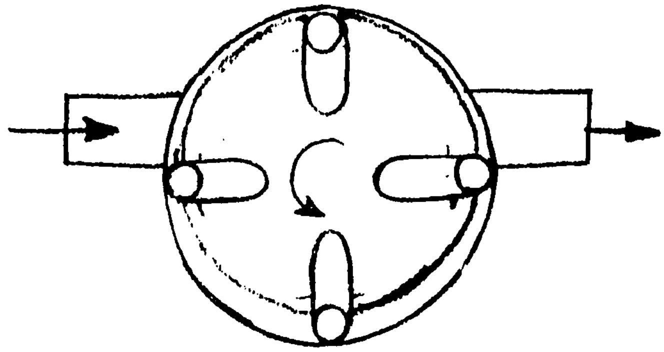

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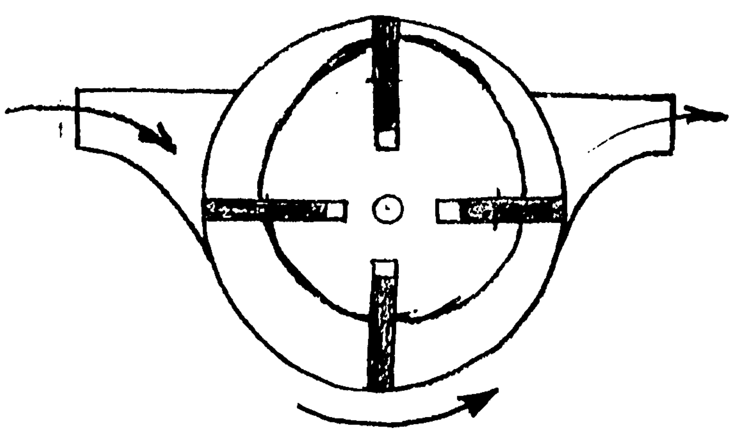

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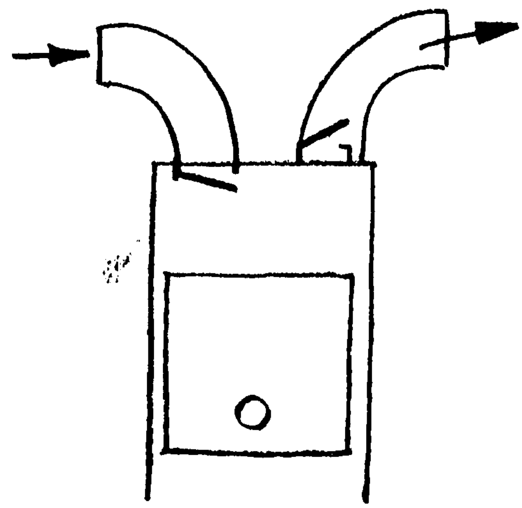

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and it is therefore harder to control the exact amount of chemical applied per acre. The roller and vane type pumps fall between these two extremes with the roller pump probably the most common.

3. When positive displacement pumps are used, there must be a safety relief valve in the system incase a passage becomes plugged, or the spray nozzles are shut off while the pump is still running. These are spring type, usually adjustable, and discharge back into the storage tank.
4. A control valve within reach of the operator will shut off the spray. On larger machines there may be two or more valves so that the left side, right side, or other sections of the spray boom may be shut off while the rest of the system is still operating.
5. The booms and nozzles control the discharge of the spray chemical. There are too many different styles of nozzles to discuss here. It is best to follow the directions of the equipment manufacturer or chemical manufacturer in selecting the proper nozzle. Generally, the nozzles have fine strainers in them, and very small holes and passages for the fluids to pass through. They present two problems: first, they become plugged up or partially plugged up easily. In which case, they either stop flowing altogether or do not spray with the proper pattern. The second problem is that with some of the corrosive and abbrasive chemicals used in sprayers, and the high pressures they operate at, these very

small passages wear oversize quickly and no longer function properly. They loose thier pattern, do not break up the fluid into fine enough droplets or discharge too much fluid.

B. As with all machinery, care must be taken in operating sprayers.

1. The chemicals can be highly toxic to man and animals. After all, they are designed to kill insects which are quite hardy little creatures.

2. Typically, they are large and cumbersome machines and to keep then lightweight, are made with a minimum of material. Therefore, they are not rugged. Drive them carefully. They are wide and high and the operator must constantly check that he has enough clearance on the sides and above.

3. The chemicals are corrosive and frequently, have finely ground solids in them. They usually are noncompatible with chemicals used for other purposes such as herbicides and insecticides, or contact chemicals and systemics. Therefore, the entire spray system must be thoroughly cleaned out after every usage. This cannot be overstressed.

VIII In Pakistan, harvesting of crops has been influenced the least by mechanization. The only operation that uses machinery extensively is the threshing of grain. There is a very strong interest in adopting combine harvesters and this will probably come about in the next few years. As agriculture officers, there is very little change that you will be operating threshers, but they are good examples of the "Look, Listen and Feel" principal. The main part of a thresher is the cylinder which is heavy and spins at high speed. Most of these cylinders are out of balance and this imbalance causes vibration in the machine. The vibration causes bearings to wear out, bolts to loosen up and metal to fatigue and break.

The vibration can be felt; it can be heard; and you can easily see whether the cylinder is out of balance. Remove all belts from the cylinder shaft and give it a little turn by hand. As it slows down and comes to a stop, it should not swing back and forth. Also, if you give it several small spins, it should not stop at the same place each time. If it does stop in the same place, or near the sample place each time, additional metal should be welded on the hammers on the top of the cylinder to balance it. This is not a perfect method of balancing the cylinder, but on most threshers, it will make a noticable improvement.

IX. In summary, remember, machinery is expensive, but if used properly it will pay for itself quickly.

Machines are like people. If you cooperate with them, they will work well. If you abuse them they will quit. If you keep them in good health they will work hard for a long time. If you listen to them they will tell you when something is wrong. They are like a wife. If you beat them, they will show their scars to all her friends.

It is suggested that each day begin with between one or two hours in the classroom with a lecture/discussion, followed by at least four hours in the chop or field, working on, or operating machinery.

A minimum level of proficiency in tractor operation must be developed by every trainee so that he can demonstrate various pieces of equipment effectively, and can recognize good or bad operating practices in other drivers.

The trainees should be able to spot faults, such as broken, loose, or maladjusted parts, on tractors and machines.

With this knowledge and skill, the Water Management Specialists should be able to establish their credibility and make significant contributions to farmers operation.

LAB I

1 ½ hours **I. INTRODUCTION TO TRACTOR:**

A. Operations manual

B. Pre-startup check

1. Fuel

a. Amount

b. Drain off sediment and water

2. Oil

3. Water

4. Visual inspection of tires, belts, hoses, etc.

1 hour II. PROPER STARTING TECHNIQUE

A. Position of brakes, gear shift, clutch, 3 pt hitch

½ hour III. SAFETY AROUND PEOPLE AND MACHINES IS AN ATTITUDE!

3 hours IV. DRIVING FORWARD AND BACKING TO HITCH A 3 PT IMPLEMENT

6 hours

LAB II

1 ½ hours	I.	SERVICING AIR INTAKE SYSTEM
		A. Precleaner
		B. Air filter; clean or replace
		C. Air pipes and hoses checked for tightness and air leaks
1 hour	II.	DRIVING IN FIELDS
		A. Starting in proper gear
		B. Controlling speed
2 hours	III.	PULLING A TWO WHEEL TRAILER
		A. Hitching
		B. Pulling and Turning
		C. Backing
<u>1 ½ hours</u>	IV.	HITCHING TO A 3 PT IMPLEMENT
6 hours		

LAB III

2 hours I. SERVICING THE FUEL SYSTEM

A. Cleaning the outside of any component before loosening or opening

B. Sediment bowl

C. Primary Filter

D. Secondary Filter

E. Priming the pump

F. Priming the injectors

2 hours II. PULLING AND BACKING A 2 WHEEL TRAILER

2 hours III. OPERATING A CHISEL PLOW IN THE FIELD

6 hours

A. Depth Control

B. Lifting the plow when turning

C. Determining proper row spacing

LAB IV

1 ½ hours — I. SERVICING ELECTRICAL SYSTEM

- A. Check battery water
- B. Check battery terminals
- C. Check battery for leaks
- D. Clean battery cables
- E. Check alternator belt for wear and tension
- F. Check alternator bearings for looseness and noise
- G. Check all wires for looseness at terminals, and bare spots in insulation
- H. Check all lights for proper functioning.

2 hours — II. PULLING AND BACKING A 2 WHEEL TRAILER

2 ½ hours — III. PULLING AND BACKING A [illegible] WHEEL TRAILER

2 hours — IV. PULLING A 2 WHEEL SCRAPER

8 hours

- A. Loading and transporting
- B. Unloading
- C. How to avoid getting stuck, and how to get unstuck. "There are those who have been stuck, and those who are going to get stuck."

LAB V

2 hours I. SERVICING THE WHEEL BEARINGS, TRANSMISSION, CLUTCH, FINAL DRIVE, AND OTHER PARTS REQUIRING GREASE

3 hours II. OPERATING THE LAND PLANE

3 hours III. OPERATING THE MOLDBOARD PLOW

8 hours

A. One way plowing

B. Two way plowing

C. Opening the field

D. Plowing the head land

E. Dividing the field into lands

F. Locating the dead farrows

LAB VI

2 hours — I. SERVICING THE LUBRICATION SYSTEM

- A. Be sure the engine is warm
- B. Draining oil
- C. Replacing filters
- D. Checking the old oil for condition, and any signs of metal indicating problems in the engine
- E. Cut open the old filter to see how it works and what matter it filters out of the oil
- F. Refill with recommended oil

2 hours — II. OPERATING THE DISC PLOW

2 hours — III. OPERATING THE HARROWS

- A. Adjust the angle of the disc harrow
- B. Compare with the spike tooth harrow

2 hours — IV. OPERATE THE BED SHAPER

8 hours

- A. Make the proper furrow spacing and bed width

LAB VII

I. REPAIRING ANY DAMAGE DONE TO THE TRACTORS DURING THE TRAINING PROGRAM PROVIDED THE TIME, MATERIALS, TOOLS, AND SKILLS ARE AVAILABLE

II. OPERATE THE GRAIN DRILLS

   A. Check the seed and fertilizer flow rate

III. OPERATE THE CORN AND/OR COTTON PLANTER

   A. Check seeding depth

   B. Check seed spacing

IV. OPERATE THE POWER SPRAYER

   A. Check the application rate

V. OPERATE THE BULLOCK DRIVER EQUIPMENT

   A. Drive a team of bullocks pulling:

      1. a karak

      2. a dessi plow

      3. a tarfahli drill

Subject: COTTON PRODUCTION GUIDELINES

Trainer Agronomist
Class Room 3 hours
Field 0 Days

OBJECTIVES

To acquaint the trainees in the important aspects involved in cotton production. This is to include every operation from land preparation and sowing to maturity of the crop including plant protection measures.

MATERIALS NEEDED

Charts showing land preparation, seeding and hoeing implements in operation. Seed of various varieties for identification for growing in different cotton regions.

TRAINING AIDS

1. Slides on related production points with slide projector.
2. "Modern Techniques of Cotton Cultivation", one copy for each trainee.

INTRODUCTION

Cotton is the most important fiber crop of the world and of Pakistan today. In addition to meeting domestic requirements, a significant part of the much needed foreign exchange is earned from its export. In Pakistan, two types of cotton, "Desi" and "American", are grown. Desi cotton is mainly used in domestic and small industries, whereas American cotton is exported as well as used in our textile industry.

PRESENTATION

The following points are important in cotton production. These are outlined in detail in the Urdu publication "Modern Techniques of Cotton Cultivation", which should be used extensively when working with farmers.

Land Preparation

Land/Field should be prepared with 4-5 ploughings and 3-4 plankings. The field must be precisely leveled for uniform irrigation and moisture distribution. This factor alone can result in up to 10% higher yields. Cotton should not be planted in water logged and saline soils.

Time of Planting

Cotton should be planted according to agro climatical zones of Pakistan as follows:

Punjab: From May-June except in Thal where the sowing is done from March-April.

Sind: From May-June except in Thatta and Tharparkar where the sowing is done rather early, starting from mid-February.

NWFP: From April-May.

Seed should be soaked for 14 hours before sowing and well mixed with dust/dung to ensure free flow through the drill pipes. Poor quality seed should not be used.

Method of Planting

Planting can be done of the flat or on ridges. Ridge planting is the best. On flat ground planting can be done with a drill, keeping a row to row distance of 2-2½ feet. Planting depth should be 2-2½ inches. Planting on ridges should be done especially when the soil is hard clay or saline. Ridge planting offers several advantages. Ridges should be raised with 2½-3 feet space between the rows. Seed should be planted on the slope of ridge in saline soil and on the top of the ridge on nonsaline soils. Irrigation is more efficient with ridge planting.

Zoning of Varieties

To maintain purity and to avoid mixtures, specific varieties are recommended for various zones. Each variety if adopted to the areas in various provinces.

Punjab

District	Area	Variety
Lahore	1. Area West of the Baloki, Sulemanki Link Canal	AC-134
	2. Rest of the District	Desi(D-9)
Sheikhupura	1. Sheikhupura and Nankana Sahib Tehsils	AC-134
	2. Ferozewala Tehsil	Desi(D-9)
Gujranwala	1. Wazirabad and Gujranwala Tehsil	Desi(D-9)
	2. Hafizabad Tehsil	AC-134
Sialkot	Whole District	Desi(D-9)
Sargodha	Whole District	AC-134
Faisalabad	Whole District	AC-134
Jhang	-do-	AC-134 & B-557
Mianwali	1. Esakhail Tehsil	Desi (D-9)
	2. Rest of the District	AC-134
Gujrat	1. Area falling to the south west of Upper Jehlum Canal right from Headworks to River Chenab	AC-134
	2. Rest of the District	Desi (D-9)
Campbellpur Rawalpindi Jhelum	Whole District	Desi

District	Area	Variety
Multan	-do-	AC-134 & 149 F (MS-39 with the special permission of the Dept.)
Mianwali	1. Esakhel Tehsil	Desi (D-9)
	2. Rest of the District	AC-134
Gujrat	1. Area falling to the southwest of Upper Jhelum Canal right from Head works to River Chenab.	AC-134
	2. Rest of the District	Desi(D-9)
Campbellpur Rawalpindi Jhelum	Whole District	Desi
Multan	-do-	AC-134 & 149F (MS-39 with the special permission of the Dept.)
Sahiwal	-do-	AC-134 & B-557
Muzaffargarh D.G.Khan	-do-	AC-134 with 149F (MS-39 with the special permission of the Dept.)
Bahawalpur	1. North of Railway line from Bahawal Mailsi Link to Samasata and from Samasata to Chenigoth main Railway line and whole of Ahmadpur East Tehsil	BS-1 (149F with the special permission of the Dept.)
	2. North of Railway Line from Bahawal Mailsi Link to Bakhshan Khan	AC-134
	3. Rest of the District	Desi
Bahawalnagar	1. North of Railway line from Bakhshan Khan to Amroka including strip north of Ber distributory	AC-134 (149F with the special permission of the Dept.)
	2. Rest of the District	Desi
Rahim Yar Khan	3. Whole District	BS-1 (149F with the special permission of the Dept.)

Sind

i. Upland Cotton

Khairpur	Mloo and S-59-1 (Sarmast)
Hyderabad Nawabshah Sanghar Tharparkar	M100 and H-59-1 (Qalandri)
Dadu	Only H-59-1 (Qalandri)

ii. Desi Cotton — T·D·I· and S·K·D· 10/19 in Desi Cotton growing Talukas of District Nawabshah (Moro, Kandiaro, Nao Shahroferoze) and Khairpur (Faiz Ganj and Mirwah)

N·W·F·P·

D·I·Khan Division	B·S·1
Peshawar Division	Peshawar Desi

Plant Population

There should be 15,000 to 20,000 plants per acre in Punjab and 25,000 to 30,000 plants per acre in Sind. Lower plant population will result in lower yield. Thinning, if necessary should be carried out. In order to get adequate plant populations, seed of good quality must be used.

Seed Rate

For American varieties 12-14 Seers/acre of seed should be used and for Desi varieties 8-10 Seers/acre with 70 to 80% germination. Higher seed rate should be used for late plantings, followed by thinning if necessary.

Irrigation

Farmers very commonly tend to over irrigate their cotton with as many as 6-10 irrigations. Recent research results have shown that 4-5 irrigations will produce optimum yields (Figure 1). The consumptive use of water is shown in Figure 2 and is about 26 inches per year. The maximum consumptive use is in September when weekly evapotranspiration approach 1.6 inches per week. This high utilization period can best be met by insuring that the soil profile is full of water before this high use period begins. This is best accomplished by proper irrigation based upon the water holding capacity of the soil, if possible. The plants should not be placed under a moisture stress during the flowering or fruiting stages of growth. If this occurs, excessive fruit abortion will occur and yields will be decreased substantially.

Fertilizers

Fertilizer recommendations will vary according to the cropping pattern and fertility level of the soil. The general fertilizer recommendations are as follows:

Punjab Province

Soil Fertility Level	Fertilizer/Application Method
a. Medium soils	One bag of DAP at planting, ½ bag Urea at first irrigation, 1 bag Urea at pre-flowering stage.
b. Poor soils	1 bag of DAP at planting, 1 bag Urea at first irrigation, 1 bag Urea at pre-flowering stage.
c. Rich soils (or cotton planted after fertilized wheat)	½ bag of Urea at planting, 1 bag of Urea at pre-flowering stage, Phosphate should be used on all soils if indicated by soil test.

Sind Province

a. Cotton followed by fertilized wheat	½ bag DAP at planting, ½ bag Urea at first irrigation, 1 bag Urea at pre-flowering stage

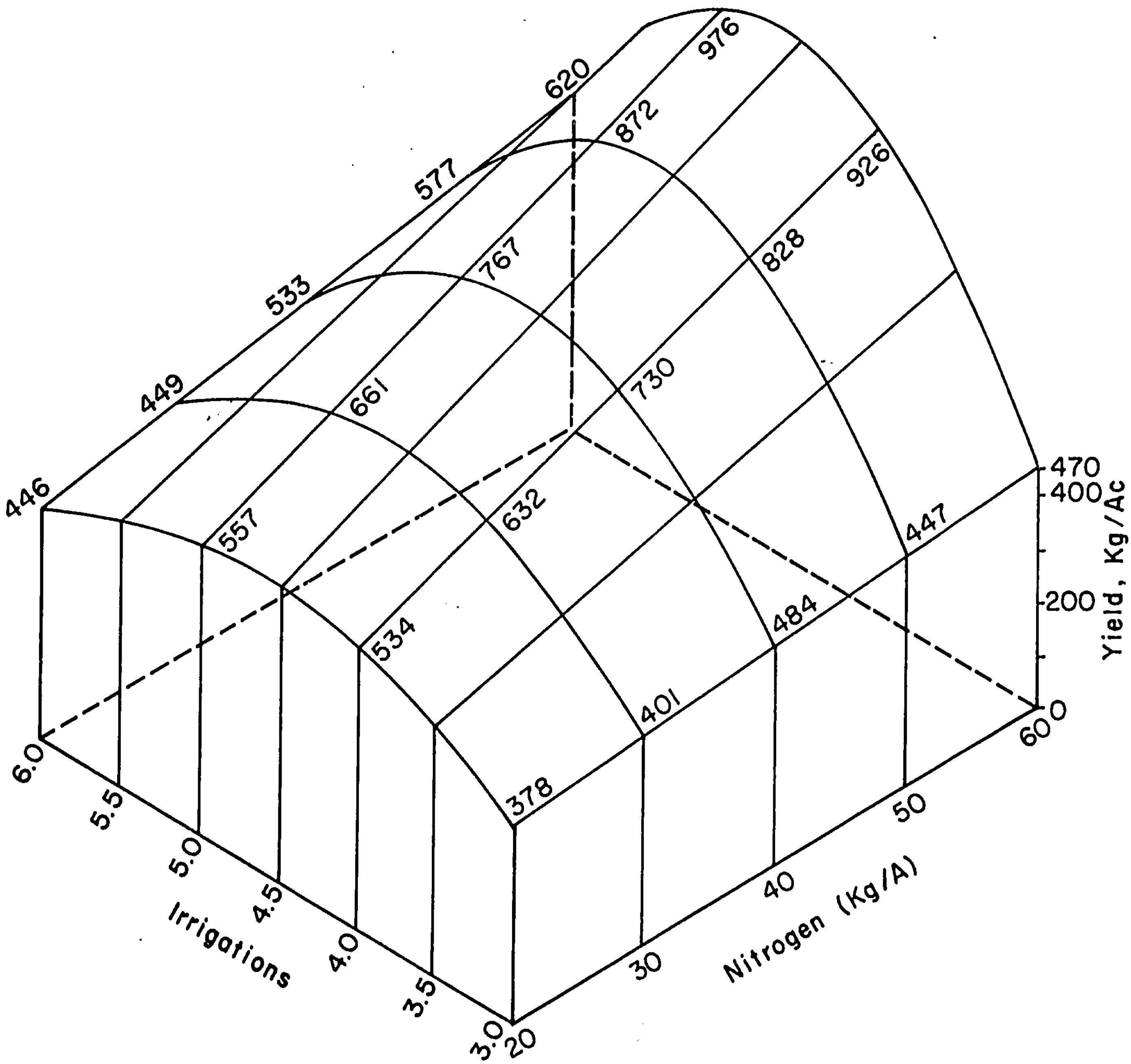


Figure 1. The Interaction of Nitrogen and Irrigation Requirement on the Yield of Cotton.

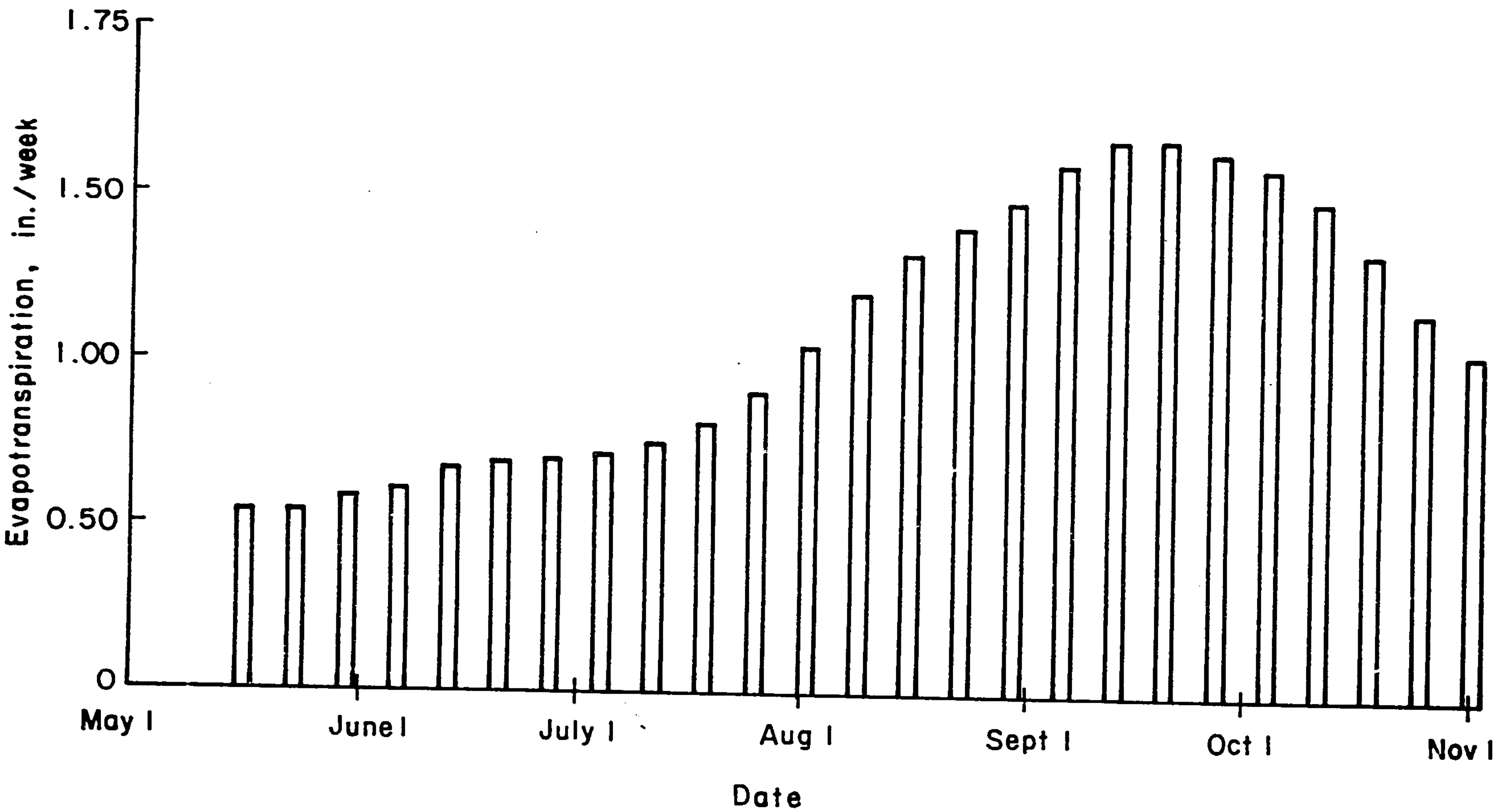


Figure 2. The Weekly Consumptive Use of Water for Cotton.

b. Fallow soils — 1 bag of DAP at planting,
½ bag of Urea at first irrigation,
1 bag of Urea at pre-flowering stage.

Notes

a. If a straight P fertilizer is used; ½ bag of Urea should be used at planting.

b. Current research shown that uptake of phosphates is improved when applied with a fertilizer drill immediately before the first irrigation, resulting in higher yields.

c. Ideally, the quantity of fertilizer to be used should be determined by a soil test.

d. The phosphatic fertilizers should preferably be incorporated in the soil after thoroughly mixing with double the quantity of farmyard manure. This will improve the uptake of phosphates by plants and increase its efficiency.

Plant Protection

Preventive Measures Against Carryover Of Pest Infestation From Previous Season:

1. Grazing in Cotton Fields after Last Picking

Wherever possible, goats should be allowed to graze cotton fields after last picking so that all pest infested bolls, seeds, etc. are eaten.

2. Disposal of Cotton Sticks, Debris and Ginning Refuse

Cotton sticks should be removed and disposed of by burning along with the debris by the following dates:

Punjab -Mid-February

Sind -End of January

Factory refuse should also be burnt by the ginners by the above dates.

3. Deep-Ploughing and Field Sanitation

All cotton fields should be ploughed deep with furrow turning plough immediately after harvest. The alternate host plants of cotton pests growing in the field such as Bhindi/Gulkhaira should also be removed and burnt.

4. Sun-heating and Fumigation of Cotton Seed Before Planting

Cotton seed should be sun-heated for 2-3 consecutive days before planting. This kills the larvae of pink bollworm which are usually found with the seeds. The seed should be spread in a thin layer on a "Pakka" floor with direct exposure to the sun for 4 to 5 hours from about 11 A.M. to 3 P.M. The cotton seed godowns must be fumigated with Phostoxin/Actia before the end of February.

Chemical Control

Use pesticides to control insect pests and diseases that attack cotton to optimize yields. Care should be exercised in the use of pesticides and they should only be used when needed. Regularly pre-arranged application of pesticides should be avoided. This will reduce the cost of production and avoid undue harm to the natural preditors of harmful insect pests.

Recommended Pest Control Measures--

1. Protection of Cotton Seed and Seedlings Against Crickets.

Crickets attack cotton seed and seedlings in certain areas of Pakistan where cricket populations are high. Higher seed rate of 15-20 seers per acre should be used in such areas. Dieldrin bait, prepared in the ratio of 4 ounces of insecticide mixed with 100 pounds of rice husk, should be spread in the fields before planting cotton @ 20-30 pounds of the material per acre.

The bait should be moist but not wet or dry. Baiting should be repeated 2-3 times or when necessary. Alternatively, 2-3 pounds BHC mixed in 10 seers of dust/ash should be dusted on the ground in the evening.

2. Control of Sucking Insect Pests (White Fly, Jassid, Thrips, etc.)

Cotton is attacked by a number of sucking insect pests in the early stages of its growth. These should be controlled by the following method.

a. Soil application of systemic granular insecticides.

Temik 10%, Disyston 10%, Solvirex 10%, or Themit 10% (in the order of efficiency) should be applied to the soil close to the plant bases @ 10-15 pounds per acre. Being toxic, these materials must be applied under the supervision of technical personnel. This is specially important with liquid pesticides which are harder to handle than granular pesticides. The field should be irrigated immediately after the application of granules. The fields should be level and bunds should be strengthened to avoid breaches. A second treatment may be made if needed. Application of systemic granules should not be made more than twice per season nor should it be repeated within 21 days.

b. Spraying.

The sucking complex can also be controlled by foliar application of the following insecticides:

Insecticide	Dosage (a·i·/acre)
Phosphamidon (Dimecron)	4-6 ounces
Dirotophos (Bidrin/Carbicorn)	4-6 ounces
Monocrotophos (Azodrin/Nuvacron)	4-6 ounces
Dimethoate (Roxion/Zolon D·T·)	4-6 ounces
Anthio	4-6 ounces

The list of approved insecticides by Department of Plant Protection may be consulted for alternate insecticides. When needed, spraying should be repeated at intervals of not less than 10 days.

c. Control of pink bollworms in the field.

The pink bollworm is the most serious cotton pest, particularly in the Multan and Tharparkar areas. The use of the following chemicals is recommended:

Insecticide	Dosage (a·i·/acre)
Carbaryl (like Sevin)	2·0 to 2·5 lbs.
Monocrotophos (Azodrin/Nuvacron)	0·6 to 1·0 lbs.
Azinphosmethyl (Gusathion)	0·5 to 1·0 lbs.

DDT can also be used in combination with compatible phosphatic pesticides.

d. Control of mites.

Mites are not controlled by common pesticides. The use of the following miticides is recommended:

Miticide	Dosage (a·i·/acre)
Dicofol @	1·0 to 1·5 lbs.
Monocrotophos @	0·2 to 1·0 lbs.
Dicrotophos @	0·1 to 1·2 lbs.

3. Disease Control in Cotton

1. Root Rot of Cotton

a. Late sown crop suffers less from root rot than does early sown cotton. Late planting may be followed in the known root rot infested areas.

b. Removal of stubbles from disease infested fields and deep ploughing reduce the chances of recurrence of the disease.

c. Planting cotton after a leguminous crop also helps to control root rot.

d. Cotton can be planted mixed with mouth in such infested areas. The mouth plants should be removed in August.

2. Boll Rot of Cotton

   a. Clean cultivation, removal of cotton sticks and plant debris should be accomplished to avoid boll rot.

   b. Use of sound, healthy seed treated with proper fungicides, i.e., T·M·T·D· is recommended.

3. Tirk or Bad Opening of Bolls

   a. Late planting helps overcome Tirk, low yield due to late planting may be compensated by increasing plant population.

   b. Application of adequate quantities of fertilizers to maintain proper plant vigour is recommended.

Picking

Immature bolls should not be picked. Picking should be done during a sunny day after 10 or 11 A.M. Leaves should not be picked with seed cotton to maintain quantity of fiber of the picked cotton. Different varieties should be picked and stored separately.

APPLICATION

1. Each trainee will examine and identify the seed of different varieties.

2. Each trainee will learn the agronomical steps involved in cotton production and their importance as to why they be adapted.

QUESTIONS

1. Why should the land be well prepared and pulverized for cotton sowing?

2. What is the best sowing method and what should be the plant population?

3. What are the critical points which must be avoided for good production?
4. Should the amount of irrigation vary under low and high water table situation; why?
5. Why should a high seed rate be used in case of late sowing?
6. What important points should be emphasized for good plant protection measures?

Subject: RICE PRODUCTION GUIDELINES

Trainer Agronomist
Class Room 3 hours
Field ________________ Days

OBJECTIVES

To teach the trainer the important aspects of profitable rice production and to enable them to help the farmer independently to improve their agronomic practice.

MATERIALS NEEDED

Charts of agricultural implements need for agricultural operations involved in rice cultivation. Seed of various varieties, fine and coarse for identification and characteristics.

TRAINING AIDS

1. Slides showing the major operations of rice production.
2. "Modern Techniques of Rice Cultivation"; 1 copy of Urdu publication by Dept. of Agri./student and "Comprehensive Plan for Control of Agricultural Pests for Rice" by Dept. of Agri., 1 copy/student

INTRODUCTION

Rice is one of the most important cereals of the world and more than half of the population of the globe subsists on it. This crop is also of great importance in Pakistan. In addition to meeting the dietary requirements of the people, it is a very good foreign exchange earner. The Pakistan Basmati rice is world famous for its special aroma and brings very high prices in the international market. Two types, coarse and fine, of rice are commonly grown.

PRESENTATION

The following points are of major importance in rice production. These are outlined in detail in the Urdu publication "Modern Techniques for Rice Cultivation" and "Comprehensive Plan for Control of Agricultural of Rice." Both of these publications should be used when contacting farmers.

Land Preparation

The land should be prepared with 4 dry plowings followed by planking. Clods must be broken and field leveled for uniform application of irrigation water. Soils that are subject to excessive leaching and will not puddle should not be used for rice production.

Time of Planting of Nursery

The nursery seedlings should be planted according to the following recommended schedule for each Province.

	Nursery Planting Date
a. Punjab	
IR-6	May 20 to June 1
Basmati 370	June 1 to 1st week of July
b. Sind	
Southern region	April 25 to June 10
Central region	May 10 to June 15
Northern region	May 20 to June 30
c. NWFP	
For plains	1st week of June
Sub-mountainous regions	3rd week of June
d. Baluchistan	
For all rice areas	May 20

The characteristics of the various varieties are shown in Table 1.

Seed Germination

Dry and selected seed should be soaked in water, piled on the floor and covered with a jute bag. No more than 15 seer of seed should be placed in

Table 1. Characteristics of Rice Varieties.

Sr. No.	Characteristics	Varieties					
		Jhona 349	IR-8	IR-6	Basmati 370	Basmati 6129	Basmati 198
1	Plant height (cm)	167.5	95.0	95.0	170.0	170.0	137.5
2	Leaf color	Green	Dark Green	Dark Green	Green	Green	Dark Green
3	Leaf habit	Droopy	Erect	Erect	Droopy	Droopy	Semi-erect
4	Stem stiffness	Weak	Very stiff	Stiff	Weak	Weak	Stiff
5	Growth period (days transplanting to maturity)	95	110	110	120	120	130
6	Yield (md/A)	25-30	55-60	45-50	20-25	20-25	30-35
7	Grain character						
	a) kernal length (mm)	6.36	6.14	6.60	7.00	7.70	6.90
	b) kernal width (mm)	2.00	2.43	2.00	1.83	1.80	1.90
	c) kernal thickness (mm)	1.94	1.94	1.70	1.60	1.66	1.69
8	Aroma	No	No	No	Yes	Yes	Yes
9	Chalkiness	No	Very Chalky	Slightly Chalky	No	No	No
10	Cooking quality	Not good	Not good	Good	Better	Best	Good

one pile. The seed should be occasionally stirred and remoistened. Germination will start in 2-3 days and they should be sown in the nursery immediately.

Seeding Rate

The nursery should be sown at a rate of ½ seer of seed per marla (272.25 ft^2). Two lbs. of ammonium sulfate or one lb of urea/marla should be applied at sowing. Sowing too many seeds results in the reduction of seedling vigor and the plants become weak and pale because of excessive crowding. Root injury to a weakened plant at transplanting reduces the vigor of these plants. Unhealthy plants also become more susceptible to pests and diseases.

Transplanting

Transplanting should be accomplished 25-35 days after sowing in the nursery. If the age of seedling varies excessively from the 25-35 day age, yields of the rice crop can be reduced (Table 2). Nursery establishment and proper transplanting are the first major step in assuring a good rice crop at harvest. Special attention should be given to stem borrer central in the nursery. The latest recommendations are outlined in the Urdu publication, "Comprehensive Plan for Control of Agricultural Epidemicy Rice."

Recommended Varieties

Punjab

IR-6 and Basmati 370

Sind

Southern Zone IR-6(Mehran 69), IR-8(IRRI-Pak) and Kharai Gunja
Central Zone IR-6, IR-8 and Kangni X Torh
Northern Zone IR-6, IR-8 and IR-841 (Abbasi-72)

Table 2. Effect of Age of Seedlings at Transplanting Time on the Yield of Rice[1]

Age of seedling at transplanting	Yield[2] (mds/acre)
15	52.3
25	56.6
35	55.4
45	51.3
55	47.7
65	44.8

[1]Asmat Ali Shah, Saeed Ahmad, M. Afzal
Rice Research Institute, Kala Shah Kaku, 1974.
[2]Average yield of a number of varieties.

Table 3. Effect of Spacing on the Yield of Rice[1]

Spacing (inches)	Plant population level	Yield[2] (mds/acre)
6 x 6	174240	34.1
4.5 x 9	154880	35.7
9 x 9	77440	41.3
12 x 12	43560	38.7
18 x 18	19360	35.7

[1]Majid, Rice Research Institute, Kala Shah Kaku.
[2]Average of a number of varieties.

Table 4. Effect of Number of Plants per Hill on the Yield of Rice[1]

No. of plants per hill	Yield (mds/acre)	
	Basmati 370	IR-4
one	16.2	65.1
two	14.1	66.9

[1]A. Majid, Rice Research Institute, Kala Shah Kaku.

NWFP

IR-8, IR-9 and Bas-370 in plains. YRL-I, JP.5 and Bas C.622 in submountainous area.

Baluchistan

IR-6 and IR-8 for plains.

Nursery Seed Rate

a. For IRRI varieties and local coarse varieties, 10-15 seers per acre.

b. For Basmati and Sugdasi varieties, 8-10 seers per acre.

Plant Population in the Field

For optimizing rice production, the plant population should be 75,000 to 80,000 hills per acre with spacing of 9" x 9" (Table 3). Two seedlings should be transplanted per hill to insure adequate populations although final grain yields are affected very little (Table 4).

Fertilizer Application

Fertilizer application would vary according to the varieties being planted, as the nutrient requirement of each variety varies. Doses may also vary according to the fertility level of the field. Basmati varieties are less responsive to fertilizer than coarse varieties. Fertilizer recommendations are given in Table 5. Zinc deficiencies have been identified in many areas. These symptoms usually occur 15-20 days after transplanting. The general recommendation is to apply 10 lbs. zinc sulfate per acre at transplanting. The seedlings can also be soaked in a solution of zinc oxide prepared by dissolving 2 lbs. of zinc oxide in 10 gallons of water.

Water Management

The two systems of irrigation of rice that are commonly used are continuous flood and alternate wetting and drying.

Table 5. Fertilizer Recommendations for Rice

Variety	Soil Fertility status	Quantity of fertilizer/A	Method and time of Application
IR-6 and Cas-198	Rich	1 bag DAP plus ½ bag Urea (45 lb N+50 lb P_2O_5)	At transplating before last plowing
		½ bag Urea (25 lbs N) ½ bag Urea	22-25 DAT 45-50 DAT
IR-6 and Cas-198	Medium	1 bag DAP plus 1 bag Urea (70 lb N+50 lb P_2O_5)	At transplanting before last plowing
		½ bag Urea ½ bag Urea	25 DAT 40-45 DAT
IR-6 and Bas-198	Poor	1 bag DAP plus 1 bag Urea 1 bag Urea (50 lb N) ½ bag Urea	At transplanting before last plowing 20-25 DAT 40-45 DAT
Basmati 370 and Pak-Basmati	Rich and medium	½ bag DAP (10 lb N+25 lb P_2O_5) ½ bag Urea ½ bag Urea	At transplanting before last plowing 20-25 DAT 40-45 DAT depending on condition of crop
Basmati 370 and Pak-Basmati	Poor	½ bag DAP lus ½ bag Urea (35 lb N+25 lb P_2O_5) ½ bag Urea ½ bag Urea	At transplanting before last plowing 20-25 DAT 40-45 DAT depending on condition of crop
Special Recommendations for the Sind.			
Local tall		½-3/4 bag Urea (25-37 lb N)	14 DAT
IR-6 and IR-8		1 bag DAP + 1 bag Urea (70 lb N + 50 lb P_2O_5) 1 bag Urea (50 lb N)	One day before transplanting 45-55 DAT* (At panicle initiation)
IR-841		1 bag DAP + 3/4 bag Urea	35-40 DAT* (At panicle initiation)

Fertilizer applications recommended before transplanting can be made 10-15 DAT without loss of yield.
*DAT = Days After Transplanting.

Continuous Flooding: In this system rice fields are continuously flooded and water is applied frequently. Continuous flooding has a number of effects on rice plants and production, some beneficial and some detrimental. The detrimental effect results from too deep of flood.

1. Continuous flooding results in elongating the plants and the risk of loding of the crop increases if the water is too deep.
2. Tillering capacity is decreased and utlimately, yield will be decreased if the water is too deep.
3. Continuous flooding controls weeds very effectively. If water is maintained 2" deep, grasses are controlled and at 3" depth, broad leaf weeds are controlled.
4. Continuous flooding increases solubility and availability of iron, manganese and phosphorus to the plant.

Alternate Wetting and Drying: Alternate wetting and drying affects plant growth in a number of ways:

1. Alternate wetting and drying encourages more tillering and decreases plant height and the risk of loding.
2. Weeds can become a big problem in this sytem and result in decreased yields.
3. Nitrogen fertilizer use is less efficient.

Various irrigation intervals have been tried. Research studies conducted at Kala Shah Kaku indicate that rice should be irrigated on a 5-day interval. Irrigation intervals of more than 5 days will reduce the weight per panicle, number of panicles per hill and yield per acre. At a 5-day interval the field does not get dry and remains in the form of soil-water suspension. If weed infestations are a potential problem, this method should not be used. Continuous flooding would be preferred.

Critical Periods of Irrigation: There are three critical stages of the growth of the rice plant where water stress will reduce yields. These are at tillering, earing and maturing stage. A water deficit at any of these stages will reduce crop yields. Basmati varieties should not be allowed to go without water for over 15 days under any circumstances. However, there are some stages when irrigation water can be saved. In research experiments conducted at Kala Shah Kaku, rice fields have been successfully drained at 40 DAT for 4-14 days without affecting crop yield. Weed infestation problems need to be considered. The depth of irrigation water should not exceed 3". At early stages of growth, the water depth should be less but adequate enough to control weeds.

Consumptive Use of Water: The consumptive use of water is the amount of water that is required to grow the crops. This includes both irrigation and rain water. The consumptive use of rice is approximately 44 to 47 inches of water depending on the planting date and maturity (growth duration) of the variety. The earlier the planting date the higher the consumptive use because of the high evapotranspiration (ET_p) rates that occur during the hot dry season. During late May and early June the ET_p will be around 0.35 in/day while during the last of July and first of August, this value will be about 0.25 in/day and weekly values range from 1.75 to 3.20 inches. Since the peak water consumption period falls during the monsoon season, a substantial amount is satisfied by rainfall. Because of this the number of irrigations is highly variable and will often vary from 6 to 15 depending on the season.

A graph showing the consumptive use over the season is shown in Figure 1. This example is of a 120-day maturing variety (Basmati). The shape of the graph for shorter maturing varieties or different planting dates is very similar.

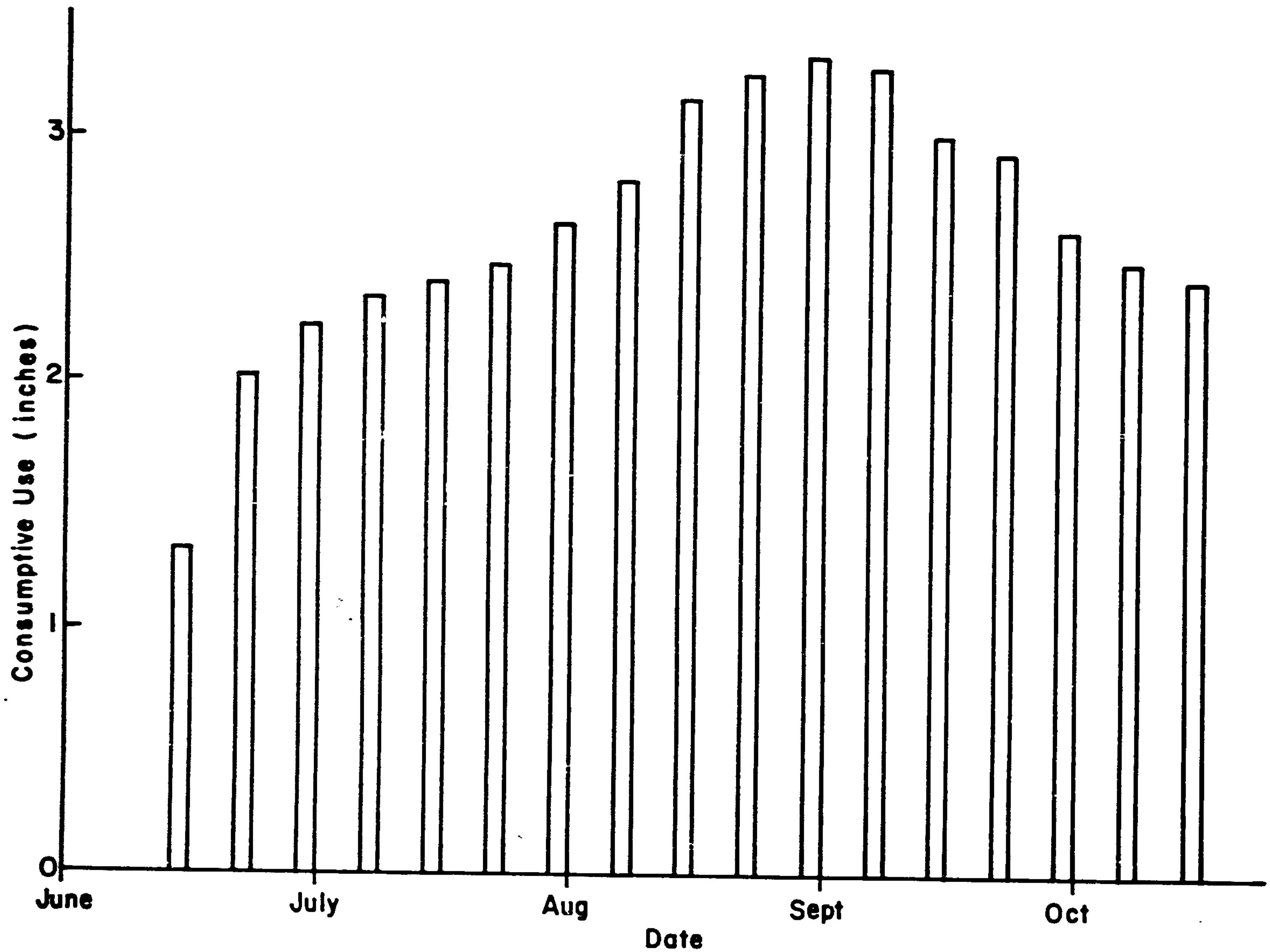


Figure 1. The Weekly Consumptive Use of Water for Rice.

Surface Drainage

Proper surface drainage is also important in rice production. Even though rice can tolerate water much better than any other crop, water standing too deep on the rice field can reduce yields. Wherever possible, the depth of water should not exceed 3 inches. During the Monsoon season this is sometimes impossible but adequate drainage should be provided for so the excess water can be drained off when the flood water level recedes.

Weed Control

Weed infestations in rice are a major problem and cause large reduction in yields if not controlled. Weeds should not be allowed to grow and removed later for animal fodder. When weeds compete with rice for nutrient, space and light for this long they cause yields to be reduced substantially. Weeds should be controlled when they are small and not allowed to compete with rice. The major weeds that infest rice fields are as follows.

Deela (Cyperus Sotandus), Dhidan (Echinochloa Crusgalli), Sawank (Enchinochloa Calonum), Mirch Booti (Sphenoclea Zeylanica), Naru (Paspalum Distichum), Ghooin (Cyperus Difformis), Bhoin (Cyperus Iria), Chati Bhoin (Fimbristylis Littoralis), Kuta Kami (Nymphaea Steelata) are the weeds that infest rice fields and must be controlled. Deela, Dhidan, Sawank, Mirch Booti and Naru are the worst, most common weeds. Several methods are useful in controlling weeds. Proper water depth is one of the most important factors. If a water depth of 2-3 inches is maintained, weed infestation levels will be kept to a minimum. Under heavy weed pressures, additional methods of control will be necessary. Cultural control, to include transplanting of weed free seedlings, is always an important factor in controlling weeds. Much research is being done on chemical control of weeds. Some chemicals are available or will be in the near future that have excellent weed control characteristics. As is with all pesticides, their success is highly dependent on the use of proper application rates, timings and methods as specified by the manufacturer.

The achievement of proper weed control involves an integrated approach including cultural as well as chemical control. The following procedures are recommended:

Cultural Control

1. Seedbed preparation

   a. Puddling of fields helps to control weed population by destroying growing weeds and by producing soil conditions which reduce the growth of weeds. This method is the best cultural method to follow.

   b. Plowing and planking the fields in vattar and then allowing the weeds to grow and plow again after about 15 days interval also helps control weeds.

2. Sowing weed free nursery

   Care should be taken that the nursery should be weed free seed. This includes sowing of weed free seed. If weeds are transferred along with the nursery plants during transplanting, they grow faster than the rice seedlings and cannot be controlled without hand weeding.

3. Method of sowing

   Sowing by transplanting helps minimize weeds as compared with the broadcast (direct) sowing.

4. Sowing in lines

This method allows easier eradication of weeds by hand or mechanical methods as compared to irregular sowing.

5. Irrigation

If 2-3" water depth is maintained in the field for one month, the rice plants will be properly established. The interception of solar radiation due to shading or rice plants will not allow weeds to grow. If the field dries up, a heavy weed infestation will occur.

Chemical Control

Although this method is not widely used by farmers, it is the best method available for control of weeds and is gaining wider acceptance every year. Typical yield responses to the use of herbicides are shown in Figure 2. Yields were increased by 27.4 mds/A. This type of response is not unusual and farmers with weed infestation problems can expect similar results if proper rate, timing and application methods are followed.

The herbicides that are in various stages of standardization and registration are given in Table 6. By the 1980 crop it is anticipated that all these herbicides will be standardized and registered for use by the farmers. Presently, only Stam F-34 is generally available. It has not been widely accepted because the field must be drained for spraying. Proper flooding after spraying is required to get weed control. This is not always possible. All the other herbicides in Table 6 are applied in 2-3" of flood water as granules, or liquid in the case of Treflon-R. This method is much easier for the farmer and proper weed control will be achieved. A great potential

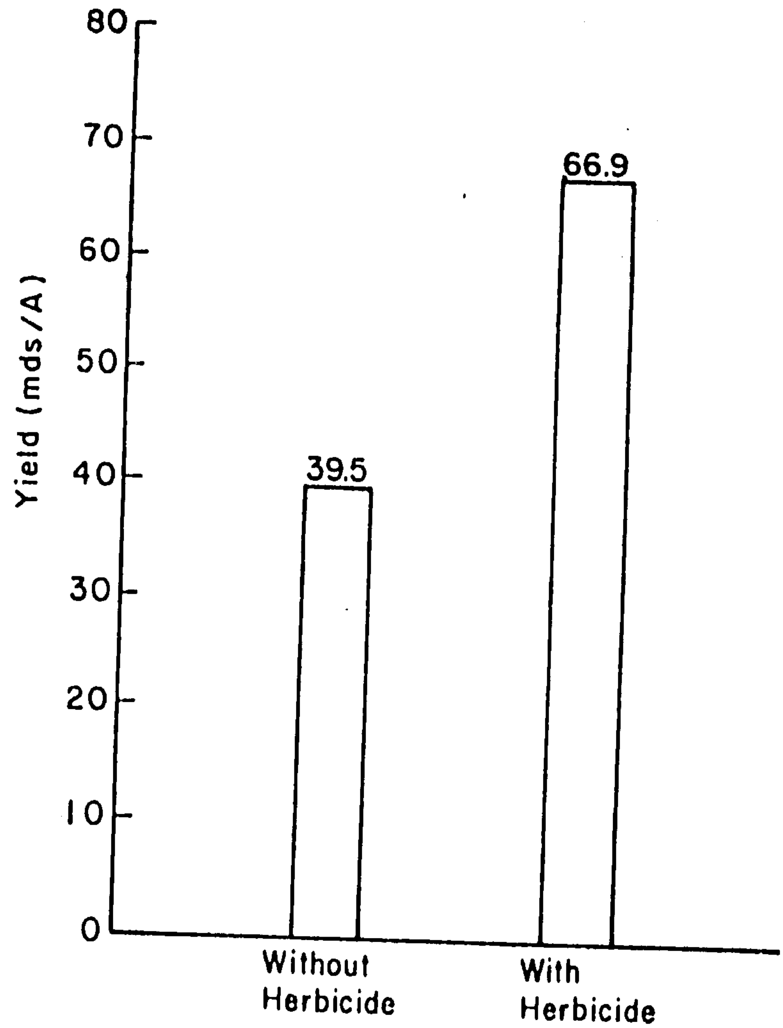


Figure 2. Yield of rice with and without herbicide weed control.*

*From A. Majid, Saeed Ahmad and Manzoor Ahmad, Rice Research Institute at Kala Shah Kaku.

Table 6. Herbicide Recommendations for Control of Weeds in Rice

Name	Rate of application of material (lb/A)	Time of Application
Stam F-34 (36% E.C.)	4.5 l/A	15-20 DAT on dry field
TOK 7% granual	29	5-6 DAT on flood water
Satum 10% granual	25	20-30 DAT in flood water
Machete 5% granual	33	20-30 DAT in flood water
Treflan-R (E.C.)	2.4 l/A	5-6 DAT dribbled in flood water

exists for the use of herbicides in the increased production of rice and all farmers should be encouraged to adopt this practice.

Plant Protection Program

Crop protection includes insects, animals, diseases as well as weed control. The methods of control include cultural, mechanical and/or chemical.

Insect Control: The common insects that attack rice are as follows:

1. Yellow Stem Borer: Active period is April to October.
2. White Stem Borer: If plant is attacked before panicle formation, then the central shoot is cut down at the base and white heads appear which have no grains.
3. Pink Stem Borer: Dead hearts and white heads occur as in the case of the white stem borer.
4. Lead Hopper: Sucks plant juices.
5. Weevil: Attacks plant roots.

The control of the major insect pests like stem borers, can be undertaken by cultural, mechanical or chemical methods. The first two are generally only partially effective under a heavy infestation history and generally the chemical method is the only effective method. If the insecticide is applied properly according to the manufacturer's specifications,effective control will be achieved. Many cases of insecticide failure that have been reported are caused by improper application rates, timings and/or methods.

Chemical Control Methods

1. Nurseries: The nursery should be treated as shown in Table 8 with one of the chemicals. An application should be made 8-10 days after planting or 15-20 days after planting depending on the insecticide used. Since stem borer infestation is readily

carried to the field in the seedlings at transplanting treatment of the nursery is very important.

2. Tranplanted Crop: The pest infestation should be checked at least once a week. If the infestation level is above 1%, the first granular application should be made 25 DAT and the second application 50 DAT. The chemicals shown in Table 6 are recommended at the dose rates given. It is recommended that for granular application 3" deep water should be mtaintained on the crop continuously for 3 days after application to produce the best results.

Cultural Control Methods

1. Plowing the rice fields with a furrow turning plow by the end of February to bury the stubbles where the larvae hibernates is necessary to control stem borer. This conforms to regulations by the West Pakistan Agricultural Pest Ordinance, 1959.
2. The harvested paddy should be removed from the field immediately after harvest ot minimize the migration of larvae from the harvested crop to the stubble

Mechanical Control Methods

1. Use of a light at night for collection and destruction of moths is recommended. If aerial spraying is being carried out it is further recommended that it should synchronize with the peak emerging period of the moths or rice stem borers.
2. Collection and destruction of egg masses of the moths and the "dead hearts" of rice plants should be done repeatedly.

Harmful Animals: Rats and mice can cause considerable damage to rice as well as to watercourses that supply water to the crop. Protective measures should be taken against these pests. Birds are a big problem particularly during harvest. Protection measures are as follows:

1. Treat the foles with phostoxin/Detia tablets with ½ to 1 tablet per hole.
2. Baiting throughout the field near the holes with anti-coagulants like Rocumin mixed with broken rice at 1:40 ratio should be done.
3. Shooting and baiting of birds will be helpful in reducing their population.

Diseases: The main disease that attacks rice is rice blast although others can occur. The protection measures are as follows:

1. Sow only disease resistant varieties.
2. Sow only diesease free seed.
3. Plants showing blight or blast symptoms (pockmarks on the leaves) should be uprooted and destroyed.
4. Spray rice crop once about 10 days before earing and then 10 days after completion of earing with Dithane M-45 or Antracol at the rate of 2 lbs. dissolved in 100 gallons of water/A. The effectiveness of these chemicals is questionable.

Smut and Rizoctonia are controlled by treating rice seed with 2 oz. of Vitavax per 22 seer seed. All nursery seed should be treated with Vitavax.

Harvesting

The last important step in the production of a good rice crop is proper harvesting. The following recommendations should be followed:

1. Time: Rice should be harvested when the upper grains in the ear dry up and the lower grains are somewhat green. This usually occurs about one month after 50% ear formation in the field.
2. Method: The fields should be dried before harvesting. Irrigation should be stopped 15 days before harvest and and standing water drained. Harvesting is usually done with the sickle. Combine harvesters are not very common; however, they are used in some areas.
3. Threshing: A soil platform, or bund of 2' x 2' should be erected, pasted with soil, dried and the rice ears struck against this platform by hand. Stationary motor driven harvesters are becoming very common and should be used when available. They are much faster and do a better job with less labor than hand threshing. Rental rates are very reasonable.

Grain Storage

After the rice has been threshed it should be stored in a place where it can be kept dry and free of rates, mice, birds and stored grain insects. If this is not accomplished large losses of grain can occur. This is an important step in the rice production sequence and should not be overlooked.

APPLICATION

1. Each trainee will examine and identify the seed of different varieties, fine and coarse.
2. Each trainee will learn the latest production factors and the reasons as to why they should be adopted.

3. A field trip to the rice production area will be conducted at a later date.

QUESTIONS

1. How is seed pregerminated before sowing the nursery?
2. What are the characteristics of a good puddled field and how the puddlings are achieved?
3. What is the proper plant population and how should it be maintained?
4. What are the symptoms for Zn deficiency and how is this cured?
5. How do you control stem borer in the nursery and field?

Modern technique for cotton cultivation. 1948

کپاس کی کاشت کے جدید اصول

COTTON CULTIVATION

کپاس کی کاشت

کپاس ہمارے ملک کی ایک نقد آور فصل ہونے کے علاوہ زرِ مبادلہ کمانے کا اہم وسیلہ ہے۔ کپاس پر ہمارے ملک کی ایک بڑی صنعت یعنی پارچہ بافی کا دارومدار بھی ہے جس سے ہم اپنے کپڑوں کی ضروریات پوری کرتے ہیں بلکہ فالتو کپڑا اور سوت باہر بھیج کر زرِ مبادلہ کماتے ہیں۔ کپاس کے بنولہ سے ہم اپنے خوردنی تیل کا بیشتر حصہ بھی حاصل کرتے ہیں اور اس کی کھل ہمارے مویشیوں کی خوراک کا کام دیتی ہے۔ گویا کپاس ہماری زرعی اور قومی معیشت میں ایک بہت بڑی اور اہم کردار ادا کر رہی ہے۔ لہذا اس فصل کی پیداوار کو بڑھانا ہمارا قومی فریضہ ہے۔ جتنی کپاس کی پیداوار بڑھے گی ملک اور کاشتکار دونوں اتنے زیادہ خوش حال ہونگے۔۔

Soil Selection and its Preparation

زمین کا انتخاب اور اس کی تیاری

ماسوائے کلراٹھی، رکڑ اور سیم زدہ زمین کے کپاس ہر جگہ اُگائی جا سکتی ہے لیکن زیادہ ریتلی اور چکنی زمین پر کپاس اُگانے سے پرہیز کرنا چاہیئے اور کپاس کو میرا زمین میں کاشت کرنا بہتر رہتا ہے۔ زمین کو چار پانچ مرتبہ ہل اور زمین چار بار سہاگہ چلا کر اچھی طرح باریک کر لیں۔ بوائی سے پہلے کھیتوں کو عین ہموار کیا جائے اس میں ایک تو پانی کی بچت ہوتی ہے دوسرے ناہموار کھیتوں کی نشیب جگہوں میں پانی جمع ہو جانے سے پودے مرجاتے ہیں۔

Seed Selection and Seed Rate

بیج کا انتخاب اور شرح بیج

زیادہ پیداوار حاصل کرنے کے لئے کپاس کا بیج خالص اور صحت مند ہو، نیز اس قسم کا ہو جس کی حکومت نے اس علاقے میں کاشت کرنے کی اجازت دی ہو۔ کاشت سے پہلے بیج کو دوائی لگا دیں تاکہ گلابی سنڈی کے حملے سے بچانے کے لئے بیج کو کاشت سے دو تین روز پہلے تیز دھوپ میں پکے فرش پر پتلی سی تہہ میں پھیلا کر سکھا لینا چاہیئے۔ امریکن کپاس کا ۱۲ سے ۱۵ سیر اور دیسی اقسام کا دس سے بارہ سیر فی ایکڑ کے حساب سے بیج استعمال کریں۔ زیادہ بیج اس لئے استعمال کرنا چاہیئے تاکہ قطاروں کا کوئی حصہ خالی نہ رہ جائے اگر زیادہ پودے اُگ آئیں تو اُن کو بعد میں چھدرا کر کے ان کا آپس میں فاصلہ درست کیا جا سکتا ہے۔ اگر بیج کم اُگیں تو دوبارہ بوائی ایک مشکل مرحلہ ہوتا ہے۔ جس پر عموماً عمل نہیں کیا جاتا اور کھیت میں مطلوبہ پودے کی تعداد پوری نہ ہونے کی وجہ سے پیداوار میں کمی واقع ہو جاتی ہے۔

New area boundaries for different 3 Cotton varieties in Punjab Province for Kharif-1978

خریف ۱۹۷۸ء میں صوبہ پنجاب میں کپاس کی مختلف اقسام کیلئے نئی علاقہ بندی

حکومت پنجاب کے ایک حالیہ نوٹیفیکیشن نمبر ایس او (آر اینڈ ای) ۱۔(۹)۷۷، مورخہ ۹ مارچ ۱۹۷۸ء کے مطابق کپاس کی مختلف اقسام کی کاشت کے لئے صوبہ پنجاب کی حسب ذیل علاقہ بندی کی گئی ہے۔ خریف ۱۹۷۸ء میں اب مذکورہ علاقوں میں کپاس کی صرف وہی اقسام ہی کاشت کی جاسکیں گی جو یہاں ان علاقوں کے سامنے درج کی گئی ہیں۔ ان کے علاوہ دیگر تمام اقسام کی کاشت ممنوع قرار دے دی گئی ہے۔

نمبر شمار	نام ضلع	[illegible]	[illegible]
۱	لاہور/قصور	۱۔ بلوکی، سلیمانکی لنک کینال کا مغربی علاقہ	دیسی (ڈی ۹)
		۲۔ باقی ماندہ ضلع میں	دیسی (ڈی ۶)
۲	شیخوپورہ	۱۔ شیخوپورہ اور فیروز والا تحصیل	دیسی (ڈی ۱)
		۲۔ سانگلہ ہل/ننکانہ صاحب	اے سی-۱۳۴
۳	گوجرانوالہ	۱۔ وزیرآباد اور گوجرانوالہ کی تحصیلیں	دیسی (ڈی ۹)
		۲۔ حافظ آباد تحصیل	دیسی (ڈی ۱)
۴	سیالکوٹ	تمام ضلع	دیسی (ڈی ۱)
۵	سرگودھا	تمام ضلع	بی-۵۵۷
۶	فیصل آباد	تمام ضلع	بی-۵۵۷
۷	جھنگ	تمام ضلع	بی-۵۵۷
۸	میانوالی	۱۔ عیسیٰ خیل تحصیل	دیسی (ڈی ۹)
		۲۔ باقی ماندہ ضلع	اے سی-۱۳۴
۹	گجرات	۱۔ اپر جہلم کا جنوب مغربی علاقہ (ہیڈ ورکس کے دائیں سے دریائے چناب تک	اے سی-۱۳۴
		۲۔ باقی ماندہ ضلع میں۔	دیسی (ڈی ۹)
۱۰	کیمبل پور	تمام ضلع	دیسی (ڈی ۹)
۱۱	راولپنڈی	تمام ضلع	دیسی (ڈی ۶)
۱۲	جہلم	تمام ضلع	دیسی (ڈی ۹)
۱۳ (الف)	ملتان	تمام ضلع میں (ماسوا تحصیل خانیوال کے ان علاقوں کے جو شیڈول نمبر ۲ میں درج ہیں)	اے سی-۱۳۴ اور ۱۴۹ الف (شیڈول نمبر ۲ میں مذکورہ علاقوں میں بی-۵۵۷)
ب	وہاڑی	تمام ضلع میں	بی-۵۵۷ اور ۱۴۹-الف
۱۴	ساہیوال	۱۔ ساہیوال تمام ضلع ماسوا دیپالپور سب ڈویژن۔	بی-۵۵۷
		۲۔ دیپالپور سب ڈویژن	بی-۵۵۷ محکمہ کی خصوصی اجازت سے ڈیلٹا پائن ۲۵
۱۵	بہاولپور	۱۔ ریلوے لائن کے شمال، بہاولپور میلسی لنک سمہ سٹہ تک، سمہ سٹہ سے چنی گوٹھ میں ریلوے لائن تک اور تمام احمد پور شرقیہ تحصیل ریلوے لائن کے شمال بہاولپور میلسی لنک سے بخشن خان تک	بی ایس ۱
		۲۔ باقی ماندہ ضلع۔	دیسی (ڈی ۶)
۱۶	بہاولنگر	۱۔ ریلوے لائن کے شمال کی طرف بخشن خان سے امروکی تک بمعہ پراجاہ کی شمالی پٹی	بی ایس ۱
		۲۔ باقی ماندہ ضلع	دیسی (ڈی ۹)
۱۷	رحیم یار خان	تمام ضلع	بی ایس ۱ (الف ۱۴۹ بیج بڑھانے کے مقاصد کے لئے)
۱۸	مظفرگڑھ	تمام ضلع	اے سی ۱۳۴ (ایم ایس ۳۹ ایم ایس ۴۰ اور ایم این ایچ ۹۳ محکمہ کی اجازت سے)
۱۹	ڈیرہ غازی خان	تمام ضلع	اے سی-۱۳۴

نوٹ : مندرجہ ذیل شیڈول نمبر۲ میں جو علاقے درج ہیں ان میں کپاس کی قسم بی - ۵۵۰ ہی کاشت کی جائے ۔

۱	ملتان	خانیوال	۶۲	چک حسن پور آری والا	۲۸	"	"	۶۷	" " ۱۸/۹-آر
۲	"	"	۶۲	" نوری سہاگ	۲۹	"	"	۶۷	" " ۱۹/۹-آر
۳	"	"	۶۳	" جنگل ڈیرہ والا جنوبی	۳۰	"	"	۶۸	" " ۸-۹-اے/۸-آر
۴	"	"	۶۴	" نمبر۱۱-۱۷/۸-آر	۳۱	"	"	۶۸	" " ۵-اے/۸-آر
۵	"	"	۶۴	" " ۱۱/۸-آر	۳۲	"	"	۶۸	" " ۶-اے/۸-آر
۶	"	"	۶۴	" " ۸/۸-آر	۳۳	"	"	۶۸	" " ۷-اے/۸-آر
۷	"	"	۶۴	" " ۹/۸-آر	۳۴	"	"	۶۹	فرید سن پال
۸	"	"	۶۴	" " ۱۷/۸-آر	۳۵	"	"	۶۹	موضع ایچ/آباد
۹	"	"	۶۴	" بوراکوٹلہ	۳۶	"	"	۶۹	چک نمبر ۱۹/۸-آر
۱۰	"	"	۶۴	" جسا کنارا	۳۷	"	"	۶۹	" " ۱۸/۸-آر
۱۱	"	"	۶۴	" " ۱۶/۸-آر	۳۸	"	"	۶۹	" " ۲۰/۸-آر
۱۲	"	"	۶۵	" " ۱۴/۸-آر	۳۹	"	"	۷۰	" " ۱۰-۱۱/۸-اے-آر
۱۳	"	"	۶۵	" " ۱۵/۸-آر	۴۰	"	"	۷۰	" " ۱۲/۸-اے-آر
۱۴	"	"	۶۵	" " ۱۲/۸-آر	۴۱	"	"	۷۰	" " ۱۳/۸-اے-آر
۱۵	"	"	۶۵	" " ۱۳/۸-آر	۴۲	"	"	۷۶	" " ۱۰۷/۱۵-ایل
۱۶	"	"	۶۵	" " ۱۰/۸-آر	۴۳	ملتان	خانیوال	۷۶	چک نمبر ۱۰۸/۱۵-ایل
۱۷	"	"	۶۵	" " ۹/۹-آر	۴۴	"	"	۷۶	" " ۱۱۱/۱۵-ایل
۱۸	"	"	۶۵	" " ۸-بی/۸-آر	۴۵	"	"	۷۶	" " ۱۳۳/۱۶-ایل
۱۹	"	"	۶۵	" " ۸-اے/۸-آر	۴۶	"	"	۷۶	" " ۱۳۷/۱۶-ایل
۲۰	"	"	۶۶	" " ۵/۹-آر	۴۷	"	"	۷۶	" " ۱۳۴/۱۶-ایل
۲۱	"	"	۶۶	" " ۷/۹-آر	۴۸	"	"	۷۶	" " ۱۳۶/۱۶-ایل
۲۲	ملتان	خانیوال	۶۶	چک نمبر ۸/۹-آر	۴۹	"	"	۷۶	" " ۱۳۵/۱۶-ایل
۲۳	"	"	۶۶	" " ۱۳/۹-آر	۵۰	"	"	۷۶	" " ۱۱۰/۱۵-ایل
۲۴	"	"	۶۶	" " ۱۴/۹-آر	۵۱	"	"	۸۸	" " ۲۱/۱۰-آر
۲۵	"	"	۶۶	" " ۱۵/۹-آر	۵۲	"	"	۸۸	" " ۲۲/۱۰-آر
۲۶	"	"	۶۷	" " ۱۶/۹-آر	۵۳	"	"	۸۸	" " ۲۳/۱۰-آر
۲۷	"	"	۶۷	" " ۱۷/۹-آر	۵۴	"	"	۸۸	" " ۲۴/۱۰-آر

۵۵	"	"	۸۸	" " ۱۰/۲۵-آر
۵۶	"	"	۸۸	" " ۱۰/۳۵-آر
۵۷	"	"	۸۸	" " ۱۰/۳۶-آر
۵۸	"	"	۸۸	" " ۱۰/۳۷-آر
۵۹	"	"	۹۰	" " ۱۰/۷۹-آر
۶۰	"	"	۹۰	" " ۱۰/۸۰-آر
۶۱	"	"	۹۰	" " ۱۰/۳۸-آر
۶۲	"	"	۹۰	" " ۱۰/۳۹-آر
۶۳	"	"	۹۰	" " ۱۰/۴۰-آر
۶۴	"	"	۹۲	" " ۱۰/۸۵-آر
۶۵	"	"	۹۲	" " ۱۰/۸۳-آر
۶۶	"	"	۹۲	" " ۱۰/۸۴-آر
۶۷	"	"	۹۲	" " ۱۰/۷۱-آر
۶۸	"	"	۹۲	" " ۱۰/۷۶-آر
۶۹	"	"	۹۲	" " ۱۰/۷۷-آر
۷۰	"	"	۹۲	" " ۱۰/۷۸-آر
۷۱	ملتان	خانیوال	۹۲	چک نمبر ۱۰/۷۵-آر
۷۲	"	"	۹۴	" " ۱۰/۸۹-آر
۷۳	"	"	۹۴	" " ۱۰/۸۸-آر
۷۴	"	"	۹۴	" " ۱۰/۹۰-آر
۷۵	"	"	۹۴	" " ۱۰/۶۸-آر
۷۶	"	کبیروالا	۲۸۰	" " ۷/وی

۷۷	"	"	۲۸۰	" " ۱۰۰/اے-ایچ
۷۸	"	"	۲۸۰	" " ۱۰۰/اے-ایچ
۷۹	"	"	۲۸۰	" " ۱۲/اے-ایچ
۸۰	"	"	۲۸۰	" " ۱۷/اے-ایچ
۸۱	"	"	۲۸۰	" " ۱۸/اے-ایچ
۸۲	"	"	۲۸۰	" " ۱۶/وی
۸۳	"	"	۲۸۰	" " ۶/اے-ایچ
۸۴	"	"	۲۸۰	رکھ مخدوم دینوئی
۸۵	"	"	۲۸۰	چک نمبر ۱۹/وی
۸۶	"	"	۲۷۸	شام کوٹ
۸۷	"	"	۲۷۸	الہ آباد
۸۸	"	"	۲۷۸	جمیس آباد
۸۹	"	"	۲۷۸	کوٹ مولا چند
۹۰	"	"	۲۷۸	نظام پور
۹۱	"	"	۲۷۹	بھیرووال
۹۲	"	"	۲۷۹	نانک پور
۹۳	"	"	۲۷۹	چک نمبر ۲۰/وی
۹۴	"	"	۲۷۹	" " ۱۵/وی
۹۵	"	"	۲۷۹	" " ۱۴/وی
۹۶	"	"	۲۷۹	پرانا خانیوال
۹۷	"	"	۲۷۹	حیات پور

وقتِ کاشت

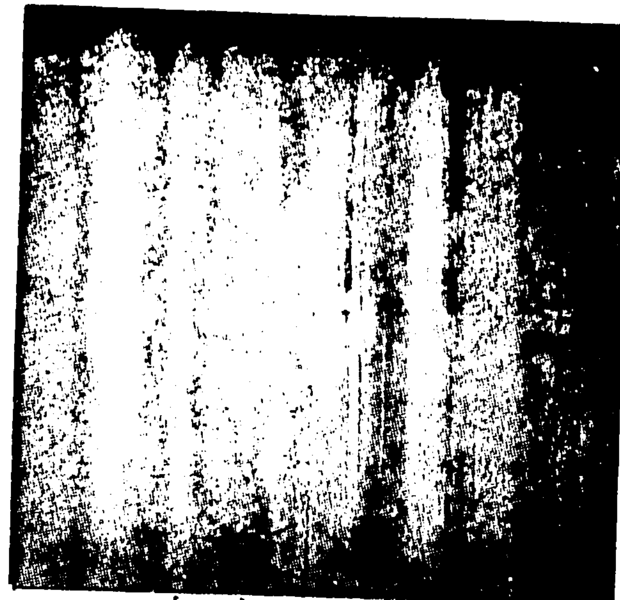
Time of sowing

مختلف علاقوں میں مندرجہ ذیل اوقات کاشت تجربات سے بہتر ثابت ہوتے ہیں۔ کپاس کی زیادہ پیداوار حاصل کرنے کے لئے کپاس کی کاشت مقررہ اوقات میں کریں۔

Weed Control

جڑی بوٹیوں کی تلفی

کپاس کی فصل میں کم از کم دو گوڈیاں پہلے پانی سے پہلے اور پانی دینے کے بعد ضرور کی جائیں۔ اس طرح وہ بیماریاں / کیڑے جو جڑی بوٹیوں میں پیدا ہو کر پرورش پاتے ہیں اور بعد میں کپاس کے پودوں پر حملہ آور ہوتے ہیں تلف ہو جاتے ہیں جڑی بوٹیاں دھوپ اور خوراک کا بہت سا وہ حصہ جو کپاس کے پودوں کو فضا اور زمین سے ملنا ہوتی ہے ہضم کر جاتی ہیں اور اس طرح مجموعی طور پر کپاس کے پودوں کی نشوونما متاثر ہو جاتی ہے اور ان کی قوت مدافعت کم ہو جاتی ہے۔ غرض کپاس کی فصل کی وقت پر اچھی گوڈی ہر لحاظ سے بہت ضروری ہے۔



Cultivation in Furrows

لائنوں میں کاشت

کپاس کی اچھی فصل حاصل کرنے اور اس کو موذی کیڑوں اور بیماریوں سے بچانے کے لیئے یہ اشد ضروری ہے کہ کپاس لائنوں میں کاشت کیجائے جو فصل چھٹے کے ذریعہ کاشت کی جاتی ہے نہ تو اس میں ٹھیک طرح پیسٹ سکاؤٹنگ ہو سکتی ہے نہ گوڈی اور نہ ہی کرم کش ادویات کا صحیح اور مؤثر استعمال ہو سکتا ہے۔ غرض لائنوں میں کاشت کرنا فصل کپاس کی حفاظت اور کامیابی کے لیئے پہلا اہم ترین قدم ہے۔ اس لیئے کپاس کے بیج کو ہمیشہ سنگل رو کاٹن ڈرل یا پوریں کے ذریعے قطاروں میں کاشت کرنا چاہیئے۔

plant population

پودوں کی تعداد

کھیت میں امریکن کپاس کے پودوں کی تعداد ۲۰,۰۰۰ بیس ہزار سے ۲۶,۰۰۰ چھبیس ہزار تک ہونی چاہیئے جس کیلیئے پودوں کا درمیانی فاصلہ ۹ انچ سے ایک فٹ اور لائن سے لائن کا فاصلہ ۲½ فٹ رکھنے سے مطلوبہ پودوں کی تعداد حاصل کی جاسکتی ہے۔ دیسی کپاس کے پودوں کی تعداد ۲۴,۰۰۰ چوبیس ہزار سے ۲۹,۰۰۰ انتیس ہزار تک ہونی چاہیئے جس کیلیئے پودے سے پودے کا فاصلہ ۹ انچ اور قطاروں کا درمیانی فاصلہ دو فٹ رکھیں۔ بوائی کے بعد اگر بیج کسی وجہ سے نہ اُگے تو جو کے لگا کر جگہ پُر کرینی چاہیئے تاکہ پودوں کی تعداد کھیت میں پوری رہے۔

Fertilizer use

کھادوں کا استعمال:

کپاس کو نائٹروجن اور فاسفورس کی ضرورت ہوتی ہے اس لیے زمین کی زرخیزی کا لحاظ رکھتے ہوئے ۷۵ پونڈ نائٹروجن اور ۴۰ سے ۵۰ پونڈ فاسفورس استعمال کریں۔

وقت استعمال	مطلوبہ خوراکی اجزاء پونڈوں میں	کھاد کی قسم، مقدار اور قیمت فی ایکڑ
بوائی کے وقت	نائٹروجن ۲۵ فاسفورس ۴۰ تا ۵۰	ڈی۔اے۔پی ایک بوری (۲، روپے) یا امونیم سلفیٹ ایک بوری + سنگل سپر فاسفیٹ دو بوری (۶۷ روپے)
پہلی یا دوسری آبپاشی کے ساتھ اگر کسی وجہ سے بوائی کے وقت کھاد نہ دی گئی ہو	نائٹروجن ۲۵ فاسفورس ۴۰ تا ۵۰	یوریا (چھوٹی بوری ایک عدد یا بڑی ½ بوری) یا امونیم سلفیٹ ایک بوری + سنگل سپر فاسفیٹ دو بوری (۶۷ روپے)
پھول آنے کے وقت	نائٹروجن ۵۰	یوریا چھوٹی بوری دو عدد یا بڑی بوری ایک عدد (۶۸ روپے)

نوٹ:۔ ریتلی یا کمزور زمینوں میں ۲۵ پونڈ نائٹروجن زیادہ ڈالنے سے پیداوار میں خاطر خواہ اضافہ ہو سکتا ہے۔

Harmful insects of cotton and its remedy

کپاس کی فصل کے نقصان دہ کیڑے اور ان کا انسداد

کپاس کی فصل کی کیڑوں اور بیماریوں سے حفاظت بڑا اہم اور خاما پیچیدہ مسئلہ ہے اور مسلسل تگ و دو چاہتا ہے۔ شروع ہی سے اس فصل کی بڑی دیکھ بھال کرنی چاہیئے۔ ذرا سی غفلت اور کوتاہی سے ساری فصل کی بربادی اور تباہی کا خطرہ پیدا ہو جاتا ہے کیڑوں اور بیماریوں کی روک تھام کے لئے کرم کش مرکبات کے استعمال سے زیادہ یہ بات ضروری ہے کہ فصل کا ہر ہفتہ باقاعدہ معائنہ کیا جائے اور پیسٹ سکاؤٹنگ (PESTSCOUTING) کے ذریعہ یہ معلوم کیا جائے کہ کون سا کیڑا اور کون سی بیماری کھیت کے کس کونے اور کن پودوں میں رونما ہونے والی ہے تاکہ شروع ہی سے اس کو تلف کر دیا جائے۔ موذی کیڑوں اور بیماریوں کو ان کی ابتدا میں مارنا آسان ہوتا ہے اور اس طرح آگے چل کر وہ وبائی صورت اختیار نہیں کر پاتے۔ یہ بات نوٹ کرنے کے قابل ہے کہ ٹھیک اور برمحل پیسٹ سکاؤٹنگ اصل میں پیسٹ کنٹرول کی جان ہے اس لئے اس کی طرف پوری توجہ دینی چاہیئے۔

رس چوسنے والے کیڑے

Juice sucking insects

رس چوسنے والے کیڑے مثلاً سبز تیلہ، سفید مکھی، تھرپس (JASSID, WHITE FLY, THRIPS) شروع ہی میں کپاس کی فصل پر حملہ کر دیتے ہیں اور ان کے شدید نقصان کا خطرہ اگست۔ستمبر تک باقی رہتا ہے۔ جن علاقوں میں ان کیڑوں کا حملہ ہر سال ہوتا ہے وہاں حفظ ماتقدم اور کنٹرول کے لئے دانے دار زہر تھمٹ (THIMET) ڈائی سسٹون (DISYSTON) اور ٹیمک (TEMIK) پہلے اور دوسرے پانی کے وقت استعمال کریں۔ گوڈی کے بعد اگر دانے دار کرم کش مرکبات استعمال کئے جائیں تو ان کا اثر زیادہ اچھا اور دیرپا ہوتا ہے۔ دانے دار زہر (GRANULES) اس طرح پودوں کے قریب زمین کے اندر ڈالے جائیں کہ ان کا اثر زہر آبپاشی کے بعد پانی میں حل ہو کر کپاس کے پودوں کی جڑ تک پہنچ جائے۔ جڑ اس زہر کو چوستی ہے اور اس طرح یہ سارے پودے میں سرایت کر جاتا ہے اور جو بھی کیڑے نازک شاخوں، پتوں، کونپلوں اور پھول وغیرہ پر بیٹھ کر پودا کا رس چوستے ہیں وہ مر جاتے ہیں اگر دانے دار کرم کش ادویات ٹھیک طریقہ سے زمین میں ڈالے جائیں (SOILAPPLICATION) تو کپاس کی فصل ڈیڑھ دو ماہ تک ان کیڑوں سے نقصان سے محفوظ رہتی ہے۔

ڈسٹنگ اور سپرے

Dusting and Spray

جیسا کہ پہلے بیان کیا گیا ہے کہ پیسٹ سکاؤٹنگ کپاس کی فصل کی حفاظت کے لئے لازمی عمل ہے اور باقاعدہ مقررہ ایک طریقہ کے مطابق کرنا چاہیئے۔ جب کھیت میں رس چوسنے والے کیڑوں کی اوسط آبادی تین یا چار کیڑے فی پتہ ہو جائے تو ڈسٹنگ اور سپرے ضروری ہو جاتا ہے۔

ڈسٹنگ کے لئے اچھی اور تازہ بنی ہوئی کاٹن ڈسٹ ۱۰ فیصدی (CTTONDUST 10%) ۱۰ یا ۱۲ کلوگرام فی ایکڑ صبح یا شام احتیاط سے استعمال کی جائے۔ پہلے چند پودوں پر ایک روز پہلے ڈسٹ کر کے دیکھ لیں کہ پودوں کو جھلساتی تو نہیں۔ کاٹن ڈسٹ کا جولائی تا اکتوبر کے دوران استعمال نہ صرف رس چوسنے والے کیڑوں بلکہ مائٹس اور سنڈیوں کے کنٹرول کے لئے بھی کارگر ہوتا ہے۔

سپرے۔ رس چوسنے والے کیڑوں کے موثر کنٹرول کے لئے پودوں میں سرایت کرنے والے کرم کش مرکبات (SYSTEMIC-PESTICIDES) استعمال کرنے چاہیئں مثلاً ڈائی میکران (DIMECRON) ڈائی میتھوئیٹ (DIMETHOATE) یا میٹا سسٹاکس (METASYSTOX) بحساب ½ کلوگرام فی ایکڑ استعمال کریں اور پودوں میں سرایت کرنے والے کرم کش مرکب دستیاب نہ ہو یا رس چوسنے والے کیڑے کے ساتھ سنڈیوں وغیرہ کا بھی حملہ ہو تو تھایوڈان (THIODON) یا گوزاتھیان (GUSATHION) زولون ڈی۔ٹی (ZOLONE.D.T)

یا میتھائل پیراتھین (METHY PARATHION) ڈی۔ڈی۔
ٹی میں ملا کر استعمال کرنے چاہئیں ۔ شروع فصل میں شدید اثر رکھنے
والے مرکبات مثلاً بڈرین (BIDRIN) کاربیکران (CARBICRON)
ایزوڈرین (AZODRIN) یا نیواکران (NUVACRON) وغیرہ
استعمال نہیں کرنے چاہئیں تیز دواؤں کے اثر سے وہ فائدہ مند کیڑے
جو کپاس کے دشمن کیڑوں کو تلف کرتے ہیں ۔ مر جاتے ہیں اور اس طرح
مفید اور مضر کیڑوں کی آبادی کے تناسب میں خلل پیدا ہو جاتا ہے
اس طرح وباؤں کی شدت میں نہایت خطرناک اضافہ ہو جاتا ہے
اور پھر سارے موسم میں اُن کو بار بار سپرے کر کے بھی کنٹرول کرنا مشکل ہوتا ہے
یہ بگاڑ پیدا نہ ہو تو تین چار سپرے سے کپاس کی فصل کی بخوبی حفاظت
ہو جاتی ہے ۔

کپاس کی فصل کی سنڈیاں

Cotton crop worm.

لشکری سنڈی

Army worm

اس سنڈی (ARMY WORM) کا حملہ اُن علاقوں میں
زیادہ ہوتا ہے جہاں غلط طریقہ سے اور بغیر ضرورت متعدد بار کرم کش
مرکبات استعمال کئے جاتے ہیں اور طبعی طریقہ انسداد کو بالکل نظر انداز
کیا جاتا ہے جن اضلاع میں ڈیلٹا پائن کپاس کاشت کی جاتی ہے ۔
اور تقریباً ہر ہفتہ عشرہ بعد فصل پر سپرے کیا جاتا ہے وہاں لشکری
سنڈی کی وبا ہر سال بڑی شدید ہوتی ہے اور اس کے علاوہ جس سال
اگست ستمبر میں بارش زیادہ ہو یہ کیڑا ساہیوال ۔ وہاڑی ۔ ملتان
اور لاہور کے بعض علاقوں میں سخت وبائی صورت اختیار کر لیتا ہے ۔
لشکری سنڈی کی چار حالتیں (INSTAR) ہوتی ہیں اور مؤثر طریقہ
سے پہلی اور زیادہ سے زیادہ دوسری حالت میں کنٹرول ہو سکتا ہے
اس لئے پیسٹ سکاؤٹنگ کے ذریعے اس کیڑے کی آبادی کا پہلی حالت
(FIRST INSTAR) میں پتہ لگانا چاہیئے ورنہ فصل کو اس کے نقصان
سے بچانا مشکل ہے ۔
حملہ کی ابتدائی صورت میں ڈی ۔ ڈی ۔ ٹی ۱۰ فیصد یا سیون
(SEVIN) ۱۰ فیصد کی ڈسٹنگ کارگر ہے ۔ فصل اور حملہ کی
کیفیت دیکھ کر ۱۰ تا ۱۲ کلوگرام ڈسٹ فی ایکڑ استعمال کی جائے ۔
جب لشکری سنڈی اور دیگر سنڈیوں کا حملہ ہو جائے تو فصل میں ایسی کرم
کش ادویات استعمال کرنی چاہیئے جو سنڈیوں کی مختلف قسموں اور رس
چوسنے والے کیڑوں کو بھی تلف کرتا ہو ۔ اس لحاظ سے تھائیوڈان
(THIODAN) گوزاتھیان (GUSATHION) زولون ڈی۔ٹی
(ZOLONE-DT) کے ساتھ ڈی ۔ ڈی ۔ ٹی کو ملا کر سپرے کیا جائے
تو کنٹرول زیادہ مؤثر ثابت ہوگا ۔ صرف ڈی ۔ ڈی ۔ ٹی یا سیون کو بھی
ایک کلوگرام فی ایکڑ کے حساب سے لشکری اور دیگر سنڈیوں کے خلاف
استعمال کیا جا سکتا ہے ۔ لشکری سنڈیاں ذرا سی سرسراہٹ یا قدموں کی
آواز سن کر فوراً زمین پر گر جاتی ہیں اور چھپ جاتی ہیں ۔ ایسی صورت میں
کھیت کی زمین کو ڈی ۔ ڈی ۔ ٹی یا سیون یا کاٹن ڈسٹ کے ذریعہ زہر آلود
کیا جائے ۔ اگر ضرورت پڑے تو کھیت کو پانی لگانے وقت ڈائی ایلڈرین
۲۰ فیصد مائع (DIELDRIN) بحساب ۲ء۵۰ لیٹر فی ایکڑ استعمال
کرنے سے زمین کے اندر چھپی ہوئی سنڈیوں کو تلف کیا جا سکتا ہے ۔

ٹینڈوں کی سنڈیاں

worms of bolls

سنڈیوں کی کئی انواع کپاس کے شگوفوں ، پھولوں اور ٹینڈوں
کو سخت نقصان پہنچاتی ہے اور بعض صورتوں میں درمیانی نازک تنے
کی چوٹی کو بھی متاثر کرتی ہیں ۔ گلابی چتکبری اور امریکن سنڈیوں کا حملہ
عام طور پر کپاس کی فصل پر پھول لگنے سے چند روز پہلے شروع ہوتا
ہے اور فصل کے اخیر تک جاری رہتا ہے ۔ دیر میں کاشت شدہ فصل اور
دیر سے تیار ہونے والی اقسام زیادہ متاثر ہوتی ہیں ۔

گلابی سنڈی

pink worm

گلابی سنڈی کا کیمیاوی کنٹرول (CHEMICAL CONTROL)
بغیر طبعی انسداد (CULTURAL CONTROL) کی مدد سے زیادہ مؤثر
ثابت نہیں ہوتا اس لئے ضروری ہے کہ اس سنڈی کی سرمائی آبادی
کو ۱۵ فروری سے پہلے جہاں کہیں بھی موجود ہو تلف کرنے کی پوری

پوری کوشش کیجائے۔ کپاس بیلنے والی فیکٹریوں میں کاٹن ویسٹ (COTTONWASTE) اور دیگر کوڑا کچرا جس میں یہ سنڈیاں چھپی ہوتی ہیں جلا دیا جائے اور جہاں جہاں بھی فیکٹری کے اندر کسی کونے میں گوداموں وغیرہ میں گلابی سنڈی کے چھپنے کا امکان ہو جو ہوا اُن جگہوں کی خوب صفائی کرنی چاہیئے تاکہ کپاس بیلنے والی فیکٹریوں سے اس کپاس کے موذی ترین کیڑے کی نسل نہ پھیلنے پائے۔

کپاس کی چنائی کے بعد باقی ماندہ ٹینڈوں کو چھڑیوں سے، توڑ کر اور کھیت میں گرے ہوئے پتوں کو اکٹھا کر کے جلا دیا جائے، یا گہرا دبا دیا جائے تاکہ موسم بہار کی آمد پر پروانے ان ٹینڈوں سے، نہ نکل سکیں۔ کپاس کی فصل کے کھیت کے ارد گرد بھنڈیاں اور دیگر ایسے پودے اور فصل کاشت نہیں کرنی چاہیئے جن پر گلابی سنڈی حملہ کرتی ہے۔ گو کپاس کی فصل اپریل مئی سے پہلے ان پروانوں کو میسر نہیں ہوتی لیکن موسم بہار اور شروع گرمی میں گل خیرا، بھنڈی اور دیگر اس قسم کے پودوں پر سنڈیوں کی پہلی نسل پروان چڑھتی ہے اس لئے کپاس کے علاقوں میں ان پودوں اور بھنڈیوں کی کم سے کم کاشت کرنی چاہیئے۔ اس کے علاوہ ان سنڈیوں کے متبادل مہمان پودے (ALTERNATE HOST PLANTS) خودرو شکل میں جہاں کہیں پائے جائیں تلف کر دینے چاہئیں۔

کیمیاوی کنٹرول Chemical Control

گلابی سنڈی انڈے سے نکلنے ہی بہت تھوڑے عرصہ بعد ٹینڈوں یا ننھے ٹینڈوں کے اندر داخل ہو جاتی ہے چنانچہ اپنی ساری زندگی سپرے کے اثر سے محفوظ ہو کر ٹینڈے کے اندر گذارتی ہے گلابی اور دیگر سنڈیوں کے موثر کنٹرول کے لئے لیپٹ سکاؤٹنگ لازمی ہے تاکہ انڈے دینے سے پہلے پروانوں کے حملہ کا علم ہو سکے۔ انڈوں سے بچے چند روز تک نکل آتے ہیں۔ اس لئے مختلف علاقوں کی آب و ہوا کے لحاظ سے یہ تعین کرنا ضروری ہے کہ پروانے انڈے کس روز دینے شروع کر دیں گے! گلابی سنڈی کو صرف چند ہی کرم کش ادویات اچھی طرح مارتی ہیں۔ ان میں ڈی۔ ڈی۔ ٹی سیون گوزاتھیان اور اینڈرین قابل ذکر ہیں۔ تھائیوڈان (THIODAN) فیزالون (PHOSALONE) یا گوزاتھیان (GUSATHION) کے ساتھ اگر ڈی۔ ڈی۔ ٹی ملا کر سپرے کیا جاوے تو یہ آمیزے زیادہ کارگر ثابت ہوتے ہیں۔ سب سے اہم بات یہ ہے کہ سپرے ٹھیک وقت پر پوری احتیاط کے ساتھ کیا جاوے تاکہ سنڈیاں شگوفوں اور ٹینڈوں میں داخل ہونے سے پہلے تلف ہو جائیں۔

چتکبری سنڈی

X

جو کرم کش ادویات گلابی سنڈی کو تلف کرتے ہیں۔ وہ چتکبری اور امریکن سنڈیوں کو بھی مارتے ہیں اس لئے بہتر یہ ہے کہ ان ہی مرکبات کو اگست تا اکتوبر استعمال کیا جائے۔ عام طور پر دس بارہ دن کے وقفہ سے تین چار سپرے کی ضرورت سنڈیوں کی روک تھام کے لیے ہوتی ہے۔

مائٹس (MITES)

مائٹس کا حملہ خشک موسم میں اکتوبر نومبر میں شروع ہوتا ہے پہلے پہل اس کا حملہ چند ایک ٹکڑوں میں ظاہر ہوتا ہے پھر چند دنوں میں ساری فصل کے پتے جھڑ جاتے ہیں اس کے علاج کے لئے کل تھین (KELTHANE) یا اینڈرین ایک کلوگرام فی ایکڑ کے حساب سے سپرے کریں اگر یہ کیڑے وسط نومبر کے بعد ظاہر ہوں تو پھر اس علاج کی چنداں ضرورت نہیں۔

کالے سر والے جھینگر (BLACKHEADED CRICKET)

ڈیرہ غازی خان اور مظفر گڑھ کے بعض علاقوں میں کپاس کی بوائی کے وقت کالے سر والے جھینگروں کا شدید حملہ ہوتا ہے۔ جھینگر فوج در فوج آس پاس کے گندم اور سرسوں وغیرہ کے خشک پرداخت کھیتوں سے کپاس کے زیر کاشت یا نئے کاشت شدہ رقبوں پر یلغار کرتے ہیں بیج زمین سے نکال کر کھا جاتے ہیں۔ اُگتی ہوئی کپاس کے پودوں (SEEDLINGS) کو کاٹ ڈالتے ہیں اس طرح کپاس

کھیت برباد ہوجاتے ہیں ۔

کانے سروالے جھینگر جب وبائی شکل اختیار کرلیں تو اُن کو تلف کرنا اور ان کے نقصان سے بچنا مشکل ہوجاتا ہے ۔ اِس لئے کوشش یہ کرنی چاہیئے کہ کیڑوں کی ابتدائی آبادی کو شروع ہی میں تلف کردیا جائے ۔ تاکہ وبائی شکل اختیار نہ کریں ۔ جھینگر سردیوں کے اخیر اور موسم بہار میں موسم ربیع کی فصلوں خاص طور پر گندم اور سرسوں وغیرہ کے سیراب شدہ کھیتوں کی منڈیروں پر جمع ہوجاتے ہیں اور یہاں ہی اُن کی پہلی نسل پیدا ہوتی ہے ۔ اگر ان کھیتوں کی منڈیوں کو بی۔ایچ۔سی (B.H.S 10%) ۱۰ فیصد ڈسٹ ہر دس پندرہ دن کے بعد ڈسٹ کردیا جائے یا زہر آلود پھک (DIELDRIN+RICE HUSK) ان کھیتوں کے اندر اور منڈیروں پر پھیلا دیا جائے تو جھینگروں کی آبادی بہت کم ہوجاتی ہے اور وہ موسم گرما میں وبائی صورت اختیار نہیں کرسکتے ۔ یہ عمل اگر تین چار سال باقاعدہ حکمت اور محنت کے ساتھ کیا جائے تو کپاس اور جوار کی فصل کو جھینگروں کی بربادی سے بچایا جاسکتا ہے ان علاقوں میں جہاں جھینگروں کے حملے کا امکان ہو وہاں کپاس کا بیج دوگنا استعمال کریں اور بیج بونے سے پہلے DIELDRIN دوائی پانی میں ملا کر بیج میں ملائیں کہ ہر بیج زہر آلود ہوجائے اور بعد میں کاشت کیا جائے بوائی کے بعد کپاس کے کھیت میں جھینگروں کو تلف کرنے کے لیے زہر آلود طعمہ (BAIT) ۱۲-۱۰ کلوگرام فی ایکڑ کے حساب سے پھیلا دیں اس کے ساتھ ساتھ کپاس کے کھیت کو بی۔ایچ۔سی ۱۰ فیصد ڈسٹ سے خوب دھوڑا کریں اور آس پاس کے خالی کھیتوں کو بھی دھوڑا کیا جائے تاکہ جھینگروں کی فوج کپاس کے کھیت میں داخل ہونے سے پہلے زہر آلود ہوجائے اور جو کھیت میں داخل ہوں وہ زہریلا طعمہ کھا کر مرجائیں ۔

Germicidal medicine Schedule for cotton crop protection.

گوشوارہ کرم کش ادویات برائے حفاظت فصل کپاس

کیڑوں کے نام اور نمودار ہونے کا وقت	کرم کش زہروں کے نام	مقدار زہر کلوگرام لیٹر فی ایکڑ	کتنی مرتبہ زہر دی جائے
مئی۔جون کترنے اور چبانے والے کیڑے کانے سروالے جھینگر۔ ٹڈی	ڈائی ایلڈرین (DIELDRIN) ۲۰ فی صد مائع	۲.۰۰	ایک یا دوبار ضرورت پڑنے پر
	بی۔ایچ۔سی (BHC) ۱۰ فی صد پوڈر	۰.۷۵ تا ۱.۰۰	
	ڈی۔ڈی۔ٹی (DDT) ۱۰ فی صد پوڈر	۰.۷۵ تا ۱.۰۰	
جون ۔ اگست رس چوسنے والے کیڑے مثلاً سفید مکھی۔ جیسڈ الفس تھرپس وغیرہ	مائع زہریں برائے سپرے	لیٹر فی ایکڑ	ضرورت پڑنے پر
	ڈائی میکران (DIMECRON) ۱۰۰ فیصد	۰.۵۰	۴ تا ۵ بار
	گوزاتھیان (GUSATHION) ۲۰ فیصد	۱.۰۰ تا ۱.۵۰	"
	انتھیو (ANTHIO) ۲۵ فیصد	۱.۰۰	
	میٹاسسٹاکس (METASYSTOX) ۲۵ فیصد	۱.۰۰	
	تھایوڈان (THIODAN) ۳۵ فیصد	۱.۰۰ تا ۱.۵۰	
	ڈائی میتھوایٹ (DIMETHOATE) ۴۰ فیصد	۰.۷۵ لیٹر	
	نیکسان (NEXION) ۲۵ فیصد	۱.۰۰ "	
	سپراسیڈ (SUPRACIDE) ۴۰ فیصد	۱.۰۰ "	

کیڑوں کے نام اور نمودار ہونے کا وقت	کرم کش زہروں کے نام		مقدار زہر کلوگرام / لیٹر فی ایکڑ	کتنی مرتبہ دوا پاشی کی جائے
	نواکران	۴۰ فیصد	۱.۵۵	
	میتھائل پیراتھیان (...)	۵۰ فیصد	۰.۷۵	
	زولون ڈی۔ٹی (ZOLONE-DT)	۴۰ فیصد	۱.۵۰	
	کاربن ڈسٹ (CARBON DUST)	۱۰ فیصد	۱۰ کلوگرام	ایک بار
	دانہ دار زہریں		کلوگرام فی ایکڑ	
	تھمک (...)	۱۰ فیصد	۵.۰۰	ایک بار
	ڈائی سسٹان (DISYSTON)	۱۰ فیصد	۷.۰۰	"
	تھائمٹ (...)	۱۰ فیصد	۷.۰۰	"
اخیر جولائی تا ستمبر لشکری سنڈی	ڈائی ایلڈرین (DIELDRIN)	۲۰ فیصد	۲.۵۵ لیٹر	
	ڈی۔ڈی۔ٹی (DDT)	۱۰ فیصد پوڈر	۱۲-۱۰ کلوگرام ڈسٹ	
	سیون (SEVIN)	۱۰ فیصد پوڈر	۱۲-۱۰ کلوگرام ڈسٹ	
	میتھائل پیراتھیان + ڈی۔ڈی۔ٹی (METHYL PARATHION + DDT)	۵۰ فیصد مائع + ۲۵ فیصد مائع	۱.۰۰ + ۰.۷۵ لیٹر	
	گوزاتھیان + ڈی۔ڈی۔ٹی (GUSATHION + DDT)	۲۰ فیصد مائع + ۲۵ فیصد مائع	۱.۵۰ + ۱.۰۰ لیٹر	
اخیر جولائی تا ستمبر چتکبری - گلابی امریکن سنڈی	سیون (SEVIN)	۸۵ فیصد پوڈر	۱.۰۰ کلوگرام	
	گوزاتھیان + ڈی۔ڈی۔ٹی (GUSATHION + DDT)	۲۰ فیصد مائع + ۲۵ فیصد مائع	۱.۰۰ + ۱.۵۵ لیٹر	
	تھائیوڈان (THIODAN)	۳۵ فیصد	۱.۰۰ لیٹر	
	زولون ڈی۔ٹی (ZOLONE DT)	۴۰ فیصد	۱.۵۰ "	
	ایزوڈرین (AZODRIN)	۴۰ فیصد	۱.۰۰ "	
	نواکران (NUVACRON)	۴۰ فیصد	۱.۰۰ "	
اخیر جولائی تا اکتوبر جوئیں	کیلتھین (KELTHANE)	۴۲ فیصد	۱.۰۰ لیٹر	دو بار
	ایزوڈرین (AZODRIN)	۴۰ فیصد	۱.۰۰ لیٹر	
	ایتھیان (ETHION)	فیصد	۰.۵۵ "	

کپاس کی فصل کے اختتام پر مندرجہ ذیل سفارشات پر عمل کرنا
ہت ضروری ہے تاکہ بیج زمین اور ٹینڈوں میں چھپی ہوئی سنڈیوں کو
ف کیا جاسکے اور یہ چھپی ہوئی سنڈیاں آئندہ فصل کو نقصان نہ پہنچائیں
بکریوں کو کپاس کے کھیتوں میں کھلا چھوڑ دینا چاہیئے تاکہ سنڈیوں
والے ان کھلے ٹینڈے۔ کھوکھڑیاں اور زمین پر گرے ہوئے
پتے وغیرہ (جن میں یہ سنڈیاں موجود ہوتی ہیں) کھا جائیں۔
کپاس کی چھڑیاں زمین سے ۲-۱ انچ نیچی کاٹ کر کھیتوں سے
ہٹا لینی چاہئیں۔ زمین میں گری ہوئی کھوکھڑیاں ٹینڈے۔
پتے اور شاخیں اکٹھی کر کے جلا دینے چاہیں۔ یہ عمل تمام علاقوں میں
فروری کے وسط تک ختم ہو جانا چاہیئے۔
کپاس کی بیلائی کے کارخانوں میں پڑی ہوئی پتی کو جلا دینا چاہیے
بیج کو ڈیٹیا (DETIA) یا فاسٹاکسین (PHOSTOXIN)
کی دھونی وسط اپریل تک گوداموں میں مکمل کر لینی چاہیے۔
بیج کو لونے سے پہلے متواتر دو تین دن تک پکے فرش میں
سکھا لینا چاہیے۔

Picking

امریکن کپاس کی چنائی پندرہ بیس دن کے وقفہ سے اور دیسی کپاس
کی چنائی آٹھ دس دن کے وقفہ سے کر لینی چاہیئے کیونکہ اس سے کم وقفہ
کے ساتھ چنائی کرنے سے کپاس کے ریشہ کی پختگی پوری نہ ہونے کی وجہ سے
سٹور میں اس کی رنگت خراب ہونے کا اندیشہ ہوتا ہے۔ اور زیادہ
وقفہ سے چنائی کرنے سے کپاس زمین پر گر کر خراب ہو جاتی ہے نیز چوری
چکاری کا بھی احتمال ہوتا ہے۔

چنائی میں پوری احتیاط کرنی چاہیئے کہ کپاس صاف ستھری
اور خشک رہے اس لئے چنائی اس وقت شروع کرنی چاہیئے جب فصل پہ
اوس نہ ہو۔ کپاس چنتے وقت کھوکھڑیاں نہ توڑیں اور کرم خوردہ کپاس
بھی نہ چنیں۔ نیز زمین پر گری ہوئی کپاس کو بھی بغیر صاف کئے، اچھی اور
صاف ستھری کپاس میں نہ ملائیں۔ چنی ہوئی کپاس کو کسی کپڑے یا صاف
ستھری خشک جگہ پر رکھیں اور اچھی طرح خشک کر کے خشک اور
ہوادار گودام میں جمع کریں۔

امید پرنٹرز ۲۳۶ بی راوی پارک

CPG-2
Modern Technique for
Rice cultivation-

دھان کی کاشت
کے
جدید اصول

محکمہ زراعت، حکومت پنجاب

Department of Agriculture,
Government of Punjab

خشک زمین کی تیاری کے وقت یوریا کھاد کے استعمال کے بارے میں

ضروری ہدایات

Essential instructions about use of urea during dry soil preparation.

زمین کی اچھی طرح تیاری نہ صرف لاب کے کھڑا ہونے میں مدد دیتی ہے بلکہ جڑی بوٹیوں کی تلفی میں بھی آسانی رہتی ہے ۔ اگر زمین کی تیاری کا وقت کم ہو تو زمین کو اچھی طرح ہل چلا کر مٹی کو بھربھرا کر لیں اور پھر زمین خشک ہونے پر یوریا استعمال کریں ۔ جسقدر زمین خشک ہوگی اسی قدر ہی نائٹروجن کا نقصان کم ہوگا ۔ یوریا کے استعمال کے فوراً بعد زمین پر سہاگہ چلا کر آبپاشی کر دینی چاہیئے ۔ آبپاشی کے بعد اگر ضرورت ہو زمین کو کدو کر دینا چاہیئے یا اگر کھیت اچھی حالت میں ہو تو آبپاشی کے فوراً بعد لاب لگائی جا سکتی ہے ۔

اگر وقت اجازت دیتا ہو اور خاص طور پہ اگر مکینیکل ٹرانسپلانٹر کے ذریعے لاب لگانی ہو تو زمین کی تیاری کے لئے بہت ہی اچھی طرح کام کرنے کی ضرورت ہوگی ۔ زمین میں اچھی طرح ہل چلا کر اور سہاگہ یا ہیرو سے زمین کو ہموار کریں ۔ پہلا ہل چلانے اور زمین کو ہموار کرنے کے بعد ایک ایک ہفتہ کے وقفہ سے خودرو جڑی بوٹیوں کو تلف کرنے اور زمین کو ہموار رکھنے کے لئے ہیرو یا ڈسک ہل چلائیں ۔

Alarming

احتیاط :- پہلا ہل چلانے کے بعد زمین میں گہری ترپھال وغیرہ نہ چلائیں ۔ تاکہ اس طرح زمین کی گہرائی میں دبے ہوئے جڑی بوٹیوں کے بیجوں کو سطح زمین پر آکر اگنے سے روکا جا سکے ۔ اگر نیری کو تیار کرنے کے لئے چار سے چھ ہفتے لیئے جائیں تو اس طرح بہت سی خودرو جڑی بوٹیاں اُگ آئیں گی اور انہیں آسانی سے تلف کیا جا سکے گا ۔ یوریا استعمال کرنے سے پہلے زمین کو اچھی طرح خشک کر لینا چاہیئے اور اس کا کوئی حصہ تر نظر نہیں آنا چاہیئے ۔ یوریا استعمال کرنے کے فوراً بعد کھیت کو سہاگہ دے کر آبپاشی کر دیں ۔ آبپاشی کے بعد اگر ضرورت ہو تو کھیت کو کدو کیا جا سکتا ہے ۔ جس سے نائٹروجن کا ضیاع نہیں ہوگا ۔

دھان کی کاشت Rice cultivation

دھان نہ صرف موسم خریف کی ایک اہم غلہ کی فصل ہے بلکہ پاکستان میں سب سے زیادہ زرمبادلہ بھی اسی فصل سے کمایا جاتا ہے ۷۷-۱۹۷۶ء میں پاکستان نے چاول کی برآمد سے تقریباً دو ارب بیس کروڑ روپے کا زرمبادلہ کمایا۔ پنجاب سے چاول کے زرمبادلہ کا ۵۶ فیصد باسمتی اور ۱۱ فیصد اری چاول سے حاصل ہوا۔ مقامی اور غیر ملکی ماہرین اس بات پر متفق ہیں کہ دھان کی پیداوار بڑھانے کے لئے جتنے مناسب موسمی حالات پاکستان کو میسر ہیں وہ محدودے چند ممالک کو ہی حاصل ہوں گے لیکن یہ بڑے دکھ کی بات ہے کہ ہمارے ہاں دھان کی فی ایکڑ پیداوار تقریباً ۲۵ من ہے جب کہ دوسرے ممالک ہمارے مقابلہ میں دوگنی سے زیادہ پیداوار حاصل کر رہے ہیں۔ اب جبکہ ہمیں اپنی بڑھتی ہوئی مقامی ضروریات اور برآمد کے لئے زیادہ چاول کی ضرورت ہے ہماری یہ قومی ذمہ داری ہے کہ زیادہ سے زیادہ دھان پیدا کرکے ہم اپنی اور ملکی خوشحالی میں بڑھ چڑھ کر حصہ لیں۔

زیادہ پیداوار حاصل کرنے کے لئے محکمہ زراعت کی کسی ایک یا دو سفارشات پر عمل کرنے سے متوقع اضافہ نہیں ہو سکتا جب تک کہ تمام سفارشات پر کماحقہ عمل نہ کیا جائے۔ پیداوار بڑھانے کے لئے چند ایک اہم عوامل مندرجہ ذیل ہیں۔

characteristics of

Following are the important rice varieties and their ~~recognition~~ distinction.

[illegible]

نمبر شمار	نام قسم	جھونا	اری ۶	باسمتی ۳۷۰	باسمتی پاک	باسمتی ۱۹۸	پی۔کے ۱۷۷
۱	قد (انچوں میں)	۷۰	۴۰	۷۰	۷۰	۵۵	۴۰
۲	تنے کی مضبوطی	کمزور	مضبوط	کمزور	کمزور	مضبوط	مضبوط
۳	دانے کی قسم	درمیانہ	درمیانہ	باریک	باریک	باریک	باریک
۴	لاب سے پکائی کی مدت (دنوں میں)	۹۵	۱۱۰	۱۲۰	۱۲۰	۱۲۵	۹۰
۵	اوسط پیداوار فی ایکڑ	۲۵	۵۰	۲۰	۲۰	۲۵	۳۵ - ۴۰

Important rice varieties according to their characteristics.

باسمتی ۱۹۸ زیادہ پیداوار دینے والی قسم ہے۔ لیکن پچھیتی کاشت سے اس کی پیداوار کم ہوتی ہے اگر وقت پر لگایا جائے یعنی باسمتی ۳۷۰ کے وقت یا اس سے ہفتہ عشرہ پہلے تو یہ باسمتی ۳۷۰ سے ۲۵ تا ۳۰ فیصد زیادہ پیداوار دیتی ہے۔ یہ قسم ساہیوال ضلع میں کامیابی سے کاشت کی جاتی رہی ہے لیکن پچھلے دو تین سال سے اس پر بلاسٹ (دھان کا جھلسا) کا شدید حملہ شروع ہو گیا ہے۔ اس کی جگہ ایک نئی قسم پی۔ کے ۱۷۷ کاشت کیلئے محکمہ زراعت نے منظور کی ہے۔

Seed Rate.

شرح بیج

چنگا بیج تے چنگا جھاڑ۔ بیج ہمیشہ تندرست اور خالص استعمال کریں۔ اری ۶ اور جھونا وغیرہ کیلئے ۶ تا ۸ سیر اور باسمتی اقسام کے لئے ۴ تا ۵ سیر بیج فی ایکڑ استعمال کریں۔

Preparation of Soil and Seed for nursery.

پنیری کاشت کرنے سے ۲۰ تا ۲۵ دن پہلے اس جگہ کو پانی سے بھر دیں تاکہ جڑی بوٹیاں اُگ آئیں ہر ہفتہ اس میں دو ہراہل چلا کر سہاگہ دیں اگر رقبہ زیادہ کاشت کرنا ہو تو پنیری وقفوں سے کاشت کریں۔ بیج کو نمکین یا گدلے پانی میں ڈال کر ہلکے اور ناقص بیج نتھار لیں پھر صاف پانی دو تین بار بدل کر بیج کو ڈھیلی بوریوں میں ڈال کر ۲۴ گھنٹے کے لئے پانی میں ڈبو دیں اس کے بعد ۱۵ تا ۲۰ سیر بیج فی ڈھیری سایہ دار جگہ میں رکھیں اور گیلی بوریوں سے ڈھانپ دیں۔ بیج کو پانی کا چھڑکاتے رہیں۔ دن میں دو تین مرتبہ ہلا دیں تاکہ زیادہ گرمی سے اسے نقصان نہ پہنچے اس طرح تقریباً ۳۶ تا ۴۸ گھنٹے میں بیج انگوری مار لے گا اب یہ بیج پنیری کے لئے تیار کی ہوئی زمین میں ایک سیر فی مرلہ کے حساب سے چھٹہ سے کاشت کریں۔ باسمتی کا بیج آدھ سیر فی مرلہ کاشت کی سفارش کی جاتی ہے تاکہ صحت مند پنیری پیدا ہو سکے، اگر پنیری کمزور نظر آئے تو امونیم سلفیٹ آدھ سیر فی مرلہ یا یوریا ¼ سیر فی مرلہ کاشت کے دس پندرہ روز بعد ڈالیں۔ درج بالا طریقہ سے تیار کی ہوئی پنیری ایک ماہ میں تیار ہو جاتی ہے اور خشک طریقہ سے کاشت کی ہوئی پنیری ۴۰ دن میں تیار ہوتی ہے خشک طریقہ سے تیار کی ہوئی پنیری میں جڑی بوٹیاں زیادہ اگتی ہیں جن کو نکالنا بہت ضروری ہے۔

Time of Nursery sowing.

موٹی اقسام (جھونا، اری ۶) ۲۰ مئی تا ۸ جون تک باسمتی اقسام (باسمتی ۳۷۰ اور باسمتی پاک) یکم جون تا ۳۰ جون اور باسمتی ۱۹۸ یکم تا ۱۰ جون تک کاشت کرنی چاہیئے۔ پی۔ کے ۱۷۷ کی پنیری بھی جون تک کاشت کرنی چاہیئے۔

Field Preparation

زمین کی تیاری کدو یا خشک حالت میں ایسے کی جائے کہ تمام جڑی بوٹیاں پوری طرح تلف ہو جائیں، کالر کے علاقہ میں زمین کی تیاری کدو کے طریقہ سے کی جاتی ہے اس طریقہ میں لاب لگانے کے تقریباً ایک ماہ پہلے کھیت کو پانی سے بھر دیا جاتا ہے پھر ہر ہفتہ عشرہ کے بعد کھڑے پانی میں دو ہراہل چلا کر سہاگہ دے دینا چاہیئے اگر زمین کی تیاری کے عرصہ کے دوران کھیت کو ایک دفعہ ہرا لگا دی جائے تو جڑی بوٹیاں اور پچھلے سال کے گرے ہوئے بیج تیزی سے اُگ آئیں گے پھر پانی دے کر ہل چلا دیا جائے، تو فصل میں جڑی بوٹیاں بہت کم اگتی ہیں اچھی طرح کدو سے تیار کئے ہوئے کھیت کی علامت یہ ہے کہ کھیت میں جڑی بوٹیوں کے گلنے سڑنے، مد زمین میں کیمیائی تبدیلی ہونے کی وجہ سے سڑاند سی آنے لگتی ہے۔

Fertilizer Recommendations for different Rice varieties.

Fertilizer USE

	Type of Soil	Basmati Pak. Basmati 370 Jhona 349	~~PK-177 Basmati 198 1961~~ - 6
۱	عام زمین	۷۵ پونڈ نائٹروجن اور ۳۷ پونڈ فاسفورس فی ایکڑ یعنی ۱½ بوری یوریا یا ۳½ بوری امونیم سلفیٹ اور ۱¾ بوری سپر فاسفیٹ۔	۱۰۰ پونڈ نائٹروجن اور ۵۰ پونڈ فاسفورس فی ایکڑ یعنی ۲½ بوری امونیم سلفیٹ یا ۲ بوری یوریا اور ۲½ بوری سپر فاسفیٹ یا ایک بوری ڈی۔ اے۔ پی اور ۳½ بوری امونیم سلفیٹ۔
۲	کمزور زمین	۹۵ پونڈ نائٹروجن اور ۵۰ پونڈ فاسفورس فی ایکڑ یعنی ۱½ بوری یوریا اور ایک بوری ڈی۔ اے۔ پی یا ۳½ بوری امونیم سلفیٹ اور ایک بوری ڈی۔ اے۔ پی۔ نوٹ:۔ ایک بوری پوٹاشیم سلفیٹ لاہور، لائل پور، جھنگ ملتان اور گجرات کے اضلاع میں دوسری کھادوں کے ساتھ پنیری کی منتقلی سے قبل ڈالیں۔	۱۲۵ پونڈ نائٹروجن اور ۷۵ پونڈ فاسفورس فی ایکڑ یعنی ۶½ بوری امونیم سلفیٹ یا ۲½ بوری یوریا اور ۲¾ بوری سنگل سپر فاسفیٹ یا ۱½ بوری ڈی اے پی معہ ۲ بوری یوریا یا ۱½ بوری ڈی اے پی معہ ۶ بوری امونیم سلفیٹ فی ایکڑ۔ نوٹ:۔ ایک بوری پوٹاشیم سلفیٹ فی ایکڑ گوجرانوالہ، سیالکوٹ اور گجرات کے اضلاع میں دوسری کھادوں کے ساتھ پنیری کی منتقلی سے قبل ڈالیں۔

نوٹ:۔ زمین کی زرخیزی کو مدِنظر رکھتے ہوئے کھادوں کی مقدار کو کم و بیش کیا جا سکتا ہے:۔ کلراٹھی زمینوں کے لئے سنگل سپر فاسفیٹ (فاسفورس کے لئے) اور امونیم سلفیٹ (نائٹروجن کے لئے) کی کھادیں زیادہ بہتر پائی گئیں ہیں۔ کیونکہ یہ کھادیں زمین کی اصلاح میں مدد کرتی ہیں۔

Method of Fertilizer application.

۱۔ پوٹاش اور فاسفورس کی کھاد کی تمام مقدار اور نائٹروجنی کھاد کا ½ حصہ پود کی منتقلی سے پہلے کھیت میں آخری ہل چلاتے وقت ڈالیں۔ نائٹروجنی کھاد کا دوسرا ¼ حصہ پنیری کی منتقلی کے ۲۰ تا ۲۵ دن بعد اور آخری ¼ حصہ پنیری کی منتقلی کے ۵۰ تا ۵۵ دن بعد ڈالیں۔ (باسمتی اور) جھونا ۳۴۹ کے لئے نائٹروجنی کھاد کا آخری ¼ حصہ پنیری کی منتقلی کے ۴۰ تا ۴۵ دن بعد ڈالیں۔

۲۔ آخری ¼ حصہ نائٹروجنی کھاد باسمتی کے لئے فصل کی حالت دیکھ کر ڈالنی چاہیئے۔ اگر فصل کی بڑھوتری اچھی ہو اور اسے ڈالنے سے فصل کے گرنے کا احتمال ہو تو یہ کھاد کا حصہ نہ ڈالا جائے۔

Method of Fertilizer use

کھاد کا طریقہ استعمال

نائٹروجنی کھاد کی وہ مقدار جو کہ پنیری کی منتقلی سے قبل ڈالنی ہے ۔ وہ زمین میں چھٹا دیکر بعد میں ہل چلا دینا چاہیئے تاکہ کھاد اچھی طرح زمین میں مل جائے اور بعد میں کھیت کو خشک نہ ہونے دینا چاہیئے کیونکہ اس سے نائٹروجنی کھاد کے ضائع ہونے کا احتمال بڑھ جاتا ہے ۔

۲ ۔ نائٹروجنی کھاد کا وہ حصہ جو پنیری کی منتقلی کے بعد ڈالنا ہے وُہ اس وقت ڈالیں جب کھیت میں کھڑے پانی کی مقدار بالکل پوری ہو ۔ یعنی خشک حالت میں کھاد نہیں ڈالنی چاہیئے ۔

Eradication of weeds.

جڑی بوٹیوں کی تلفی

دھان کی فصل میں جڑی بوٹیوں کی وجہ سے پیداوار میں کافی کمی واقع ہو جاتی ہے اس لیے جڑی بوٹیوں کا بروقت تلف کرنا نہایت ضروری ہے ۔ اس میں تقریباً ایک ماہ پہلے پانی لگا کر چھوڑ دیں تاکہ اُس میں جڑی بوٹیاں اُگ آئیں اور اس کے بعد کو و کرنے سے تمام جڑی بوٹیاں تلف کر دیں ۔

لاب لگانے کے بعد کھیت میں پانی کھڑا رکھنا چاہیئے اور خشک نہیں ہونے دیا جائے ورنہ جڑی بوٹیاں پھر نکلنے کا امکان ہے ۔

کیمیاوی علاج کے لئے سٹایم الیف ۳۴ STAM-F(34)) یا سرکوپار (SURCOPAR) یا پروپنل ا PRO-1 PONIL) میں کوئی ایک دوا کا بحساب ایک لیٹر فی ایکڑ سے سپرے کریں ۔

Diseases of Rice

دھان کی بیماریاں

ہمارے علاقہ میں ویسے تو دھان کی چار بیماریاں مثلاً ۱ ۔ دھان کا بھبکا یا بلاسٹ ۲ ۔ دھان کے پتوں کا جھلساؤ ۳ ۔ دھان کے تنا کا سڑانڈ ۴ ۔ دھان کی کانگیاری دیکھنے میں آئی ہیں لیکن ان سب بیماریوں میں سے دھان کا بھبکا سا بلاسٹ زیادہ نقصان پہنچاتی ہے یہ بیماری شروع میں زرد سیاہی مائل دھبوں کی شکل میں پتوں پر نمودار ہوتی ہے بعد میں یہ دھبے تکلا نما (◊) شکل اختیار کر لیتے ہیں دھبوں کے ارد گرد کا حصہ زرد رنگ کا اور درمیانی حصہ خاکستری رنگ کا ہو جاتا ہے یہ بیماری تنے کی گانٹھوں پر بھی حملہ کرتی ہے اور تنے کی گانٹھیں سیاہ رنگ کی ہو جاتی ہیں اور فصل گر جاتی ہے آخر میں اس کا حملہ سٹے کی گردن پر ہوتا ہے اور سٹے کی گردن سیاہ رنگ کی ہو جاتی ہے اور سٹہ ٹوٹ بھی جاتا ہے ۔ اس بیماری کے حملہ سے بچاؤ کے لئے یہی ہے کہ جس فصل پر حملہ ہو چکا ہو اُس کا بیج استعمال نہ کریں ۔ زرخیز زمین میں زیادہ کھاد نہ ڈالیں ۔ فصل کو پچھیتا کاشت نہ کریں اور فصل کی برداشت پر پرالی کھیت سے اٹھالیں ۔ نیز اس بیماری سے بچاؤ کے لئے ڈائی تھین ۴۵ بحساب ۲ تا ۳ پونڈ فی ایکڑ سپرے کریں پھر بیماری ظاہر ہونے کے وقت سے شروع کریں ۔

دھان کی سنڈی کے کیمیائی انسداد کا گوشوارہ

Schedual about chemical control for Rice worm.

Poisons and their Composition.

زہر

اس کی طاقت اور اس میں عنصر موثرہ

		کل مقدار زہر برائے استعمال فی ایکڑ (پونڈ) برائے نرسری	برائے فصل	
		دھوڑا صرف ایک بار ۱۰ دن کی پنیری پر	پہلی دفعہ لاب سے ۳۰ سے ۳۵ دن بعد	دوسری دفعہ ۵۰ سے ۵۵ دن بعد
۱.	گامابی ایچ سی ۵ بز دھوڑا + ڈی ڈی ٹی ۱۰ بز دھوڑا یا	۵،۲۰ + ۱۵۰ [?]		
۲.	گامابی ایچ سی ۱۰ بز دھوڑا + ڈی ڈی ٹی ۱۰ بز دھوڑا یا	۲،۵ + ۱۵۰ [?]		
۳.	گامابی ایچ سی ۱۲ بز حل پذیر پوڈر + ڈی ڈی ٹی ۱۰ بز دھوڑا	۲،۰ + ۱۵۰ [?]		
		کھڑے پانی میں دانہ دار ۱۵ دن کی پنیری پر		
۴.	باسوڈین ۱۰ فیصد دانے دار	۱۵	۱۵	۱۵
۵.	ڈائزنیان ۱۴ فیصد " "	۱۰	۱۰	۱۵
۶.	فیوراڈان ۳ فیصد	۱۵	۱۵	۲۰
۷.	پاڈان ۱۰ فی صد	۱۵	۱۵	۲۰
۸.	سوڈال دانے دار (سیون نمبر ۸ + بی ایچ سی ۸٪)	۲۰	۲۰	۲۰
۹.	ایکالکس دانے دار ۵ فی صد	۱۵	۲۰	۳۰

دھان کے تنڈے اور دوسرے کیڑے بھی ان ہی زہروں کے استعمال سے کافی حد تک ختم ہو جاتے ہیں

If none or two, even single chemical mentioned above is not available, then contact Agri. officer or Field Assistant of your area.

اگر مندرجہ بالا زہروں میں سے کوئی بھی دستیاب نہ ہو تو اپنے حلقہ سے زراعت افسر یا فیلڈ اسسٹنٹ کے مشورہ سے دوائی استعمال کریں۔

Control of harmful insects.

ضرر رساں کیڑوں کا انسداد

دھان کی فصل پر سب سے زیادہ نقصان تنے کے گڑویں سے ہوتا ہے۔ لہٰذا دھان کے مڈھوں کو ماہ فروری کے آخر تک ہل چلا کر اکھاڑ دیں۔ اور خود رو پودوں بھوٹ کو بھی ساتھ ہی تلف کریں اور ۲۰ مئی سے پہلے پنیری کاشت کریں کیونکہ کیڑا اگیتی فصل پر پل کر پچھیتی فصل کو تباہ کر دیتا ہے۔ پنیری کاشت کرنے کے ۸ تا ۱۰ دن بعد ڈی ڈی ٹی اور بی ایچ سی کا دھوڑا کریں۔ اس کے ایک ہفتہ بعد سیویڈال ۱۶ بز ۲۰ پونڈ فی ایکڑ یا ڈائزینان ۱۴ بز دس پونڈ فی ایکڑ یا فیوراڈان ۳ بز ۱۷ پونڈ فی ایکڑ کے حساب سے کسی ایک کا چھٹہ دیں۔ دانہ دار زہروں کا استعمال بہت ضروری ہے۔ برسیم کے کھیتوں میں مارچ کے آخر سے لے کر اپریل کے تیسرے ہفتے تک روشنی کے پھندے لگائیں تاکہ پروانے نکلتے ہی جل کر مر جائیں۔

Zinc deffiency.

جست (زنک) کی کمی

جست کی کمی کلراٹھی زمینوں میں شدت سے ظاہر ہوتی ہے یہ زمینی بیماری لاب لگانے کے ۱۵ سے ۲۰ دن بعد شروع میں پودے کے نچلے پتوں پر سیاہی مائل چھوٹے چھوٹے دھبوں کی شکل میں ظاہر ہوتی ہے پھر اوپر کے پتوں پر ظاہر ہونا شروع ہو جاتی ہے اس سے پودے کی بڑھوتری رک جاتی ہے۔ جن کھیتوں میں جست کی کمی نمودار ہوتی ہے وہاں لاب لگانے کے بعد ۸ تا ۱۰ پونڈ زنک سلفیٹ کا چھٹہ دے دیں۔ اگر پہلے زنک سلفیٹ نہ ڈالا گیا ہو تو جست کی کمی کی علامتیں ظاہر ہونے پر ڈال دیں۔ اگر جست کی کمی کی علامتیں معمولی ہوں تو کھیت کو سوکا لگانے سے بھی کام چل جاتا ہے۔ لیکن زیادہ کمی کی صورت میں زنک سلفیٹ ڈالنے کے سوا کوئی چارہ نہیں۔ اگر مناسب وقت پر علاج نہ کیا جائے تو پیداوار بہت کم ہو جاتی ہے۔ لاب لگانے سے پہلے پنیری کی جڑوں کو اگر زنک آکسائیڈ والے پانی میں ڈبو کر لگایا جائے تو جست کی کمی ظاہر نہیں ہوتی۔ ایک ایکڑ پنیری کے لئے دو پونڈ زنک آکسائیڈ کافی ہے۔ اگر ۱۰ گیلن پانی میں ۲ پونڈ زنک آکسائیڈ ملا لیا جائے تو ایک ایکڑ کی پود کے لئے کافی ہے۔ جست کی کمی کی معمولی علامت ظاہر ہونے پر DITHANE M - 45 ایک کلوگرام فی ایکڑ کے حساب سپرے کرنے سے متاثر فصل کو بچایا جا سکتا ہے۔

Harvesting.

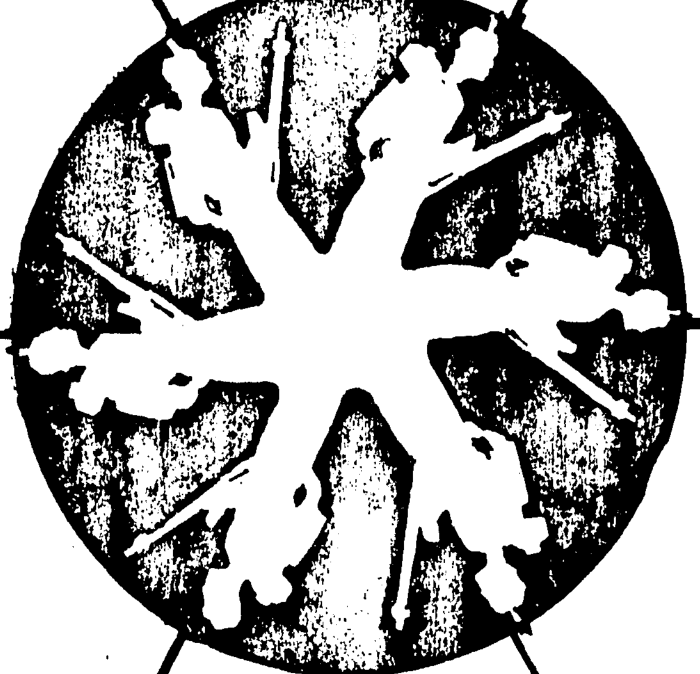
[illegible]

ایک اندازے کے مطابق ۵ تا ۱۰ فیصد نقصان کٹائی اور پھنڈائی میں مناسب احتیاط نہ کرنے سے ہو جاتا ہے۔ فصل کی کٹائی اس وقت شروع کر دینی چاہیئے جب سٹہ کے نچلے حصہ میں دو یا تین دانے پورے بھر چکے ہوں۔ لیکن ابھی ہرے ہوں۔ زیادہ دیر تک کھیت میں فصل رکھنے سے دانے جھڑنا شروع ہو جاتے ہیں۔ پھنڈائی کے وقت آگے ترپال یا بڑی چادریں بچھا لینی چاہیئں تاکہ دانے مٹی میں مل کر ضائع نہ ہوں۔ فصل اتنی ہی کاٹنی چاہیئے جتنی کی ساتھ ساتھ پھنڈائی کر سکے اور ڈھیر کو رات کے وقت ترپال یا پرانی بوری وغیرہ سے ڈھانپ دیں اور جلدی قریبی سنٹر میں پہنچا دیں۔ مونجی گیلی ہونے کی وجہ سے زیادہ عرصہ ڈھیر میں نہ رکھیں ورنہ گرمی پیدا ہونے سے بدبو آنے لگے گی اور چھڑائی کے وقت معیاری چاول بھی حاصل نہ ہو سکے گا۔

Comprehensive plan for control of Agri. Epidemics of Rice CPG-2

دھان کی زرعی وباؤں کے انسداد کا جامع منصوبہ

غلام قادر چودھری



ادارہ زرعی اطلاعات و مطبوعات محکمہ زراعت، حکومت پنجاب

چاول جو کہ پنجاب میں خریف کی سب سے بڑی غذائی فصل ہے اس کی تقریباً سترہ لاکھ ایکڑ رقبہ پر کاشت ہوتی ہے اور تقریباً ۷۔۹ لاکھ ٹن سالانہ پیداوار حاصل ہوتی ہے۔ باسمتی چاول جو کہ لاہور ڈویژن کے "کالر" کے علاقے میں کاشت ہوتا ہے۔ پکوائی اور خوشبو کے لحاظ سے برصغیر پاک و ہند میں بہت مقبول ہے اور زرمبادلہ کمانے کا ایک اچھا ذریعہ ہے۔ فالتو مواد سے مویشیوں کی خوراک حاصل ہونے کے علاوہ چاول کا پیال صنعتی مقاصد مثلاً کارڈ بورڈ وغیرہ کی تیاری کے لئے استعمال ہوتا ہے۔

Epidemics of Rice.

دھان کی وبائیں

بیرن (BEIRNE) کے نظریئے کے مطابق "وبا" کی اصطلاح میں تمام تباہ کن کیڑے، بیماریاں، نقصان دہ جڑی بوٹیاں اور نقصان دہ فقاری حیوانات شامل ہیں۔ مندرجہ ذیل وبائیں، پنجاب میں چاول کی فصل کو کافی نقصان پہنچاتی ہیں۔

Insects

۱۔ کیڑے

پنجاب میں دھان کی فصل کو نقصان پہنچانے والے کیڑے مندرجہ ذیل ہیں۔

Stem borers

(الف) تنے کی سنڈیاں

۱۔ تنے کی پیلی سنڈی
۲۔ تنے کی سفید سنڈی
۳۔ تنے کی گلابی سنڈی
۴۔ تنے کی دھاری دار سنڈی

Juice sucking insects

(ب) رس چوسنے والے کیڑے

۵۔ پتے کا سبز ٹڈا
۶۔ دھان کا سفید تیلا CICADELLA SPECTRA DISTANT
۷۔ دھان کا سفید تیلا KOLLA MIMICA DISTANT
۸۔ ٹیلا ٹیلا SOGATELLA FURCIFERA HORV.
۹۔ دھان کی لاٹری (دبگ) LEPTOCORISA VARICORNIS Fb.
۱۰۔ دھان کی گدھیڑی RIPERSIA ORYZAE Fb.

Leaf eating insects

(ج) پتے خور کیڑے

(Leaf hopper)

۱۱۔ دھان کا ٹڈا HIEROGLYPHUS SPP.
۱۲۔ اورکسا ٹڈا AIOLOPUS SPP.
۱۳۔ سطحی ٹڈا AIOLOPUS SPP
۱۴۔ سطحی ٹڈا CHROTOGONUS SP
۱۵۔ دھان کی لشکری سنڈی
۱۶۔ بالدار سنڈی PORTHESIS XANTHORRHOEA KOLL
۱۷۔ بالدار سنڈی DASYCHIRA SECURIS HUBN
۱۸۔ دھان کا سکیپر PARNARA MATHIA Fb.
۱۹۔ دھان کی پتہ لپیٹ سنڈی CNAPHALOCROCIS MEDINALIS

Root Borers

(د) جڑ خور کیڑے

۲۰۔ جڑ کی بھونڈی HYDRONOMIDIUS MOLLITOR Fst.

۱۹۵۰ء میں لاہور ڈویژن میں دھان کی فصل پر دھان کی سنڈیوں نے بھرپور حملہ کیا تھا جس کی وجوہات ذیل میں درج ہیں۔

۱۔ محکمہ زراعت کی منظور شدہ سفارش کے مطابق سال میں دھان کی دو فصلیں حاصل کرنے کے لئے مارچ، اپریل میں دھان کی نرسریوں کی اگیتی کاشت۔

۲۔ رسدار زیادہ پیداواری اقسام کی دریافت جو کہ دھان کی سنڈی کے لئے زیادہ مرغوب ثابت ہوئیں۔

۳۔ کھاد کی وجہ سے دھان کا تنا رس دار ہو گیا جس کی

وجہ سے سنڈیوں کا حملہ زیادہ ہوتا گیا۔

۴۔ ایسے علاقے جہاں ٹیوب ویل کے ذریعے آبپاشی کی جاتی تھی۔ وہاں خوراک کی قلت کے دنوں میں یعنی اپریل مئی میں بھی سنڈیوں کو خوراک ملتی رہی جس کی وجہ سے وہ اس قابل ہوگئیں کہ دھان کی اگلی فصل پر حملہ آور ہوسکیں۔

۱۹۵۱ء میں محکمہ زراعت نے لاہور ڈویژن میں دھان کی نرسریوں پر دھوئیں کے ذریعے سنڈیوں کے حملہ کی روک تھام کی۔ وبا پر مکمل طور پر قابو نہ پایا جاسکا کیونکہ دھان کی کاشت کی تاریخوں پر کوئی پابندی نہیں تھی۔ ۱۹۵۷ء کے دوران دھان کی فصل پر سنڈیوں کا حملہ اتنا شدید تھا کہ پچھیتی کاشت کا ۸۰ فیصد حصہ اس سے متاثر ہوا اور ایسے کھیتوں میں کاشتکار کٹائی بھی نہ کر سکے۔ اس کا مقابلہ کرنے کے لئے محکمہ زراعت نے ۱۹۵۸ء میں دھان کی فصل خریف کے لئے جامع پروگرام مرتب کیا جس کے تحت دھان کی نرسریوں میں کیڑوں کے انسداد کے علاوہ یکم جون کے بعد دھان کی کاشت پر پابندی عائد کردی گئی۔ اس انسدادی پروگرام پر عمل کرتے ہوئے ۱۹۶۵ء تک دھان کی سنڈیوں پر قابو پا لیا گیا۔

۱۹۶۶ء میں حکومت نے یہ حکم جاری کیا کہ صارفین سے کرم کش ادویات کی ۲۵ فیصد قیمت وصول کی جائے۔ اس کا نتیجہ یہ ہوا کہ سنڈیوں کی افزائش نسل میں دوبارہ اضافہ ہوگیا اور ۱۹۷۰ء میں دھان کی فصل پر ان کا حملہ اتنا شدید تھا کہ پچھیتی فصل کا ۳۰ فیصد حصہ ضائع ہوگیا۔ ۱۹۷۱ء میں محکمہ زراعت نے دھان کی سنڈیوں کے خلاف ایک جامع پروگرام مرتب کیا اور اس طرح سنڈیوں کے حملے میں ۱۰ سے ۱۲ فیصد تک کمی واقع ہوگئی۔ ۱۹۷۲ء میں محکمہ زراعت نے دوبارہ بڑے جوش و خروش کے ساتھ یہ انسدادی پروگرام شروع کیا جس کا نتیجہ یہ ہوا کہ اس سال حملہ کی شرح صرف ۵ء۴ فیصد تھی۔ اس سے معلوم ہوا کہ دھان کی وباؤں کا موثر انسداد ناگزیر ہے۔

صوبہ میں فصلوں کے لئے نقصان دہ کیڑوں کی بہت سی اقسام ہیں جن میں سے تنے کی پیلی سنڈی، تنے کی گلابی سنڈی، تنے کی سفید سنڈی اور تنے کی دھاری دار سنڈی خاص طور پر اہم ہیں۔ ان میں سے اوّل الذکر تین بہت زیادہ نقصان کرتی ہیں جب کہ آخری قسم نسبتاً کم نقصان دہ ہے۔

سنڈیوں کا دوران زندگی

گلابی سنڈی کے سوا دھان کی ہر سنڈی کا دور زندگی تقریباً ایک جیسا ہے۔ مادہ پروانے مارچ کے آخر یا اپریل کے شروع میں پیوپا سے نکلتے ہیں جو کہ سردیوں کے بعد نمودار ہونے والے لاروے سے بھورے مائل بالوں سے ڈھکے ہوتے ہیں۔ ایک مادہ انفرادی طور پر اپنی زندگی کے دوران ۳-۴ مرتبہ ڈھیریوں کی صورت میں انڈے دینے کی صلاحیت رکھتی ہے۔ موسمی کیفیات کے مطابق انڈوں سے بچے ۴ سے ۹ دن میں نکلنے شروع ہو جاتے ہیں۔ انڈوں سے نکلنے کے بعد لاروے کچھ وقت تک پودے کی سطح پر ادھر ادھر پھرتے رہتے ہیں۔ پھر تقریباً ۲۴ گھنٹہ بعد لاروے پودے کی اوپر والی گانٹھ سے پودے کے اندرونی حصوں میں راستہ بناتے ہوئے نیچے کی گانٹھوں تک پہنچتے ہیں۔ ایک پودے کو تباہ کرنے کے بعد لاروے پانی کی کشتی کے ذریعے دوسرے پودے میں منتقل ہوجاتے ہیں۔ لاروے کی عمر ۱۷ تا ۳۸ دن ہوتی ہے مکمل لاروا تنے کے اندر جا کر پیوپا میں تبدیل ہوجاتا ہے اور پیوپا میں تبدیل ہونے سے پہلے لاروا تنے کے اندر باہر سے سوراخ کر دیتا ہے۔

انڈہ

پیوپا

لاروا

پروانہ

سنڈی کا دوران زندگی

Rice borers, their habits and distinction

دھان کی سنڈیاں، ان کی عادات اور پہچان

Sr. No. نمبر شمار	Name of borer سنڈی کا نام	Adult بالغ	Egg انڈہ	Larva لاروا	Pupa پیوپا	Crop میزبان فصل
١	تنے کی پیلی سنڈی	رنگ پیلا زرد، جسامت میں مادہ نر سے بڑی۔ اگلے پروں کے درمیان میں ایک دھبہ، نر سنڈی پر بھورے بھورے بال۔	گول۔ چپٹے، سفید رنگ کے چکنے انڈے جو کہ پتوں پر تہہ در تہہ دیئے جاتے ہیں۔ انڈوں پر چھوٹے چھوٹے بھورے بال ہوتے ہیں۔	لاروا مکمل حالت میں زردی مائل سفید یا پیلا مائل سفید یا تھوڑا تھوڑا سبزی مائل۔ سر کا رنگ گہرا زرد۔	زردی مائل سفید جو کہ سفید ریشمی ٹیوب میں بند ہوتا ہے۔	صرف دھان
	مدت دنوں میں	۵ - ۷ دن	۶ - ۷ دن	۱۷ - ۲۷ دن	۹ - ۱۲ دن	
٢	تنے کی سفید سنڈی	بالکل سفید۔ جسامت میں مادہ، نر سے بڑی۔ مادہ میں دم کی طرف گہرے زرد رنگ کے بالوں کا گچھا۔	ایضاً	ایضاً	ایضاً	دھان، کماد اور گھاس کی مختلف اقسام
	مدت دنوں میں	۵ - ۷ دن	۴ - ۹ دن	۱۹ - ۳۱ دن	۷ - ۱۱ دن	
٣	تنے کی گلابی سنڈی	کاہی رنگ، سر پہ گھنے بال۔ اگلے پروں میں درمیانی نس کے پاس سرخی مائل بھوری لکیریں۔ پچھلے پر سفید، مادہ جسامت میں نر سے بڑی	چکنے سفید، سر والے حصے سے چپکے ہوئے پتے کے اندر والے حصے میں قطار اندر قطار دیئے جاتے ہیں۔	لاروا مکمل حالت میں گلابی رنگ کا ہوتا ہے پیٹ پر دم کی طرف ٹانگوں کا جوڑا سر گہرا زردی مائل سرخ	سرخی مائل بھورا دم کی طرف چھوٹے چھوٹے کانٹے نما بال	چاول مکئی کماد گندم اور گھاس
	مدت دنوں میں	۵ - ۷ دن	۴ - ۹ دن	۳۱ - ۳۸ دن	۶ - ۱۲ دن	..
٤	دھاری دار سنڈی	اگلے پر کاہی رنگ کے	(STRYPRYZA) کی	عقبی پہلو پر پانچ	رنگ ہلکا بھورا	چاول

Continued →

نمبر شمار	سنڈی کا نام	بالغ	انڈہ	لاروا	پیوپا	میزبان فصل
		جن پر جابجا چھوٹے چھوٹے بھورے دھبے ہوتے ہیں۔ پچھلے پروں میں CUBITAL VEINS پر ریشمی بالوں کا چھوٹا سا سلسلہ	شکل جیسے مگر بالوں کے بغیر۔	لمبی لمبی دھاریاں سر کا رنگ پیلا زرد۔	خول کی لمبائی ۱ ملی میٹر اور زیادہ سے زیادہ قطر کی چوڑائی تقریباً ۲،۵ ملی میٹر	جوار اور گھاس
	مدت دنوں میں		۴ - ۶ دن	۳۰ - ۳۶ دن	۵ - ۱۰ دن	

اپریل سے اکتوبر تک سنڈیاں سرگرم رہتی ہیں۔ اس مدت میں ہر نسل چار پانچ نسلوں میں تبدیل ہو جاتی ہے، آخری نسل کے لاروے نومبر تا مارچ یعنی دھان کی نزائی کے دوران خول میں بند ہو جاتے ہیں۔ لیکن گلابی سنڈی سردیوں کے دوران بھی اپنا کام جاری رکھتی ہے۔ مارچ اپریل جو کہ سونڈی کے لئے سازگار موسم ہے، اس میں لاروے سے پیوپا بنتا ہے اور پیوپا سے پروانے بنتے ہیں جو کہ چاول کی اگلی فصل کو نقصان پہنچاتے ہیں۔

فصل پر سنڈیوں کی تمام اقسام کے حملے کا طریق کار تقریباً ایک جیسا ہے۔ سنڈیاں پودے کی نشو ونما والی شاخوں پہ حملہ کرتی ہیں۔ جس سے پودا سوکھنا شروع ہو جاتا ہے جسے عام اصطلاح میں "سوکھی" (DEAD HEART) بھی کہا جاتا ہے۔

خوشے دانوں سے محروم رہ جاتے ہیں۔ جو سفید رنگ کے ہوتے ہیں۔ اور انہیں (WHITE HEADS) بھی کہا جاتا ہے۔ اگیتی فصل میں حملے کی شدت ہمیشہ کم ہوتی ہے لیکن پچھیتی یا منی کی کٹائی کے وقت حملہ شدید ترین ہوتا ہے کیونکہ حشرات اس وقت تک زور پکڑ چکے ہوتے ہیں۔

Rice Diseases

دھان کی بیماریاں

سوبہ میں دھان کی فصل پر جو بیماریاں حملہ آور ہوتی ہیں ان میں سے بڑی بڑی بیماریاں مندرجہ ذیل ہیں۔

Burning

جھلساؤ

جھلساؤ کی بیماری فطری کی وجہ سے پیدا ہوتی ہے۔ ساری دنیا میں دھان کی فصل پر حملہ آور ہوتی ہے پنجاب میں جہاں بھی دھان کی کاشت ہوتی ہے ایک اندازہ کے مطابق یہ بیماری فصل کی پیداوار کا ۹۰ فیصد حصہ ضائع کر سکتی ہے۔

یہ بیماری پتوں کے اندرونی حصوں، تنوں اور گودے پر حملہ کرتی ہے۔ پھوئی کا حملہ پودے کی نموت پہلے اور بعد دونوں وقت ہوتا ہے۔ اور ٹھنڈی زمینوں پر نسبتاً اس کا حملہ زیادہ ہوتا ہے۔ پنجاب میں پھوئی کا پہلے اور بعد والا حملہ عام نہیں ہے۔ پتوں اور تنوں کے اندرونی حصوں پر گول گول بھورے دھبے پڑ جاتے ہیں جن کے سرے سرخی مائل بھورے اور مرکز بھورے رنگ کے ہوتے ہیں۔ یہ دھبے شروع شروع میں چھوٹے چھوٹے ہوتے ہیں اور ان کا قطر تقریباً ۰،۵ ملی میٹر ہوتا ہے لیکن بعد ان کو نشو ونما ہوتی ہے جس کی وجہ سے یہ پھیل جاتے ہیں اور بالآخر ایک دوسرے سے مل ہوتے ہیں۔ شدید حملہ کی صورت میں پودے کے پکنے سے پہلے ہی سڑ جاتے ہیں۔ پودے کی گانٹھیں سیاہ رنگ کی ہو جاتی ہیں۔ اور ان پر بڑی مقدار میں پھوئی اُگ آتی ہے۔ جب موسم سازگار ہو تو بیماری عام ہوتی ہے۔ دانوں پر بہت زیادہ دھبے پڑ جاتے ہیں جسکی وجہ سے فصل اور اس کی پیداواری مقدار میں بہت بڑی کمی واقع ہو جاتی ہے۔

Rice Jaundice

دھان کا یرقان

یہ بیماری (PIRICULARIU ORYZAE) کی وجہ سے پیدا ہوتی ہے ۔ پنجاب میں چاول کی کاشت کے علاقے میں یہ بیماری ہر جگہ حملہ آور ہوتی ہے ۔ حملہ کی زد میں زیادہ آنیوالی اقسام اور کھاد کے زیادہ استعمال نے اس بیماری کی اہمیت میں اضافہ کر دیا ہے ۔ ٦٢ - ١٩٦١ء میں باسمتی کی قسم ٦٢٢ جس کی منظوری محکمہ زراعت نے دی تھی صرف اس بیماری کی زد میں آنے کی وجہ سے ناکام ہو گئی اس بیماری کے حملہ سے پتے، گودا، خوشے اور شاخیں متاثر ہوتی ہیں ۔ فصل میں اُگنے کے مرحلہ اور حملہ کے موقع پر اسے "پنیری کا یرقان" پتے کا یرقان اور گردن کا یرقان کہا جاتا ہے ۔

Rice Sudden Death

دھان کا بھبکا

یہ بیماری جراثیم (NEROSSIA HORRIDA) کی نسل سے پیدا ہوتی ہے ۔ پودے کی کانگیاری بھی کہا جاتا ہے ۔ یہ بیماری کافی زیادہ ہوتی ہے لیکن اس وجہ سے ہونے والا نقصان زیادہ نہیں ہوتا ۔ کیونکہ دھان کے ایک پودے میں صرف چند گودوں ہی کو اس کی وجہ سے نقصان اٹھانا پڑتا ہے ۔

١٩٦٩ء میں ضلع شیخوپورہ کی تحصیل ننکانہ صاحب میں اس بیماری کی وجہ سے چاول کی فصل کو خاصا نقصان اٹھانا پڑا محکمہ زراعت نے اس بیماری کا اس طرح انسداد کیا کہ انہوں نے کاشتکاروں کو بتایا کہ صحتمند بیج کا استعمال کیا جائے اور اور مارچ سے پہلے پہلے تمام فصل کے بچے ہوئے حصے تلف کئے جائیں ۔

اس بیماری سے براہ راست چاول کا دانہ متاثر ہوتا ہے ۔ ایسے دانوں میں عام نشاستہ کی بجائے سیاہ رنگ کا سفوف ہوتا ہے ۔ اور ان میں گودے کی نشوونما بہت کم ہوتی ہے یا بالکل نہیں ہوتی ۔ کھیت میں بھبکے سے متاثرہ دانوں کا اس وقت تک علم نہیں ہوتا جب تک انہیں توڑا نہ جائے ۔ شدید حملہ کی صورت میں چاول کے دانے کی بیرونی جھلی شکستہ ہو جاتی ہے اور کالے رنگ کا سفوف جس میں بھبکے کے تخم ہوتے ہیں نظر آنا شروع ہو جاتا ہے ۔ تخم یا تو زمین پر گرتے ہیں اور یا کسی صحتمند پودے پر گرتے ہیں ۔ یہ تخم نسل کو چلاتے ہوئے سپورانڈ یا پیدا کرتے ہیں جو دھان کے دانوں کو مزید نقصان پہنچاتے ہیں ۔ پھول نکلتے وقت بارش کا موسم اس بیماری کے پھیلانے میں بہت مدد دیتا ہے ۔ دھان کی گھٹیا اقسام مثلاً "ستھرا" اور "جھونا" اس بیماری سے بہت زیادہ متاثر ہوتی ہیں ۔ لیکن عمدہ اقسام بالخصوص "باسمتی" وغیرہ اس بیماری کے خلاف کافی مزاحمت رکھتی ہیں ۔ اگر موسمی حالات صحیح ہوں تو پنجاب میں اس بیماری کے نقصان کی شرح ٢-٣ فیصد سے زیادہ نہیں ۔ لیکن اگر بیماری کے لئے موسمی حالات سازگار ہوں تو گھٹیا اقسام میں ٥٠ فیصد تک نقصان ہو سکتا ہے ۔

Rice Stem Burns

دھان کے تنے کی سڑاند

تنے کی سڑاند پھپھوندی (سلیروٹیم اورائزی (SELEROTIUM ORYZAE CALT) سے پیدا ہوتی ہے ۔ تنے کی سڑاند ایک اہم بیماری ہے اور یہ لاہور ڈویژن میں چاول کی پیداوار کے مخصوص اضلاع شیخوپورہ، گوجرانوالہ اور سیالکوٹ میں عام ہوتی ہے ۔ پنجاب میں اس بیماری سے نقصان کی شرح اب ٢٥ فیصد ہے ۔ اس بیماری کی وجہ سے دھان کی کسی کھیت کے ٨٠ فیصد یا اس سے بھی زیادہ حصے کو نقصان پہنچ سکتا ہے ۔ پودے کے صحیح طرح کھڑا ہونے کے ایک مہینہ سے چھ ہفتہ قبل سب سے پہلے تنے کے غلاف پر پانی کی لائن کے قریب زخم ہونے شروع ہو جاتے ہیں ۔ تنے اور تنے کے ریشوں کے اندر سیاہ رنگ کا حصہ پھیلنا شروع ہو جاتا ہے ۔ پہلے تنے کے غلاف کے اندر اور پھر تنے میں بہت سے سیلروٹیا (SELEROTIA) نشوونما پانے لگتے ہیں ۔ پھپھوندی کے کائی سیلیم (MYCELIUM) کے باہر کی پرت پر تاریک رنگ کے دھاگے بناتے ہیں ۔ پھر یہ زخم گہرے بھورے رنگ کی لکیروں کی صورت میں پرانے سیاہ رنگ کے (NECTORIC) علاقوں کی طرف پھیلنا شروع ہو جاتا ہے اور جونہی (PANICLES) نمودار ہوتے ہیں ۔ تنے کے انحطاط پذیر حصے ٹوٹنے شروع ہو جاتے ہیں ۔ اور جو دانے کم بھرے ہوتے ہیں ۔ اس حملے کا پہلا شکار بنتے ہیں ۔

Rice Leaf Spots

دھان کے پتوں کے دھبے

یہ بیماری جو کہ (...REO PORA ORYZAE) کی وجہ

پھیلتی ہے۔ اس کی شناخت سے دھاری دار تنگ تنگ دھبوں سے کی جاتی ہے جن کا رنگ کناروں پر ہلکا بھورا اور پرانے مرکزوں پر ہلکا سلیٹی ہوتا ہے۔ صرف شدید ہونے کی صورت میں تنوں اور پودے کے دوسرے حصوں پر بھی دھبے پڑ جاتے ہیں۔

(ب) خیطیے

ادارۂ تحقیقات کی کوششوں سے پہلی بار مندرجہ خیطیے منظرِ عام پر آئے ہیں جو دھان کی فصل کو نقصان پہنچاتے ہیں:

۱ ۔ ایکروبلز
۲ ۔ افیلینکس
۳ ۔ کاکوپارس
۴ ۔ سفیولس
۵ ۔ کاٹیوپلیکس
۶ ۔ ڈوری لائمش
۷ ۔ یوسفیلوبس
۸ ۔ گرینا
۹ ۔ لونگی ڈورس
۱۰ ۔ میزوڈوری لائمش
۱۱ ۔ مونوکس
۱۲ ۔ مائیونکس
۱۳ ۔ ریڈوفلس
۱۴ ۔ ریڈورٹس
۱۵ ۔ ٹائلینکس
۱۶ ۔ ٹائلینکورائکس

حال ہی میں لاہور اور سرگودھا ڈویژن کے دھان کی کاشت والے علاقوں کے سروے سے پتہ چلا ہے کہ ریڈوفس RADOPHUS ایک ایسا اندرونی طفیلی خیطیہ (EUDOPARA SITIC NATODE ہے جو کہ دھان میں سفید چوٹی (WHITE TIP) کی بیماری پھیلانے کا موجب ہے یہ خیطیہ (NEMATODE) جڑوں کا رس چوستا ہے جس کی وجہ سے پودا سوکھ جاتا ہے۔ بالیوں کی نمو کے وقت جن پودوں پر حملہ ہو چکا ہو ان کے خوشوں پر سفید رنگ کے (TIP) ہوتے ہیں۔ متاثرہ حصے یعنی سفید چوٹی (WHITE TIP) پر کوئی دانہ نہیں لگتا جس کا نتیجہ یہ ہوتا ہے کہ پیداوار میں کمی واقع ہو جاتی ہے۔

III فاسد جڑی بوٹیاں (NOXIOUS WEEDS)

جڑی بوٹیوں (گھاس، چوڑے پتے وغیرہ) کی وجہ سے پیداوار میں کمی واقع ہو جاتی ہے۔ کیونکہ یہ سب فصل کے حصے کی روشنی یا پانی اور خوراک ہی پر پرورش پاتی ہیں۔ مزید یہ کہ جڑی بوٹیاں دھان کے لئے نقصان دہ کیڑوں اور پھپھوندی وغیرہ کے لئے پناہ گاہ کا کام کرتی ہیں۔ پس جڑی بوٹیاں دھان کی صحتمند پرورش کے راستے میں رکاوٹ ہوتی ہو جس کی وجہ سے پیداوار اور منافع دونوں متاثر ہوتے ہیں پنجاب میں جڑی بوٹیوں کی وجہ سے دھان کی فصل کو نقصان پہنچتا ہے وہ مندرجہ ذیل ہیں۔

۱ ۔ موتھا یا ڈیلا
۲ ۔ مرچ بوٹی
۳ ۔ سوانک
۴ ۔ کتا کامی
۵ ۔ چھپائی
۶ ۔ نارو
۷ ۔ گھوٹن
۸ دبڑال

دھان سلسلہ میں جڑی بوٹیوں کے انسداد کی اشد ضرورت ہے۔ ۱۹۶۵ء میں رائس ریسرچ اسٹیشن کالا شاہ کاکو میں مون سانٹو امریکہ کی تیار کردہ جڑی بوٹی کش دوائی میشیٹ (MACHETE) دھان کی (IRRI) قسم کی فصل پر پودا پھوٹنے سے پہلے اور پھر ایک دفعہ لاب اگانے کے ۴ دن بعد کھڑے پانی میں ۳ پونڈ اصل زہر فی ایکڑ کے حساب سے دوا کا استعمال کیا گیا تاکہ جڑی بوٹیاں تلف کی جا سکیں۔ علاج شدہ فصل کی شرح پیداوار ۸۳ من ایکڑ ہوئی جبکہ غیر علاج شدہ فصل کی پیداوار صرف ۲۰ من/ایکڑ تھی۔ متعلقہ فصل کی پیداوار میں ۸۰٪ فی صد کا قابلِ قدر اضافہ صرف جڑی بوٹیوں کے انسداد ہی سے ممکن ہوا۔

(Harmful animals)

نقصان دہ جانور

۱. جنگلی سؤر (Wild pigs)

آزادی کے بعد ان کی آبادی میں بے پناہ اضافہ ہوا ہے دھان کی ایسی فصل جو کہ دریائی علاقے یا جنگل کے قریب کاشت کی جاتی ہے. خاص طور پر ان کا نشانہ بنتی ہے اور یہ فصلوں پر حملہ عموماً رات کے وقت کرتے ہیں۔

۲- چڑیاں (Sparrows)

دھان کے ایسے کھیت جو درختوں کے آس پاس واقع ہوں انہیں چڑیاں بہت زیادہ نقصان پہنچاتی ہیں. یہ پکے ہوئے دانے چگتی ہیں اور بعض دفعہ ایسا بھی ہوا ہے کہ انہوں نے فصل کا ۴۲ فیصد حصہ تک اجاڑ دیا. چڑیاں دھان کی اری قسم اور دیگر اقسام کو شدید نقصان پہنچاتی ہیں۔

۳- چوہا (mices)

یہ جانور زیادہ تر رات کے وقت حملہ کرتا ہے اور فصل کو نقصان پہنچاتا ہے. تنے کو کھوکھلا کرنے کے علاوہ یہ کٹائی سے پہلے خشک شدہ بیج کو بھی ہڑپ کر جاتا ہے. یہ ایسے کھیتوں میں زیادہ نقصان پہنچاتا ہے جو نہروں یا جنگلوں کے قریب ہوں یا جہاں پہلی بار کاشت کی جائے۔

(Comprehensive Control measures)

جامع انسدادی اقدامات

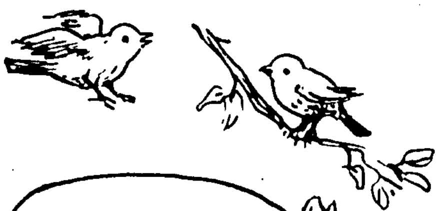
عام طور پر تحفظ نباتات کا زیادہ تر انحصار کیمیائی طریقے پر کیا جاتا ہے جس کی وجہ سے خطرات پیدا ہوتے ہیں۔
ان کی وجہ سے فضا اور پانی کی آلودگی تو کوئی ڈھکی چھپی بات نہیں. ان حالات کے تحت جب کہ ہم غیر ممالک سے بھاری مقدار میں کرم کش ادویات اور تحفظ نباتات کے لئے مشینری درآمد کر رہے ہیں. یہ کیمیائی طریقہ ہمارے کاشتکاروں کو بہت مہنگا پڑتا ہے. اس بات کے پیش نظر محکمہ زراعت نے دھان کے لئے نقصان دہ پیسٹ کی تلفی کے لئے جو فنی سفارشات منظور کی ہیں انہیں تنے کی سنڈیوں کے زمرے میں بیان کیا جا چکا ہے.
تاریخ کاشت کا پتہ نہ ہو تو کیمیائی طریقے سے بیماری کے حملے کا پتہ چلانا ناممکن ہوتا ہے. مغربی پاکستان کی سابق حکومت نے ان سفارشات پر عمل کرنے کے لئے ویسٹ پاکستان ایگریکلچرل آرڈی ننس مجریہ ۱۹۵۹ء جاری کیا جس کے تحت.

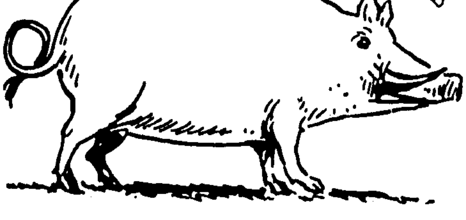
۱. یکم جون سے قبل نرسریوں کی کاشت پر پابندی عائد کر دی گئی (اب ۲۰ مئی)

۲. زمین کے مالکان کو مجبور کیا گیا کہ وہ ہر سال فروری کے آخری دنوں سے پہلے پہلے اپنے کھیت میں تلائی کرائیں اور جڑی بوٹیوں کو تلف کریں۔

۳- ہر سال ۷. اگست کے بعد کاشت پر پابندی عائد کر دی گئی۔

صوبہ میں وباؤں کے حیاتیاتی انسداد پر ابھی تک کوئی کام نہیں ہوا کیونکہ منافع بخش کیڑوں (شکاری اور طفیلی) اور چھوٹے حیاتیاتی نظاموں پر بہت کم توجہ دی گئی ہے۔ بہرحال وائلڈ لائف ایکٹ کے تحت باز، الو، اور جنگلی بلیوں کا تحفظ کیا جا رہا ہے کیونکہ چڑیوں اور چوہوں سے نجات پانا ضروری ہے. کھیتوں کے مختلف حالات کے تحت کیمیائی، فنی، میکانکی اور حیاتیاتی طریقے علیحدہ علیحدہ طور پر اختیار کئے گئے ہیں معاشی نقصان سے بچنے کے لئے مختلف طریقوں کو جامع طور پر قابل عمل بنانے کا گوشوارہ اگلے صفحہ پر دیکھیں۔





Schedule 9 1

Comprehensive plan to Control Rice epidemics.

کیلنڈر ۔ دھان کی وباؤں کا جامع انسداد

Time of attack حملے کا وقت (مہینہ)	Harmful insect/Name of disease ضرر رساں کیڑا / بیماری کا نام	Treatment علاج	Remarks کیفیت
مارچ تا اپریل	دھان کی سونڈیوں کے مختلف مراحل	۱۔ سونڈیوں کے پروانوں کو تلف کرنے کے لئے روشنی کے پھندے استعمال کئے جائیں۔ ۲۔ دھان کے دوبارہ پھوٹے ہوئے پودوں کو تلف کیا جائے۔ ۳۔ اگر دھان کی نرسریوں کو پیسٹ آرڈیننس کی مقررہ تاریخوں سے پہلے کاشت کیا گیا ہو تو انہیں تباہ کر دیا جائے۔	—
مئی	۱۔ دھان کی سونڈیوں کے مختلف مراحل	۱۔ دوبارہ اُگے ہوئے پودوں اور وقت مقررہ سے قبل کاشت شدہ نرسریوں کو ختم کر دیں۔ ۲۔ سونڈیوں کے پروانوں کی تلفی کے لئے روشنی کے پھندوں کا استعمال جاری رکھا جائے۔	—
	۲۔ بیج سے پیدا شدہ بیماریاں	۱۔ دھان کے صحت مند بیج کا انتخاب کیا جائے۔ ۲۔ نرسریوں کی کاشت سے پہلے بیج کو فطری کش کے استعمال سے قابل استعمال بنایا جائے۔	
	۳۔ دھان کی جڑی بوٹیاں	جہاں دھان کی کاشت کی جاتی ہو وہاں پہلے ایک مہینے تک خوب جڑی بوٹیاں اُگی رہنے دیں۔ بعد میں کدو کے ذریعے انہیں تباہ کر دیں۔	
جون، جولائی	۱۔ دھان کی سونڈیوں اور طفیلی کیڑوں کے مختلف مراحل	۱۔ پودے کے پھوٹنے کے ایک ہفتہ بعد بی ایچ سی اور ڈی ڈی ٹی کے آمیزہ کا دھوڑا کیا جائے اور پودے کے پھوٹنے کے پندرہ دن بعد ڈایازنیان (دانہ دار) کا استعمال کیا جائے۔ ۲۔ نرسریوں سے کیڑوں کے انڈوں کو جمع کیا جائے	—

۱	۲	۳	۴
حملے کا وقت (مہینہ)	ضرر رساں کیڑا / بیماری کا نام	علاج	کیفیت
	۲۔ بیماریاں ۳۔ جڑی بوٹیاں	اور تلف کر دیا جائے۔ ۳۔ جولائی میں لاب لگانے کے ۳ ہفتہ بعد دانہ دار زہر کا پہلا استعمال کیا جائے (گوشوارہ نیچے دیکھیئے) ۱۔ زسریوں کی کاشت سے قبل بیج کو کیمیائی طریقے سے قابل کاشت بنایا جائے۔ ۲۔ قابل کاشت بیج کو ۳۱ مئی کے بعد کاشت کیا جائے بکدو اور گرڈی کے ذریعے چاول کی زسریوں سے جڑی بوٹیوں کا انسداد کیا جائے۔	
اگست تا ستمبر	چاول کے کیڑوں کے تمام مراحل	۱۔ ۷ اگست کے بعد کسی نرسری کی کاشت نہ کی جائے ۲۔ کاشت کے ۷ ہفتے بعد دانے دار زہر کو دوسری مرتبہ استعمال کیا جائے (کاشت جولائی کے شروع میں کی گئی ہو) ۳۔ ہاتھوں سے جڑی بوٹیوں کو تلف کیا جائے۔ ۴۔ منظور شدہ نبات کش ادویات کو استعمال کیا جائے۔	
اکتوبر تا فروری	۱۔ دھان کی سونڈیوں کے مختلف مراحل خاص طور پر ایسے کھیتوں میں جہاں پچھیتی کٹائی ہو۔ ۲۔ دھان کے خیطیے دھان کا بھبکا اور دھان کا ہلمینتھوسپوریم بلائٹ (جھلساؤ) ۳۔ چڑیاں، چوہے اور جنگلی سور	۱۔ کھیتوں میں خوب ہل چلایا جائے۔ مڈھوں اور پیال کو جمع کر کے جلا دیا جائے۔ ۲۔ سرکنڈا اور ڈب۔ دوسری جنگل گھاس اور پودوں کو تلف کیا جائے جو کہ سونڈیوں کیلئے میزبان کا کام کرتی ہے دسمبر، جنوری میں فصل کے ان دشمن جانوروں اور پرندوں کی تلفی کے لئے پروگرام بنائے جائیں۔	دھان کی فصل جس میں ہل چلایا گیا ہو اُس میں نائٹروجنی کھاد کا استعمال کیا جائے اور باقی ماندہ مڈھوں کو تلف کیا جائے۔

Recommended Schedule for the treatment of Rice nursery and transplings (crops)

دھان کی نرسریوں اور کاشت شدہ فصل کے علاج کیلئے منظور شدہ گوشوارہ

نمبر شمار	نام کرم کش (طاقت اور فارمولا)	خوراک برائے ایک ایکڑ (پونڈ)		
		نرسری، دوائی پہلی بار استعمال	کاشت شدہ فصل	
			دوائی کا دوسری بار استعمال	
۱	۲	۳	۴	۵
		پہلی مرتبہ استعمال		
۱	گاما ۔ بی ۔ ایچ ۔ سی ۵ فیصد ڈسٹ + ڈی ڈی ٹی ۱۰ فی صد ڈسٹ	۷٫۵ + ۵٫۰	—	—
۲	گاما ۔ بی ۔ ایچ ۔ سی ۱۰ فیصد ڈسٹ + ڈی ڈی ٹی ۱۰ فی صد ڈسٹ	۷٫۵ + ۲٫۵	—	—
۳	گاما ۔ بی ۔ ایچ ۔ سی ۱۲ فیصد ڈبلیو پی + ڈی ڈی ٹی ۱۰ فی صد ڈسٹ	۷٫۵ + ۲٫۰	—	—
		دوائی کا دوسری مرتبہ استعمال (یا دوسرا علاج)		
۴	ڈایازینون ۱۴ فیصد دانے دار	۱۰	۱۰	۱۵
۵	اینڈرین ۵ فیصد دانے دار	۱۰	—	—
۶	ڈول دانے دار (گاما بی ایچ سی ۲۰ فیصد)	۳۰	۳۰	۴۰
۷	سیوٹیڈول دانے دار (سیون ۸ فیصد + بی ایچ سی ۸ فیصد)	۲۰	۲۰	۲۰

جامع کنٹرول کی اہمیت

اپنے ملک کے کاشت کاروں کے تعلیمی اور معاشی معیار کو پیش نظر رکھتے ہوئے کرم کشی کے انسداد کے زرعی طریقے ہی بہتر اپنا کردار بخوبی انجام دے سکتے ہیں۔ مصنف کو اس امر کا پورا یقین ہے کہ اگر ہر علاقہ کے کاشت کار وسیع پیمانے پر اور ایک ہی وقت پر مشفقانہ سفارشات پر عمل کریں تو منظور شدہ زرعی طریق کار کو جو کہ بالکل سادہ اور ارزاں ہے صرف اپنانے سے ہی ۷۰ فیصد پیسٹ پر کنٹرول کیا جا سکتا ہے۔

جامع کنٹرول کے منظور شدہ اور موثر کرم کش ادویات کا وسیع پیمانے پر استعمال اب ناگزیر ہو چکا ہے۔ ہمیں کسی کیڑے یا بیماری کے حملے کو صرف معاشی نقطہ نظر سے دیکھنا ہو گا جس کا اندازہ صرف معاشی علم حشریات جاننے والے اور خاص طور پر تربیت یافتہ عملہ کو لگانا چاہیئے۔

اس لئے ہمیں "جامع پیسٹ کنٹرول" کے منظور شدہ اقدامات پر عمل کرنا چاہیئے تاکہ ہم مستقبل میں پنجاب میں پیسٹ کی وجہ سے ہونے والے نقصانات پر قابو پا سکیں۔

تحفظ نباتات پر ہماری دیگر مطبوعات

other publications on plant protection.

پمفلٹ، لیف لٹ، فولڈر

۱۔ تحفظ کپاس کے لئے کرم کش مرکبات کا انتخاب
۲۔ کپاس کے ضرر رساں کیڑوں کا انسداد (جامع منصوبہ)
۳۔ کپاس کی بیماریاں اور ان کا انسداد
۴۔ دھان کی سنڈی
۵۔ دھان کی بیماریاں اور ان کا علاج
۶۔ مکئی کے ضرر رساں کیڑے اور اُن کا علاج
۷۔ سبزیوں کی حفاظت کے لئے چند محفوظ تر کرم کش مرکبات
۸۔ حشراتی وباؤں سے کپاس کی فصل کی حفاظت کا جامع منصوبہ
۹۔ کاڈلنگ ماتھ کا جامع انسداد
۱۰۔ آم کی بیماریاں اور ان کا انسداد
۱۱۔ گندم کے نقصان رساں کیڑے اور ان کا انسداد
۱۲۔ آم کے ضرر رساں کیڑے اور ان کا انسداد
۱۳۔ گنے کا رتا روگ اور اس کا علاج
۱۴۔ لشکری سنڈی اور اس کا انسداد
۱۵۔ جھینگروں کی وبا کا انسداد
۱۶۔ روغنی اجناس کے کیڑوں کا انسداد
۱۷۔ سؤروں کی تلفی
۱۸۔ مکڑی اور اس کا انسداد
۱۹۔ زہریلی دواؤں کا استعمال اور حفاظتی تدابیر
۲۰۔ کرم کش ادویہ کا استعمال
۲۱۔ دھان کی فصل کا تحفظ
۲۲۔ حشرات کش ادویہ کا استعمال
۲۳. SAFER PESTICIDES FOR THE PRODUCTION OF VEGETABLES
۲۴ SELECTION OF SAFER PESTICIDES FOR COTTON CROP.

چارٹ

۱۔ مکئی کے کیڑوں کا کیمیائی انسداد۔
۲۔ کپاس کے کیڑوں کا کیمیائی انسداد۔
۳۔ دھان کے کیڑوں کا کیمیائی انسداد۔
۴۔ بیماریوں کے انسداد کے لئے فصلوں، پھلوں اور سبزیوں پر زہر پاشی کا سالانہ کیلنڈر۔

شائع کردہ

شعبۂ مطبوعات محکمہ زراعت حکومت پنجاب ۵۰۔ آئیہ نگر (سمن آباد) لاہور

اسعد پریس، [illegible] پارک۔ لاہور

Subject: WHEAT PRODUCTION GUIDELINES

Trainer Agronomist
Class Room 3 hours
Field ______ Days

OBJECTIVES

To make the trainees familiar with the practical knowledge of wheat production. To make them knowledgeable of the information on production factors and enable them to handle the situation independently.

MATERIALS NEEDED

Sketches of agricultural implements needed for agricultural operations involved in wheat cultivation. Seeds of various varieties for identification for their early, medium and late sowings varieties.

TRAINING AIDS

1 - Slides on the various cultural operations of wheat production

2 - One copy per trainee of Undu publication, "Recommendations for Rabi Wheat" compiled from wheat conference.

INTRODUCTION

Wheat is the most important cereal crop and is consumed as a staple food in Pakistan. This crop probably occupies the first position among the world cereals, and is extensively grown around the world. It is consumed as a part of daily diet everywhere in the world in one form or the other. At present, huge amounts of money are being spent on its import annually and this may continue until self-sufficiency is achieved through the adoption of scientific technology. In Pakistan, there is a great potential for increasing wheat production on an acre basis as well as total production.

PRESENTATION

Trainees shall be given the following information on wheat production factors, along with some explanation.

Land Preparation

The land should be well prepared with 4-6 plowings and plankings. The land should be leveled precisely and a fine seed bed should be prepared. This aids uniform application of water and proper germination and root development.

Planting

The seed should be drilled in rows 9" apart. All high yielding varieties should be sown at 1½" depth and local tall varieties at 2-2½" depth. High yielding varieties should be adopted on 100% of the plowed land in both the irrigated and nonirrigated areas because these varieties have greater genetic yield potential than the local tall varieties.

Recommended Varieties and Time of Planting

Punjab

Areas	Varieties	Time of Sowing
Barani	Lyp-73, Noori, Pawan	Oct. 20 - Nov. 20
Irrigated (Early sowing)	Chenab 70, Lyp-73 Pawan, HD-2009 and WL-711	Nov. 1 - Nov. 20 Except Chenab 70 which may not be sown after Nov. 15
Irrigated (Medium sowing)	Sandal, Pari-73 Noori, LU-26 and Yakora	Nov. 15 - Nov. 30 LU-26 and Yakora up to Dec. 7
Irrigated (Late sowing)	SA-75, Blue Silver Sona Lika	Nov. 23 - Dec. 31 except SA-75 which may not be sown after Dec. 15

Sind

Areas	Varieties	Time of Sowing
All areas	Pak-70, Pawan HD-2009, WL-711, Sandal, Yakora, Lyp-73, SA-75, Blue Silver, Sona Lika, LU-26	Oct. 1 - Dec. 15 Depending on variety

NWFP

All areas	All above varieties plus "Ariz"	Nov. 1 - Dec. 31 depending on variety

Baluchistan

All areas	Chenab 70, Pawan HD-2009, Sandal, Lyp-73, Maqami 398 Sona Lika	Nov. 1 - Dec. 15 Depending on variety

Rotation

Cotton-wheat rotation should be practiced. An alternate rotation can be soybean-wheat-moong or other leguminous pulse. In rice growing areas, wheat-rice rotation can also be followed.

Seed Rate

High yielding varieties at 40 seers/acre, with a germination of over 95% should be sown. In case of late sowings, the seed rate should be increased to 50 seers/acre. Seed should be free of weed seeds.

Irrigation and Water Management

A soaking irrigation "Rauni" of 4 inches should be applied before seed bed preparation to assure adequate moisture for seed germination.

The wheat plant has two critical stages of development where water stress will reduce yields substantially. This is at tillering (12-18 days after emergence) and between anthesis and grain formation. Water availability should be high during these two periods.

The timing of the first irrigation after emergence is probably the most important irrigation that influences yield. The effect of delaying this irrigation on the various yield components of wheat is shown in Figure 1. The first irrigation should be applied from 18-20 days after planting. If this irrigation is delayed beyond 21 days after planting, yields can be reduced at a rate of 2.6% a day. This is shown in Figure 1. Another irrigation should be applied just before anthesis.

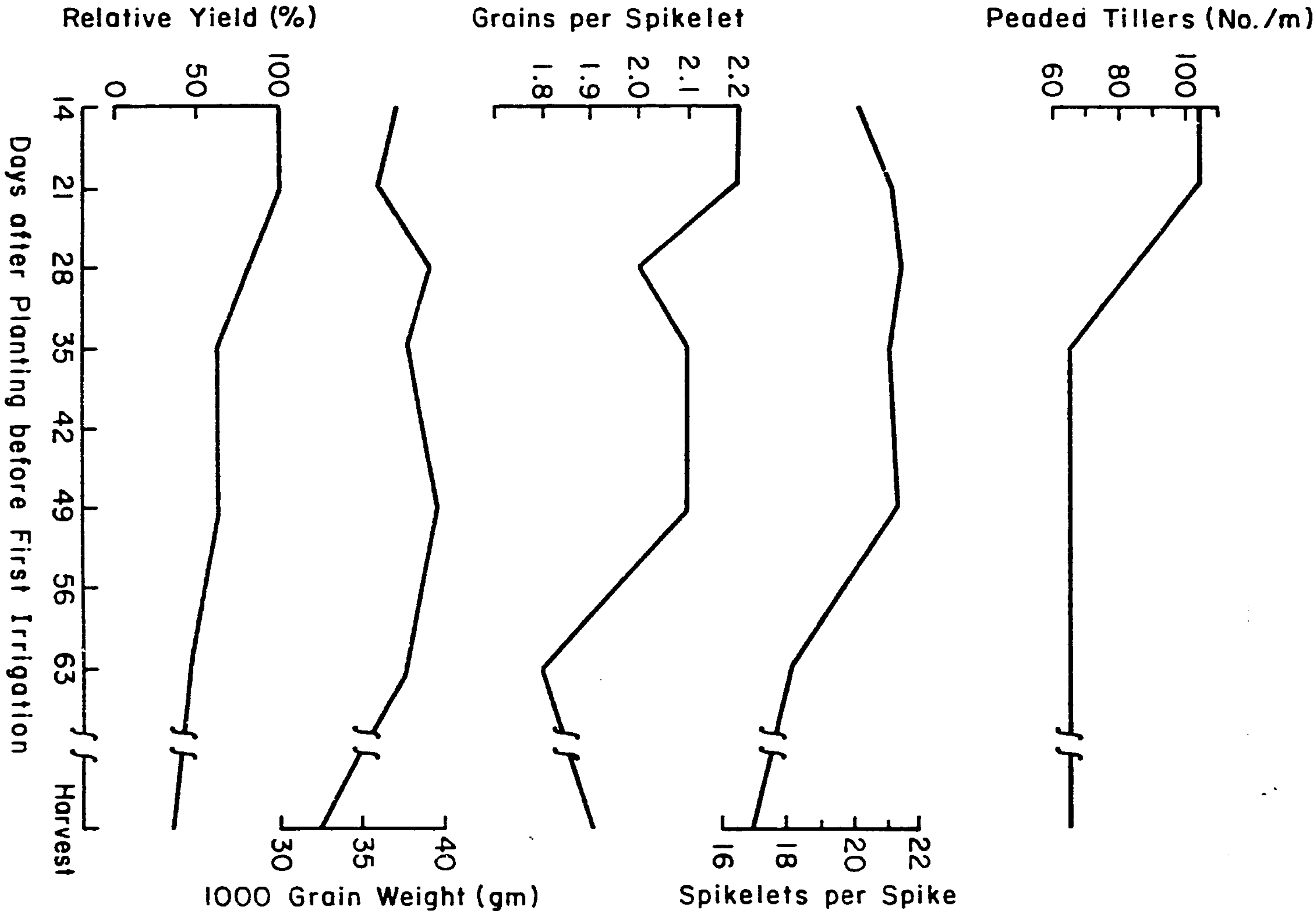


Figure 1. Yield Components Associated with Varying Delays in Application of the First Irrigation.

The season consumptive use of water by wheat will be approximately 14 inches. The weekly consumptive use for wheat is shown in Figure 2. The weekly consumptive use is as low as about 0.3 in/week during tillering and increases to over 1 inch/week during grain formation and head filling. In order to satisfy this high use period, the soil profile should be full of water prior to this time. This will ensure adequate water availability and optimum yields. The wheat plant can take up water from 4-5 feet deep in the soil profile.

The number of irrigations required to grow wheat should be about 4-5. The common practice is to overirrigate. This results in excessive leaching of nitrogen plus unnecessary addition of water to the already high water table in the Indus Basin.

Weed Control

Many weeds, particularly Dumbi gras (Phalorisminn) and wild oats are increasing in level of infestation and cause substantial yield losses. Typical experimental results showing the effect of different methods of control on wheat yields are shown in Figure 3. Hoeing with a charpa and bar handowing with a bullock increased yields somewhat but the use of herbicides to control yields resulted in approximately a 60% yield increase over no control. This demonstrates the potential benefit that the use of herbicides has for the future. Reference should be made to the Undu publication, "Recommendations for Rabi Wheat" to get the most recent information on herbicides that are registered for use on wheat by the Government. Herbicides are dangerous chemicals and should be treated accordingly.

Fertilizer

The quantity of fertilizer to be used for wheat crop depends upon whether the area is rainfed or irrigated and whether a local variety or a dwarf high yielding variety is planted. The fertilizer requirement also

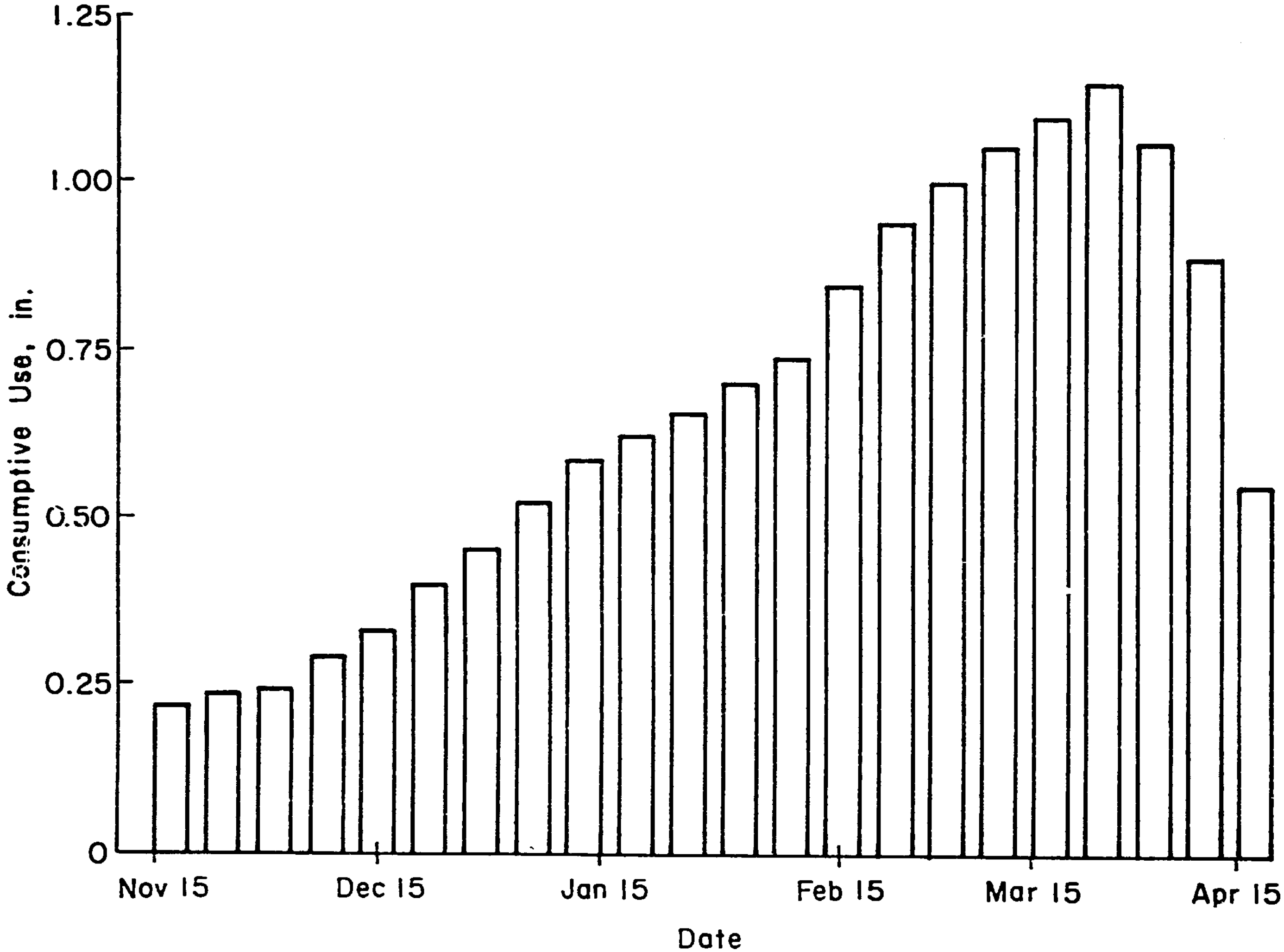


Figure 2. The Average Consumptive Use of Water for Wheat.

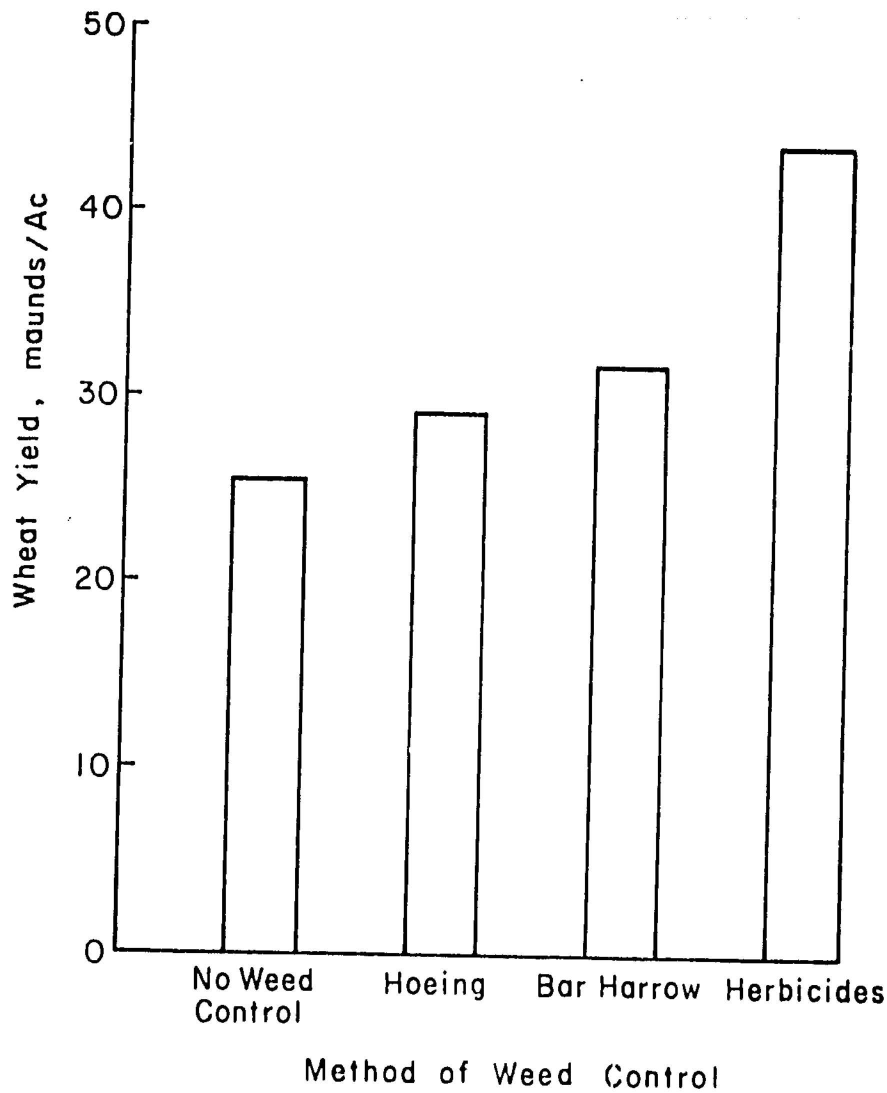


Figure 3. The Effect of Various Methods of Weed Control on the Yield of Wheat.

depends on the soil fertility level of the soil. However, to obtain optimum yields, the following recommendations should be followed.

Fertilizer Recommendations (Bags/Acre)

1) Barani Areas

Fertilier Combination	Local Variety Poor Soil	Local Variety Rich Soil	Dwarf Variety Poor Soil	Dwarf Variety Rich Soil
Urea	½	-	3/4	½
or				
A/S* or A/N*	1¼	-	1-3/4	1
plus				
Nitrophos	1	1	1½	1½
Urea	1	¼	1¼	1
or				
A/S or A/N	2	3/4	2-3/4	2
plus				
DAP*	½	½	3/4	3/4
Urea	1¼	3/4	1½	1¼
or				
A/S or A/N	2½	1¼	3½	2½
plus				
SSP*	1¼	1¼	2	2
or				
TSP*	½	½	3/4	3/4

2) Irrigated Areas

Fertilier Combination	Local Variety Poor Soil	Local Variety Rich Soil	Dwarf Variety Poor Soil	Dwarf Variety Rich Soil
Urea	½	-	1¼	½
or				
A/S or A/N	1	-	2-3/4	1
plus				
Nitrophos	1½	1½	2½	2½
Urea	1	½	2	1
or				
A/S or A/N	2	1	4	2½
plus				
DAP	3/4	3/4	1¼	1¼
Urea	1¼	3/4	2¼	1½
or				
A/S or A/N	2½	1-3/4	5¼	3½
plus				
SSP*	2	2	3	3
or				
TSP*	3/4	3/4	1¼	1¼

NOTE: All fertilizer should be applied before planting and should be mixed into the soil at the time of last plowing.

NOTE: In case a straight P fertilier (SSP or TSP) is being used, half of the N fertilizer and the entire quantity of P fertilizer should be applied at planting. The balance N fertilizer should be applied with second irrigation.

A/S = ammonium sulfate (20.5-0-0)

A/N = ammonium nitrate (26-0-0)

DAP = diammonium phosphate (18-46-0)

SSP = single superphosphate (0-18-0)

TSP = triple superphosphate (0-46-0)

Harvesting

Grain shattering in the field causes considerable loss. The crop should not be allowed to stay in the field any longer than is absolutely necessary.

After harvesting, threshing and winnowing should be completed as soon as possible since rains, which are quite common during this period, can also cause great damage to the harvested crop. Further, a quick removal of the harvested crop from the field will enable land preparation for the following cotton crop. Stationary threshers are becoming more popular and are excellent means of getting the threshing done in a timely manner.

Storage

For storage, wheat grains should be dried as much as possible with a moisture percentage of less than 13. Special care should be taken to ensure pests do not damage stored grain.

APPLICATION

Each trainee will examine and identify the seed of different varieties for various regions and sowings. Each trainees will learn and understand the agronomical steps involved in wheat production, along with reasons as to shy they be adopted. On one of their field trips, wheat production practices by farmers will be discussed.

QUESTIONS

1. What are the suitable varieties for late sowing?
2. Which varieties are suitable for "Barani" sowings?
3. What is the best time for fertilizer application in irrigated areas?
4. What is the correct time to apply the first irrigation after sowing?
5. What are the critical periods of applying irrigation water to ensure the yield is not adversely affected?

گندم کی کاشت
کے
جدید اصول

گندم کی کاشت

Cultivation of wheat

گندم کی فصل رقبہ پیداوار اور خوراک کے لحاظ سے ہمارے ملک کی اہم ترین فصل ہے پنجاب میں گذشتہ سال تقریباً ۱۱۰۵۰۰۰۰ ایکڑ رقبہ پر گندم کی کاشت کی گئی جس میں تقریباً ۸۷۹۱۰۰۰ ایکڑ آبپاش اور ۲۲۵۹۰۰۰ ایکڑ کے قریب بارانی رقبہ شامل تھا۔ گندم کی کل پیداوار ۵۶ لاکھ ٹن حاصل ہوئی۔ گندم کی پیداوار میں ہر سال خاطر خواہ اضافہ کاشت کے جدید اصول اپنانے اور بہتر اقسام گندم کی موجودگی کی وجہ سے ہو رہا ہے اور یوں ہم خوراک کے مسئلے میں خود کفالت کی حد تک پہنچ رہے ہیں۔ تجربات کی روشنی میں درج ذیل سفارشات پر عمل کر کے ہم زیادہ سے زیادہ گندم پیدا کر سکتے ہیں۔

Soil selection and its preparation.

زمین کا چناؤ اور تیاری

ایسی میرا اور بھاری میرا زمین جس میں نامیاتی مادہ موجود ہو اور پانی کا نکاس بھی عمدہ ہو۔ گندم کی کاشت کے لئے بہترین تصور کی جاتی ہے کلراٹھی اور سیم زدہ زمینوں کے علاوہ ہر قسم کی زمین پر گندم کاشت کی جا سکتی ہے۔ گندم کی زیادہ پیداوار حاصل کرنے کے لئے زمین کی صحیح تیاری خاص اہمیت کی حامل ہے۔ زمین کی تیاری کے وقت درج ذیل باتوں کو ذہن میں رکھنا ضروری ہے۔

1. کھیت بالکل ہموار ہوں تاکہ پودے پانی اور کھاد کا پورا پورا فائدہ اٹھا سکیں۔ بارانی علاقوں میں قدرتی نشیب و فراز کو مدنظر رکھ کر گندم کاشت کی جائے۔
2. زمین باریک اور بھربھری ہو جائے۔ کیونکہ اس مقصد کے لئے اچھی طرح تیار شدہ زمین کی یہی نشانی ہے۔ اور اس کے علاوہ اس میں جڑی بوٹیاں بالکل نہ ہوں۔
3. زمین پچھلی فصل کے مڈھوں اور ناخواستہ پودوں سے پاک ہونی چاہیئے۔ نہری علاقوں میں راؤنی کے بعد زمین وتر آنے پر صرف سہاگہ چلا کر دو تین دن تک کھیت کو پڑا رہنے دیا جائے۔ اس کے بعد ایک دو ہل چلا کر سہاگہ دینا چاہیئے اور اس کے بعد کھیت کو پانچ چھ دنوں کے لئے یوں ہی پڑا رہنے دینا چاہیئے تاکہ جڑی بوٹیاں اُگ آئیں (اس طریقہ کو عام اصطلاح میں داب کہتے ہیں) اس کے بعد ایک یا دو مرتبہ بہت ہلکا ہل چلا کر گندم کاشت کر دینی چاہیئے۔ جن علاقوں میں سیلاب کا پانی ستمبر تک کھڑا رہا ہو۔ وہاں وتر آنے پر اکتوبر کے مہینے میں کم گہرا ہل چلا کر زمین کی نمی کو محفوظ کر لیا جائے۔ بارانی علاقوں میں ساون کی پہلی بارش کے بعد وتر آنے پر ایک گہرا ہل چلا دیا جائے اور اس کے بعد زمین کو کھلا رکھا جائے تاکہ بارش کا پانی اچھی طرح جذب ہو جائے۔
4. زمین کی تیاری کے بعد گندم کی موزوں قسم کا چناؤ، اس کی شرح تخم اور کاشت کے وقت کا تعین بہت اہم امور ہیں۔ درج ذیل گوشوارے سے آپ اپنے علاقے کے مطابق گندم کی موزوں قسم کے چناؤ، اس کی شرح تخم اور وقت کاشت معلوم کر سکیں گے۔

Shedule No 1

اقسام گندم شرح تخم اور وقت کاشت و کیفیت

Wheat variety, Seed rate and sowing time.

نمبر شمار	قسم گندم	بارانی/آبپاش	وقت کاشت	شرح تخم (فی ایکڑ) بذریعہ ڈرل یا پور	کیفیت بذریعہ چھٹہ
	بارانی				
۱	پوٹھوار	بارانی	شروع اکتوبر تا ۳۰ اکتوبر	۲۸ تا ۳۰ کلوگرام	
۲	لائل پور ۷۳	"	۲۰ اکتوبر تا ۱۰ نومبر	۳۰ تا ۳۲ "	
۳	بارانی ۷۰	"	۲۵ اکتوبر تا ۱۵ نومبر	۳۰ تا ۳۲ "	
	نہری (اگیتی)				
۱	پنجاب ۷۶	آبپاش	یکم نومبر تا ۱۵ نومبر	۳۰ تا ۳۲	" ۳۷ کلوگرام
۲	پنجاب ۷۰	"	یکم نومبر تا ۱۵ نومبر	۳۰ تا ۳۲	" ۳۷ کلوگرام
۳	لائل پور ۷۳	"	یکم نومبر تا ۱۵ نومبر	۳۰ تا ۳۲	" ۳۷ کلوگرام
	نہری (درمیانی)				
۱	سانول	آبپاش	۳ نومبر تا ۱۰ دسمبر	۳۰ تا ۳۲	" "
۲	نوری	"	۲۰ نومبر تا ۱۰ دسمبر	۳۰ تا ۳۲	" "
۳	پاری ۷۳	"	۳ نومبر تا ۱۵ دسمبر	۳۰ تا ۳۲	" "
۴	یکورا	"	۲۰ نومبر تا ۱۵ دسمبر	۳۰ تا ۳۲	" "
	نہری (پچھیتی)				
۱	ایس اے ۷۵	آبپاش	۱۵ نومبر تا ۳۱ دسمبر	۳۰ تا ۳۲	" ۴۰ کلوگرام
۲	بلیو سلور	"	یکم دسمبر تا ۳۱ دسمبر	۳۰ تا ۳۲	" ۳۷ ہ

[illegible]

Sowing Method

نئی چھوٹے قد والی اقسام کے بیجوں کو اگر ڈیڑھ سے دو انچ زیادہ گہرائی پر کاشت کیا جائے تو ان کی روئیدگی پر برا اثر پڑتا ہے
اس بات کا خاص طور سے خیال رکھا جانا چاہیئے کہ اس سے بیج زیادہ گہرائی پر نہ گرے۔ اس لئے آبپاش علاقوں میں ڈرل کا استعمال مفید ہے۔ ڈرل میسر نہ ہونے کی صورت میں کیرا کیا جا سکتا ہے۔ اور بارانی علاقوں میں گندم بذریعہ پور کاشت کرنی چاہیئے۔

تجربات سے یہ بات ثابت ہوئی ہے کہ گندم کی پچھیتی کاشت بذریعہ خشک طریقہ کاشت (DRY SOWING) کرنے سے بہتر نتائج برآمد ہوئے ہیں۔ خشک طریقہ کاشت میں راؤنی نہیں کی جاتی۔ بلکہ گندم بونے کے بعد پانی لگایا جاتا ہے۔ یہ طریقہ ان زمینوں کے لئے بھی موزوں ہے۔ جہاں کلر کا اثر ہو چکا ہو۔ خشک بوائی میں ساری کی ساری کھادیں مطلوبہ مقدار میں ہی ڈال دینی چاہئیں۔ اس طریقہ کاشت میں ایک آبپاشی، دو ہلوں اور تقریباً ۱۵ - ۲۰ دنوں کی بچت ہوتی ہے۔

Chemical Seed treatment.

بیج کو بیماریوں (SEED BORN DISEASES) سے بچانے کے لئے بوائی سے پہلے دوائی لگانا بہت ضروری ہے
درج ذیل ادویات درج کردہ شرح سے استعمال کرنے سے مفید نتائج برآمد ہوتے ہیں۔

-۱

بحساب دو اونس برائے ۲۸ کلوگرام بیج

-۲

بحساب دو اونس برائے ۲۸ کلوگرام بیج
[illegible] دو اونس دوا ایک ایکڑ میں ڈالنے کے لئے تمام بیج کے لئے کافی ہے۔

Method of Seed treatment.

۲۸/۳۰ کلوگرام بیج گندم کو دوائی سمیت پلاسٹک کے ایک مضبوط تھیلے میں ڈال کر الٹ پلٹ کریں۔ یہاں تک کہ دوائی
یکساں طور پر تمام بیج پر لگ جائے۔

Fertilizer dose and method of application.

کھادوں کی [illegible]

گندم کی فصل کے لئے نائٹروجنی اور فاسفورسی کھادوں کی اشد ضرورت ہے۔ کہیں کہیں پوٹاش کی کمی بھی محسوس کی
[illegible] آور ہے۔ تجربات سے ثابت ہو چکا ہے کہ نائٹروجن اور فاسفورس ۲:۱ یا ۱:۱ کی نسبت سے استعمال کی جائیں تو مفید

نتائج برآمد ہوتے ہیں۔ نصف نائٹروجن اور تمام فاسفورس بوائی سے پہلے اور باقی نصف پہلے یا دوسرے پانی سے ساتھ ڈالنے کی سفارش کی جاتی ہے۔ ریتلی زمینوں میں نائٹروجن والی کھاد کو دو یا تین قسطوں میں استعمال کرنے کی سفارش کی جاتی ہے۔ اگر کسی وجہ سے فاسفورسی کھاد بوائی کے موقع پر نہ ڈل سکے تو پہلے پانی کے ساتھ ڈالنے سے بھی اچھے نتائج برآمد ہوتے ہیں۔ درج ذیل گوشوارے (گوشوارہ نمبر ۲) میں تفصیل کے ساتھ کیمیاوی کھاد کی فی ایکڑ مقدار مختلف اقسامِ گندم کی صورت میں، مختلف حالاتِ زمین اور مختلف علاقوں کے لئے علیحدہ علیحدہ درج کی گئی ہے اس پر عمل کرنے سے بہت بہتر نتائج حاصل کئے جا سکتے ہیں۔

Schedule No-9 گوشوارہ نمبر ۲

Wheat variety, fertilizer dose/A and cost of fertilizer

قسم گندم	کیمیاوی کھاد کی مقدار فی ایکڑ کل اجزاء کلو گراموں میں — آبپاش علاقے: نائٹروجن	فاسفورس	پوٹاش	قیمت کا کیفیت: بوریوں میں	روپوں میں	
الف۔ ملکی اقسام: پنجاب ۷۶، چناب، لائل پور، بارانی ۷۳	۴۱	۲۷	—	۱½ بوری ڈی اے پی بوقت بوائی اور ۱½ بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۱۸۵٫۰۰	اوسط زمین کیلئے جس میں قریباً ۱۸ من پیداوار فی ایکڑ بغیر کھاد کے ہو سکتی ہو
سانڈل، ایس ایل ۷۵، بلیو سلور				یا ½ ۱ بوری نائٹروفاس بوقت بوائی اور ایک بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۱۹۳٫۰۰	
〃	۴۴	۲۳	—	ایک بوری ڈی اے پی اور ایک بوری یوریا بوقت بوائی	۱۴۰٫۰۰	بھاری زمین کے لئے
				یا ۲ بوری نائٹروفاس اور نصف بوری یوریا بوقت بوائی	۱۳۴٫۰۰	
〃	۵۵	۲۱	—	۲ بوری ڈی اے پی بوقت بوائی اور ½ ۱ بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۲۴۶٫۰۰	ہلکی زمین کے لئے
				یا ½ ۲ بوری نائٹروفاس بوقت بوائی اور ایک بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۲۴۳٫۰۰	

قسم گندم	کیمیاوی کھاد کی مقدار فی ایکڑ کل اجزا ر کلوگراموں میں				قیمت کھاد	کیفیت
	آبپاش علاقے					
	نائٹروجن	فاسفورس	پوٹاش			
ب۔ غیر ملکی اقسام یکورا۔ نورمی	۵۵	۲۷	۔	۱½ بوری ڈی۔ اے۔ پی بوقت بوائی اور ۲ بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۲۲۶٫۰۰	اوسط زمین کے لئے
				یا		
				۲½ بوری نائٹروفاس بوقت بوائی اور ۱½ بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۲۱۰٫۰۰	
״	۵۵	۴۱	۔	۲ بوری ڈی۔ اے۔ پی بوقت بوائی اور ۱½ بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۲۴۶٫۰۰	بہت کمزور ریتلی زمین اور پچھیتی کاشت کیلئے بس یں
				یا		
				۳½ بوری نائٹروفاس بوقت بوائی اور ایک بوری یوریا پہلے یا دوسرے پانی کے ساتھ	۲۴۳٫۰۰	فی کھاد ۸۰۰ من پیداوار فی ایکڑ ہو۔ فصل خریف کے فوڑاً بعد میں
قسم گندم بارانی علاقے						
پوٹھوار بارانی ۷۰	۲۳	۲۳	۔	ایک بوری ڈی۔ اے۔ پی اور نصف بوری یوریا بوقت بوائی	۱۰۹٫۰۰	کم بارش والے علاقے جن میں ۳۲۵ ملی میٹر سے کم بارش ہوتی ہو
				یا		
				دو بوری نائٹروفاس بوقت بوائی	۱۰۰٫۰۰	
لائل پور سوچنا نوری	۳۴	۲۳	۔	ایک بوری ڈی۔ اے۔ پی اور ایک بوری یوریا بوقت بوائی	۱۴۰٫۰۰	درمیانی بارش والے علاقے جن میں ۳۲۵ اور ۸۹۰ ملی میٹر کے درمیان بارش ہوتی ہو
				یا		
				۲ بوری نائٹروفاس اور نصف بوری یوریا بوقت بوائی	۱۲۴٫۰۰	
״	۴۱	۲۷	۔	۱½ بوری ڈی۔ اے۔ پی اور ۱½ بوری یوریا بوقت بوائی	۱۷۵٫۰۰	زیادہ بارش والے علاقے جن میں ۸۹۰ ملی میٹر سے زیادہ بارش ہوتی ہو
				یا		
				۲½ بوری نائٹروفاس اور نصف بوری یوریا بوقت بوائی	۱۵۹٫۰۰	

★ ریتلی زمینوں۔ دھان والی زمینوں اور ان زمینوں میں جن کو صرف ٹیوب ویل کے پانی سے سیراب کیا جاتا ہو پوٹاش والی کھاد (پوٹاشیم سلفیٹ) کی نصف سے ایک بوری فی ایکڑ استعمال کی جائے۔

★ پچھیتی کاشت میں نائٹروجن اور فاسفورس والی کھادوں کی تمام مقدار بوقت بوائی استعمال کی جائے۔

Irrigation.
آبپاشی

عام طور پر خیال کیا جاتا تھا۔ کہ زیادہ کھاد ڈالنے کے بعد فصل کی پانی کی ضرورت بڑھ جاتی ہے۔ لیکن تجربات نے ثابت کر دیا ہے۔ کہ ایسا نہیں ہے۔ اس کی وجہ یہ ہے۔ کہ کھادوں کے استعمال سے پودے کی جڑیں اچھی طرح پھیلتی پھولتی ہیں اور زمین میں نسبتاً زیادہ گہرائی تک جا کر نمی حاصل کر سکتی ہیں۔ اس لئے کھادوں کے استعمال سے پانی کی نسبتاً کم مقدار کی ضرورت ہوتی ہے۔ بلکہ کھادوں کے استعمال سے پانی کی افادیت میں معتدبہ اضافہ ہو جاتا ہے۔ اور جتنا پانی عام طور پر استعمال کیا جاتا ہے۔ اسی سے ہی فصل برداشت کی جا سکتی ہے۔ اس کے علاوہ آبپاشی کی تعداد کی نسبت بروقت آبپاشی کا زیادہ دھیان رکھا جانا چاہیئے۔ پانی کی زیادہ ضرورت اُس وقت ہوتی ہے۔ جب پودا شاخیں نکالتا ہے۔ گندم کو پہلا پانی مناسب وقت پر لگانا نہایت اہم ہے، پہلا پانی فصل اگنے کے دس سے پندرہ دن کے اندر اندر لگا دینا چاہیئے۔ باقی ماندہ پانی حسبِ ضرورت پودے کی نشوونما کے دوران یعنی فروری کے اختتام تک لگا دینا چاہیئے۔ اس کے بعد موسمی حالات اور زمین کی حالت کے مطابق پانی لگایا جائے اور اگر ضرورت نہ ہو تو اس کے بعد پانی لگانا سود مند نہیں ہوگا۔

Control of turmite (white-ant) and borer
دیمک اور سونڈی وغیرہ کا انسداد

ابتدا میں ہی یعنی نئی انگوری (SEEDLING) پر ٹوکے کا حملہ ہوتا ہے۔ جس کو کہ ½۲ پونڈ بی۔ ایچ۔ سی باریک مٹی میں ملا کر دھوڑا کرنے سے کنٹرول کیا جا سکتا ہے۔ بعض علاقوں میں اُگتے وقت دیمک بھی نقصان کرتی ہے۔ جن کھیتوں میں دیمک کا حملہ ہو جائے اس سے بچنے کے لئے زمین کی تیاری کے وقت ڈائی ایلڈرین ۲ پونڈ اصل زہر فی ایکڑ کے حساب سے ڈالنی چاہیئے اس کے علاوہ پہلا پانی جلد لگا دینے سے بھی دیمک کا حملہ رُک جاتا ہے۔ مارچ کے مہینے میں بعض اوقات آرمی ورم یعنی لشکری سُنڈی کا حملہ دیکھا گیا ہے۔ اس کو روکنے کے لئے ہر کھیت کے اردگرد بی ایچ سی ملی مٹی بکھیر دی جائے۔

Wheat harvest and threshing

جب گندم پک جائے تو جلد از جلد اُسے کاٹ لینا چاہیے تاکہ مزید نقصانات وغیرہ سے بچت ہو سکے اور اسی طرح جلد سے جلد گہائی بھی ختم کر لینی چاہیے تاکہ بارشوں وغیرہ کے نقصانات سے فصل محفوظ رہ سکے ۔

Method of wheat storing

گندم کو محفوظ کرنے کے لئے گودام ہوا دار اور پکے ہونے چاہئیں اور گندم کو رکھنے سے پہلے ان کو زہریلی دھونی (فیومی گیشن) کے ذریعے گودام کے کیڑوں سے پاک کر لینا چاہیے ۔ خالی بوریوں کو بھی گوداموں کے ساتھ ہی فیومیگیٹ کر دینا چاہیے ۔

شائع کردہ

شعبہ مطبوعات محکمہ زراعت حکومت پنجاب لاہور

امید پرنٹرز ۲۳۶ بی راوی پارک لاہور

CPG-3

Recommendations

سفارشات

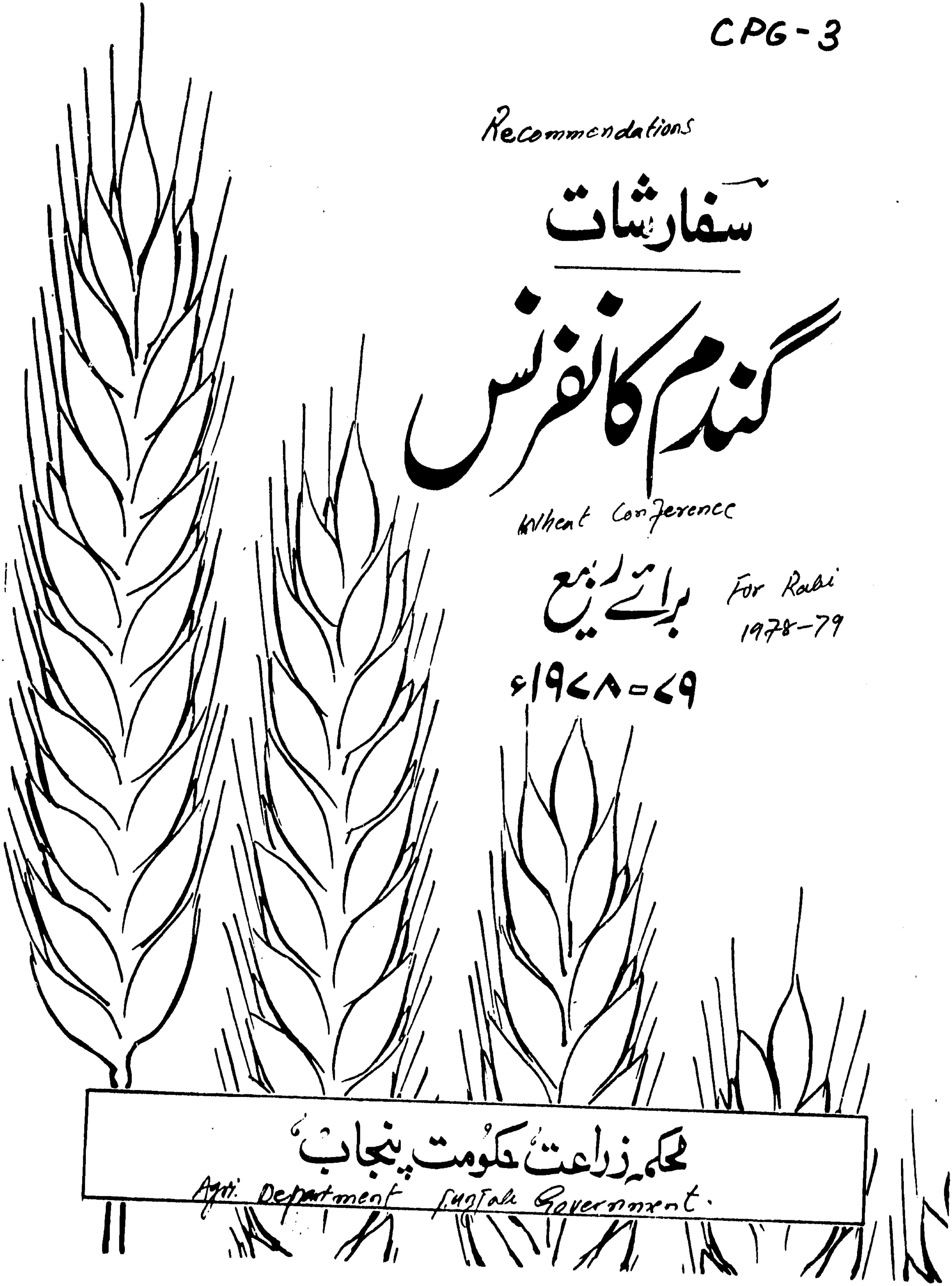
گندم کانفرنس

Wheat Conference

برائے ربیع

For Rabi 1978-79

۱۹۷۸-۷۹ء



محکمہ زراعت حکومت پنجاب

Agri. Department Punjab Government.

Recommendations for wheat cultivation 1978-79

گندم ہمارے ملک پاکستان کی ایک نہایت اہم فصل ہے۔ گذشتہ سال یہ سال تقریباً ۳۷۰۰۰۰۰ و ۱۱۱ ایکڑ پر کاشت کی گئی جس میں تقریباً ۹۸۰۰۰ و ۹۰ ایکڑ آبپاشی اور ۲۲۰۶۴۴۰۰ ایکڑ بارانی رقبہ شامل تھا۔ پچھلے سال کی پیداوار میں تقریباً ۱۱ فیصد کمی واقع ہوئی جس کی وجہ بوائی کے وقت کورا، فاسفورس کی کمی، کاشت کا بروقت نہ ملنا، کنگی اور فصل پکتے وقت معمول سے زیادہ درجہ حرارت اس کمی کی اہم وجوہات تھیں۔ حال ہی میں لاہور میں ایک گندم کانفرنس منعقد کی گئی جس میں گندم کی پیداوار میں کمی کی وجوہات اور آئندہ سال کے لئے گندم کی پیداوار بڑھانے کے طریقوں پر غور کیا گیا۔ موزوں اقسام اور ان کے بیج کی سپلائی، کھادوں کا انتظام، نہری پانی کی فراہمی اور ٹیوب ویل کے لئے بجلی اور ڈیزل کا تفصیلی جائزہ لیا گیا۔ اور مناسب انتظامات کی نشان دہی کی گئی۔ غیر موزوں موسمی تبدیلیاں زیادہ سے زیادہ اور کم سے کم درجہ حرارت میں کمی اور ہلکی ہلکی بارشیں کنگی پھیلانے میں معاون ثابت ہوئیں اور اپریل کے دوسرے ہفتہ میں یکدم درجہ حرارت میں زیادتی کی وجہ سے دانہ ہلکا پڑ گیا اور نتیجۃً پیداوار میں کمی واقع ہوگئی۔ پنجاب ۷۶، ایس ایل ۷۴، پوٹھوار اور بارانی ۷۰ پر کنگی کا حملہ ہو جانے کی وجہ سے ان اقسام کی کاشت روک دی گئی۔ چنانچہ کاشتکاروں کو سفارش کی جاتی ہے کہ آئندہ فصل ربیع ۷۹-۱۹۷۸ء میں ان اقسام کی کاشت نہ کریں۔ ایل یو ۲۶ اور چناب ۷۰ کی کاشت کی مشروط طور پر سفارش کی جاتی ہے۔ اول الذکر پر زرد کنگی کا حملہ ہوتا ہے۔ اس لئے اس قسم کو جنوبی اضلاع میں کاشت کرنے کی سفارش کی جاتی ہے۔ جہاں زرد کنگی کی بیماری کا اتنا اہم مسئلہ نہیں۔ چنانچہ یہ قسم فیصل آباد کے تمام جنوبی اضلاع میں کاشت کی جا سکتی ہے۔ دوسری قسم چناب ۷۰ نہری علاقوں میں اگیتی کاشت کے لئے ۱۵ نومبر سے پہلے پہلے کاشت کرنے کی سفارش کی جاتی ہے۔

Suitable wheat varieties for general cultivation — عام کاشت کیلئے موزوں اقسام

مول پور ۷۳، نوری، پاری ۷۳، سندل، یکورا، ایس ایل ۷۵، بلوچستان، ایل یو ۲۶ اور چناب ۷۰ جیسی اقسام کی کاشت کی سفارش کی جاتی ہے۔ ان اقسام کی کاشت کے لئے موزوں علاقے، مناسب وقت کاشت، شرح بیج وغیرہ گوشوارہ نمبر ا میں درج ہیں۔

Schedule – I

گوشوارہ نمبر ۱

Sr. No. نمبر شمار	Area علاقہ	Wheat Variety اقسام گندم	Time of Sowing وقت کاشت	Seed Rate/A -kg- شرح تخم فی ایکڑ وغیرہ کلوگرام میں
۱	بارانی	۱- دیسی اقسام	وسط اکتوبر سے آخیر اکتوبر تک	۲۲ تا ۲۶
		۲- لائل پور ۷۳	اکتوبر کے آخری ہفتہ سے وسط نومبر تک	۲۲ تا ۲۸
		۳- نوری	اکتوبر کے آخری ہفتہ سے وسط نومبر تک	۲۲ تا ۲۸
۲	آبپاشی / اگیتی کاشت	۱- چناب ۷۰	اکتوبر کے آخری ہفتہ سے وسط نومبر تک (وسط نومبر کے بعد کاشت نہ کی جائے)	۲۵ تا ۳۰
		۲- لائلپور ۷۳	یکم نومبر سے ۱۵ نومبر تک	۲۵ تا ۳۰
	درمیانی کاشت	۱- سانڈل	۱۵ نومبر سے ۳۰ نومبر تک	۳۰ تا ۳۲
		۲- پاری ۷۳	"	" " "
		۳- نوری	"	" " "
		۴- ایل پور ۷۲	وسط نومبر سے دسمبر کے پہلے ہفتہ تک	۳۰ تا ۳۲
		۵- یکورا	نومبر کے تیسرے ہفتہ سے دسمبر کے پہلے ہفتہ تک	۳۰ تا ۳۲
	پچھیتی کاشت	۱- ایس ایل ۷۵	نومبر کے آخری ہفتہ سے وسط دسمبر تک	۳۰ تا ۳۵
		۲- بلیو سلور	نومبر کے آخری ہفتہ سے دسمبر کے آخر تک	۳۲ تا ۳۵

Important Note –

ضروری نوٹ

موسم گرما کی فصلیں کاٹنے کے بعد جہاں نمی موجود ہونے کی وجہ سے زمین اچھی طرح تیار نہ ہو سکتی ہو۔ وہاں پچھیتی کاشت کرتے وقت شرح بیج فی ایکڑ ۲ تا ۳ کلوگرام زیادہ ڈال کر کاشت بذریعہ "چھٹہ" کرنی چاہیئے۔

اگرچہ ان اقسام کا بیج پنجاب زرعی سپلائی کارپوریشن نے حاصل کیا ہے۔ لیکن یہ مقدار اتنی کافی نہیں جس سے بیج کی تمام کی تمام مانگ پوری کی جا سکے ان حالات کو مدنظر رکھتے ہوئے زمینداروں سے سفارش کی جاتی ہے۔ کہ وہ اپنی آئندہ ربیع کی بیج کی ضروریات کے تحت ان اقسام کا اپنا بیج خود سنبھال کر رکھیں اگر کسی کے پاس ان اقسام کا بیج موجود نہ ہو تو اپنے پڑوسی کاشتکاروں، دوستوں اور عزیز و اقارب سے حاصل کرنے کی کوشش کریں۔ گوداموں میں بیج رکھتے وقت بڑی احتیاط کی ضرورت ہے۔ تاکہ بیج کو کیڑے مکوڑوں سے بچایا جا سکے۔ گوداموں کو کیڑوں سے صاف کرنے کے لئے محکمہ زراعت کے عملہ کے تعاون سے دھوتی (FUMIGATION) کی جا سکتی ہے۔ دھونی کرتے وقت بوریاں وغیرہ بھی اسی گودام میں بند کر دینی چاہیئے۔ تاکہ ان بوریوں کے کیڑے بھی مر جائیں۔ بیج کو دھوپ میں خشک کر کے گودام میں رکھیں۔

۱- طریق کاشت Method of Sowing

بارانی علاقے: Barani Areas بارانی علاقوں میں بذریعہ پورا گندم کاشت کرنی چاہیئے اس طریقے سے بیج مناسب گہرائی اور نمی میں پہنچ جاتا چاہیئے۔ جو کہ اچھے اگاؤ کیلئے نہایت ضروری ہے۔ کھاد بوائی سے دو تین دن پہلے چھٹہ دیکر زمین میں ملا دینی چاہیئے کھاد کی مقدار گوشوارہ نمبر ۲ میں درج ہے۔

Schedule - 2

نقشہ/گوشوارہ نمبر ۲

No. of bags of different fertilizers | Fertilizer /A | Soil Condition | Area

نمبر شمار	علاقہ	نوعیت زرخیزی زمین	کھاد کی مقدار فی ایکڑ نائٹروجن فاسفورس پوٹاش	مختلف کھادوں کی بوریوں کی تعداد
۱	بارانی علاقہ	کم بارش کا علاقہ (۳۵۰ ملی میٹر تک)	کلوگرام ۲۱ – ۲۲ – ۰ پونڈ ۵۰ – ۵۰ – ۰	ایک بوری ڈی اے پی اور نصف بوری یوریا کاشت کے وقت یا دو بوری نائٹروفاسفس بوقت کاشت اڑھائی بوری سنگل سپر فاسفیٹ اور پونے دو بوری ایمونیم نائٹریٹ یا دو بوری ایمونیم سلفیٹ کاشت کے وقت
		اوسط بارش کا علاقہ (۳۵۰ سے ۵۰۰ ملی میٹر تک)	کلوگرام ۳۴ – ۲۳ – ۰ یا پونڈ ۷۵ – ۵۰ – ۰	ایک بوری ڈی اے پی اور ایک بوری یوریا بوقت کاشت یا دو بوری نائٹروفاس اور نصف بوری یوریا بوقت کاشت یا اڑھائی بوری سنگل سپر فاسفیٹ اور اڑھائی بوری ایمونیم نائٹریٹ یا سوا تین بوری ایمونیم سلفیٹ بوقت کاشت -
		زیادہ بارش کا علاقہ (۵۰۰ ملی میٹر سے زیادہ)	کلوگرام ۴۱ – ۲۷ – ۰ یا پونڈ ۹۰ – ۶۰ – ۰	$1\frac{1}{4}$ بوری ڈی اے پی اور $1\frac{1}{4}$ بوری یوریا بوقت کاشت یا اڑھائی بوری نائٹروفاس اور نصف بوری یوریا بوقت کاشت یا تین بوری سنگل سپر فاسفیٹ اور سوا تین بوری ایمونیم نائٹریٹ یا چار بوری ایمونیم سلفیٹ بوقت کاشت -
	آبپاشی رقبہ	اوسط درجہ کی زرخیزی جہاں بغیر کھاد کے ۱۵ تا ۱۸ من فی ایکڑ پیداوار حاصل ہو سکتی ہے۔	کلوگرام ۴۱ – ۲۷ – ۰ یا پونڈ ۹۰ – ۶۰ – ۰	$1\frac{1}{4}$ بوری ڈی اے پی بوقت کاشت اور $1\frac{1}{4}$ بوری یوریا پہلے یا دوسرے پانی کے ساتھ یا اڑھائی بوری نائٹروفاس بوقت کاشت اور نصف بوری یوریا پہلے یا دوسرے پانی کے ساتھ
		زرخیز زمین دریائی رقبہ جہاں بغیر کھاد ۲۵ تا ۳۰ من فی ایکڑ پیداوار حاصل ہو سکتی ہے	کلوگرام ۳۴ – ۲۳ – ۰ یا پونڈ ۷۵ – ۵۰ – ۰	ایک بوری ڈی اے پی بوقت کاشت اور ایک بوری یوریا پہلے یا دوسرے پانی کے ساتھ یا دو بوری نائٹروفاس اور نصف بوری یوریا یا اڑھائی بوری سنگل سپر فاسفیٹ بوقت کاشت اور $1\frac{1}{4}$ بوری پہلے یا دوسرے پانی کے ساتھ ایمونیم نائٹریٹ بوقت کاشت اور $1\frac{1}{4}$ بوری ایمونیم نائٹریٹ پہلے یا دوسرے پانی کے ساتھ یا سوا تین بوری ایمونیم سلفیٹ آدھی آدھی کر کے ڈال لیں ۔۔

نمبر شمار	علاقہ	نوعیت زرخیزی زمین	کھادوں کی مقدار فی ایکڑ نائٹروجن فاسفورس پوٹاش	مختلف کھادوں کی بوریوں کی تعداد
		کمزور زمین ایسا رقبہ جہاں خریف کے چارہ کے بعد بغیر کھاد صرف ٨ تا ١٠ من فی ایکڑ پیداوار حاصل ہو سکتی ہے۔	کلوگرام ٥٥ - ٤٥ - یا پونڈ ١٢٠ - ١٠٠ - ٠٠	دو بوری ڈی اے پی بوقت کاشت اور ڈیڑھ بوری یوریا پہلے یا دوسرے پانی کے ساتھ یا چار بوری نائٹروفاس بوقت کاشت اور نصف بوری یوریا ایک بوری ایمونیم سلفیٹ پہلے یا دوسرے پانی کے ساتھ یا پانچ بوری سنگل سپرفاسفیٹ اور سوا دو بوری ایمونیم نائٹریٹ بوقت کاشت اور دو بوری ایمونیم نائٹریٹ پہلے یا دوسرے پانی کے ساتھ یا اڑھائی بوری ایمونیم سلفیٹ بوقت کاشت ١١ ، اڑھائی بوری پہلے یا دوسرے پانی کے ساتھ

(ب) آبپاشی علاقے — Irrigated Areas

چونکہ نئی ترقی دادہ اقسام کی ابتدائی شاخ چھوٹی ہوتی ہے۔ اس لیے ان کی بوائی ڈیڑھ دو انچ گہرائی پر کرنی چاہیئے۔ ڈرل کی بوائی میں بیج ایک جیسی گہرائی اور مناسب نمی میں گرتا ہے۔ اگاؤ اچھا ہوتا ہے اور پیداوار میں اضافہ ہوتا ہے۔ دوسرے نمبر پر کیرا آتا ہے۔ کیرے کا طریقہ استعمال کرتے وقت تر وتر کا خاص خیال کرنا چاہیئے۔ چھٹے سے اچھا اگاؤ حاصل نہیں ہوتا لیکن اگر کھیت میں مڈھ وغیرہ سے چھٹہ ضروری ہو جائے تو دو تین کلوگرام بیج فی ایکڑ کا اضافہ کر دینا چاہیئے۔ پچھیتی بوائی اور کلراٹھی زمینوں میں خشک بوائی کی سفارش کی جاتی ہے۔ خشک بوائی میں ریج ڈرل سے بوائی کرنے کے بعد کھیت کو پانی دے دینا چاہیئے۔ ... بوائی کی صورت میں بیج اتھلا (SHALLOW) رہنا چاہیئے۔

بیج کو دوائی لگانا: — Seed treatment

بیج کے ذریعے پھیلنے والی بیماریوں کے تدارک کے لیے بیج کو دوائی لگانا بہت مفید ہے۔ محکمہ زراعت کے توسیعی عملہ سے دوائی حاصل کی جا سکتی ہے اور انہی کی ہدایات کے مطابق بیج کو لگائی جا سکتی ہے۔ دوائی لگانا نہایت آسان طریقہ ہے۔

کھادوں کی مقدار اور طریقہ استعمال — Rate and method of Fertilizer use

گندم کی فصل کے لئے نائٹروجن اور فاسفورس والی کھادوں کی اشد ضرورت ہے۔ جبکہ ایسی زمینوں جن پر بار بار کماد اور دھان کی فصلوں کی کاشت ہوتی ہے۔ پوٹاش والی کھاد کی بھی ضرورت پڑتی ہے۔ تجربات سے ثابت ہو چکا ہے کہ نائٹروجن اور فاسفورس کا آپس میں توازن ١ : ١ یا ٢ : ١ کی نسبت سے رکھا جائے۔ تو بہترین پیداوار حاصل ہوتی ہے۔ نائٹروجن کی آدھی مقدار اور فاسفورس کی ساری مقدار کاشت کے وقت اور باقی نائٹروجن کی آدھی مقدار پہلے یا دوسرے پانی کے ساتھ ڈالنے کی سفارش کی جاتی ہے۔

ریتلی زمینوں میں نائٹروجن والی کھاد دو تین قسطوں میں ڈالنے کی سفارش کی جاتی ہے۔ اگر کسی وجہ سے فاسفورس والی کھاد کاشت کے وقت نہ ڈالی جا سکے تو یہ کھاد پہلے پانی کے ساتھ ڈالنے سے اتنے ہی اچھے نتائج برآمد ہو سکتے ہیں۔ گوشوارہ نمبر ٢ میں تفصیل کے ساتھ کیمیائی کھادوں کی فی ایکڑ مقدار بارانی اور آبپاشی علاقے درج کی گئی ہے۔ اس پر عمل کرنے سے بہترین نتائج حاصل کیے جا سکتے ہیں۔

امتیاز پرنٹرز ٢٣٦ بی راوی پارک

Irrigations.

گندم کی پانی کی ضروریات کے مطابق پانی لگانے کے دو اہم مواقع ہیں پہلا موقع اُگنے سے تقریباً ایک ہفتہ بعد آتا ہے جبکہ پودا جھاڑ کرنا شروع کرتا ہے (TILLERING)۔ اس لیے پہلا پانی اُگنے سے ۱۲-۱۸ دن بعد دے دینا چاہیئے۔ اگر اُگنے سے ۱۲ دن سے پہلے بھی پانی لگا دیا جائے تو کوئی نقصان نہیں ہوگا لیکن اگر ۱۸ دن سے زیادہ دیر سے پانی لگایا جائے تو نقصان کا احتمال ہے۔ تاہم چاول والے علاقوں میں پہلا پانی جہاں تک ممکن ہو دیر سے لگایا جائے کیونکہ ایسی زمینوں میں نمی دیر تک قائم رہتی ہے۔ یہ وقفہ گندم اُگنے کے بعد کم و بیش ایک ماہ سے بھی زیادہ ہو سکتا ہے۔ پانی لگانے کا دوسرا اہم موقعہ بُور آنے کے اور دانہ بننے کے درمیان ہے۔ اس وقت آبپاشی ضروری ہے تاکہ نر۔ ماؤ کے ملاپ کے لئے زیادہ وقت مل سکے۔ باقی ماندہ پانی بارشوں کو مدِ نظر رکھتے ہوئے ضرورت کے مطابق مناسب موقعوں پر لگانے چاہئیں۔ اگر موسم گرم اور خشک ہو تو مارچ کے آخر میں بھی ایک پانی ضروری ہے۔ چار یا پانچ سے زیادہ پانی لگانے کی ضرورت نہیں۔

Weed eradication

جڑی بوٹیاں خاص طور پر، دبی گھاس، اور جنگلی جئی گندم کی پیداوار پر بُری طرح اثر انداز ہو رہی ہیں۔ داب کا طریقہ اپنانے سے ماسوائے ان دونوں جڑی بوٹیوں کے اکثر بوٹیاں تلف کی جا سکتی ہیں۔ چونکہ جڑی بوٹیاں کھاد اور پانی کا کافی سارا حصہ ضائع کرتی ہیں۔ اس لیے انہیں شروع میں بار ہیرو چلانے سے اور بعد میں رنبے یا کسولے سے گوڈی کر کے تلف کر دینا چاہیئے۔ بعض اوقات جڑی بوٹیوں کی وجہ سے ۴۰ فیصدی تک پیداوار میں کمی ہو جاتی ہے۔

Wheat Threshing and Storage.

کٹائی سے پہلے کھیت کے ایسے حصے جہاں فصل اچھی رہی ہو اور کھڑی ہو بیج کے لیے منتخب کر لینے چاہیئے۔ ان حصوں میں سے غیر اقسام کے پودے نکال کر ان کی علیحدہ کٹائی گہائی کر کے صاف ستھرا بیج علیحدہ سٹور کر لینا چاہیئے۔ نئی ترقی دادہ اقسام کی کٹائی دیسی اقسام کی نسبت دو تین دن پہلے کی جانی چاہیئے۔ ورنہ دانے جھڑنے کی وجہ سے نقصان ہوتا ہے۔ کٹائی کے فوراً بعد گہائی کا بندوبست کرنا چاہیئے۔ کیونکہ موسم برسات کی اگیتی بارشوں سے نقصان کا احتمال ہے۔ گہائی کے بعد صاف ستھری کیڑوں سے پاک بوریوں میں بھر کر غلہ گودام میں لانا چاہیئے۔ گوداموں کی اچھی طرح صفائی کرنی چاہیئے اور دھونی دے کر کیڑے مکوڑے مار دینے چاہیئے۔ تاکہ غلہ کیڑوں سے محفوظ کیا جا سکے۔ گوداموں کو دھونی دینے کے لیے محکمہ زراعت کا توسیعی عملہ مددگار ثابت ہو سکتا ہے۔ اس کام کے لیے ان کے پاس تکنیکی مہارت اور دوائیاں موجود ہیں۔

Wheat Production

ادارہ زرعی اطلاعات و مطبوعات

۵۰ ڈ، آریہ نگر رحمن آباد، لاہور

امتیاز پرنٹرز ۲۳۶ بی راوی پارک

Subject: SUGARCANE PRODUCTION GUIDELINES

Trainer Agronomist
Class Room 2 hours
Field ______________ Days

OBJECTIVES

To acquaint the trainees with agronomical operations involved in the production of sugarcane, including plant protection measures.

MATERIALS NEEDED

1 - Charts of agricultural implements for sugarcane cultivation.

2 - Seeds of various varieties for identification.

TRAINING AIDS

1 - Slides related to the topic with slide projector. Material for developing new slides on various operations.

2 - Urdu-Modern Techniques of Sugarcane Cultivation (1 per student)

INTRODUCTION

Sugarcane belongs to the great grass family. With perennial growth habits, it is grown both under tropical and sub-tropical conditions. Sugar, a main source of energy, can also be obtained from some other sources but sugarcane is the main and the cheapest source which meets 2/3 of the total requirements of the world. Besides the supply of sugar, its bi-products are used for many purposes, including the manufacturing of paper, hard board and mulch, etc. In Pakistan, its cultivation is also done as a major cash crop due to its high average acre yield with attractice market rates.

PRESENTATION

Trainees shall be given information on the following production factors, along with explanations.

The current detailed cultural recommendations are given in the Urdu publication, "Modern Techniques of Sugarcane Cultivation." These recommendations should be covered in detail with the trainees. An outline of presentation is presented below. Some very important points are also presented.

1. Better Planting Season.

Early planting, preferably in the month of February should be done. Any planting done after March will result in yield losses, which should be avoided. September and October plantings have also produced encouraging results.

2. Suitable Time of Harvesting.

Time of harvesting sugarcane is important not only for the yield and quality of the plant crop, but it also has a great bearing on the following ratoon crop. Experimental results show that late harvesting reduces yield by 25-30%. Harvesting beyond March shows significant losses in the quality of cane. The results have also shown that plant crop harvested in May or June or before January, has detrimental effects on the yield and quality of following ratoon crop.

3. Method of Planting.

Yields of 35.11 tons per acre were obtained with 2½-3 ft. row to row distances and 32,000 sets per acre. Wider spacing also improves the quality of the cane. Two foot row to row distance was the old recommendation.

4. Inter-cropping of Cane with Kharif Crops.

Spring sugarcane was intercropped with Mung, Tobacco and Soybeans. Compact variety of tobacco and less bushy Mung can be grown with advantage without significant ill effect on early planted cane. 40.27 tons of cane and 0.51 tons of Nung were obtained per acre which seems to be an attractice combination.

5. Fertilizers and Irrigation.

Organic matter plays an important role in improving the yield of sugarcane. About 150 lbs. of nitrogen, half in the form of farm yard manure and half in the form of artificial fertilizer, has always resulted in a marked increase in yield.

Excessive irrigation without appropriate rates of nitrogen does not yield optimum cane weight. Even 70 to 87 inches of water applied without nitrogen or fertilizers gave significantly lower yields. April to June is a crucial period of cane growth during pre-monsoon season. Liberal irrigation should be applied and the irrigation interval should not be more than 7-10 days during this period.

The weekly consumptive use of water is shown in Figure 1. The peak consumptive use occurs during June when weekly rates will reach 2.3 inches. The only way that this demand can effectively be met is to ensure that the soil profile is full of water as this period begins. This is accomplished by overirrigating during May. Care should be taken not to retard growth by overirrigating.

6. Plant Protection Measures.

In case of some serious disease or insect pest, plant protection department may be consulted for the use of various chemicals. Recommendations are also given in the enclosed Urdu publication, "Modern Techniques of Sugarcane Production."

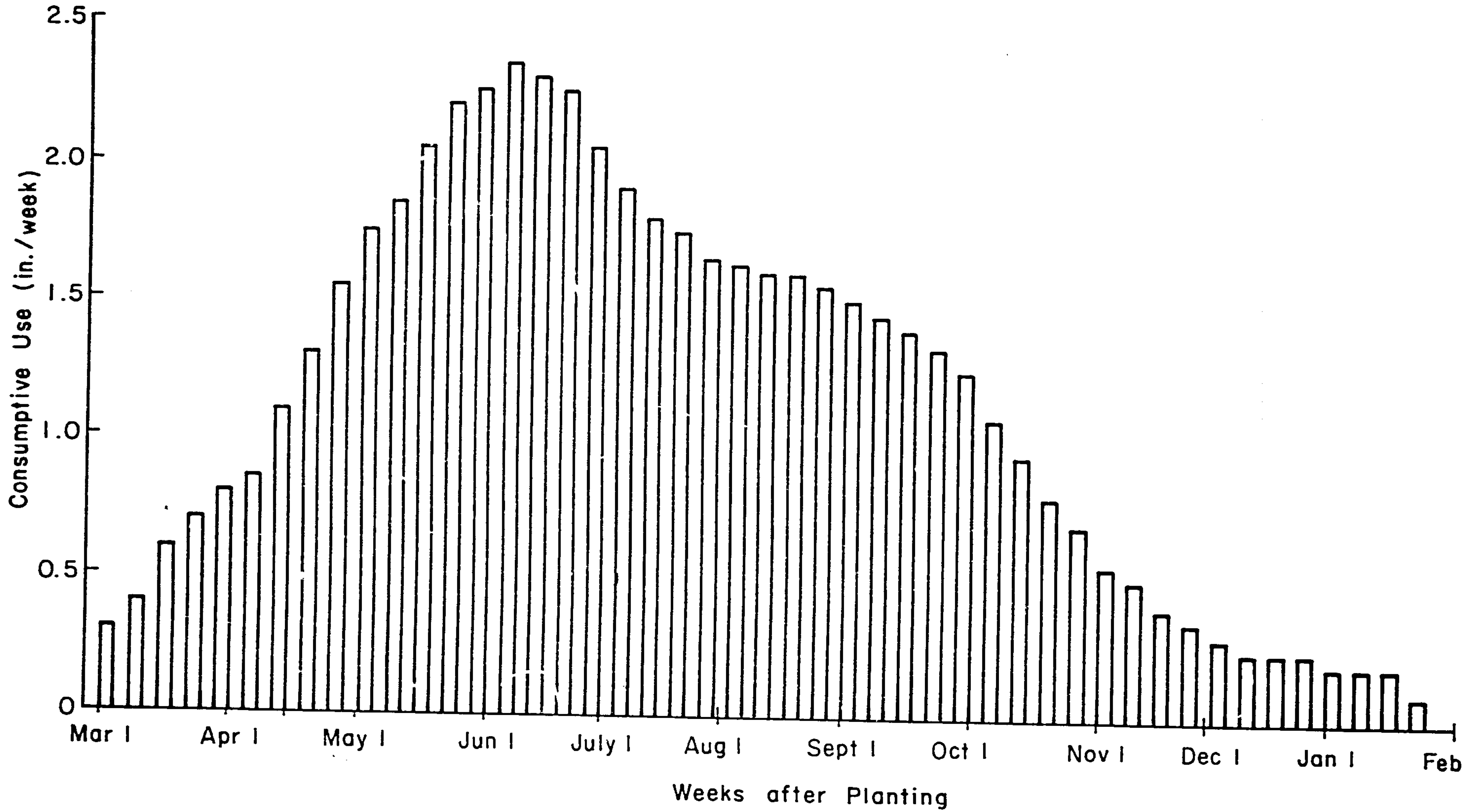


Figure 1. The Weekly Consumptive Use of Water for Sugar Cane.

7. Chemical Weed Control.

One of the major causes of low national average is the extensive weed population in cane fields. Selective weedicides like Gessapex-Combi or Cencor used as pre-emergent or post emergent can effectively control weeds and thus, can meet the labor problem.

8. Improvement of Recovery of Sugar at the Mills.

The recovery of sugar in mills is considerably low, mainly due to the crushing of runout varieties. The recovery at the mills can be increased from 8.5% to 10.15% by crushing fresh canes of varieties according to their period of maturity. The new varieties, L.116 and BL.4, should be accommodated in an organized crushing program.

9. Rotations.

1. Corn-Sengi-Sugarcane.
2. Corn-Sengi-Sugarcane-Wheat.
3. Wheat-Fallow-Sugarcane.
4. Sugarcane-Wheat-Cotton-Sengi.
5. Wheat-Cotton-Sugarcane.
6. Corn-Mash-Sugarcane.
7. Sorghum/Bajra-Sugarcane.

APPLICATION

1 - Each trainee will acquaint himself with different varieties of cane; new and old ones.

2 - Each trainee will learn the production guidelines as to why these be adopted.

QUESTIONS

1 - What is the best planting and harvesting season for sugarcane?

2 - Explain the best sowing method.

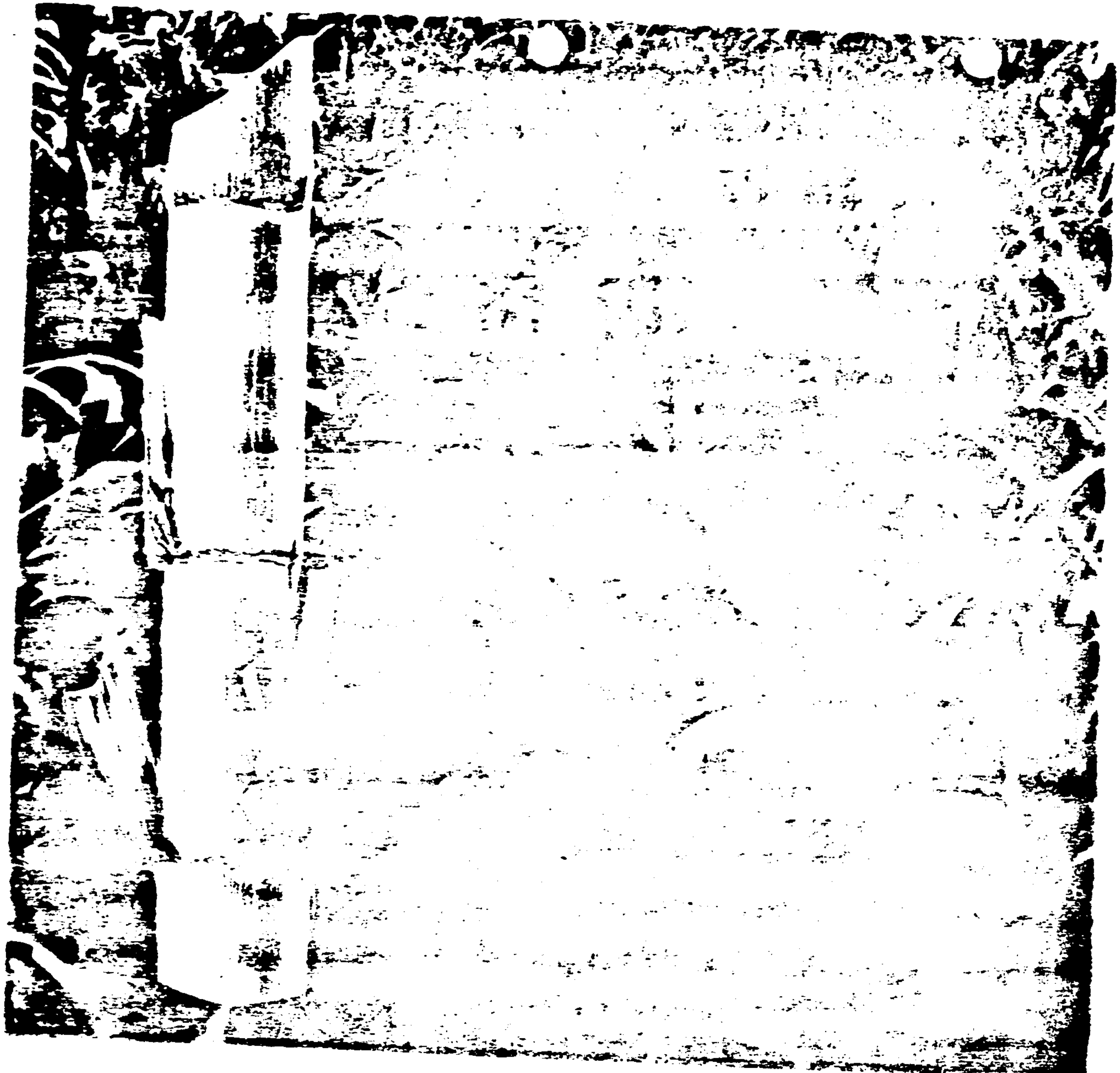
3 - What inter-cropping is recommended to increase the total income of the farmer?

4 - What do you know about fertilization and irrigation of sugarcane?

5 - What weedicides would you recommend for chemical weed control in sugarcane?

6 - How can the recovery of sugar at mills be improved?

CPG-4
Modern Technique for
Sugarcane cultivation.



محکمہ زراعت، حکومت پنجاب

ڈال دیں۔ اور جڑی بوٹیوں کی اچھی طرح تلفی کر دیں یہ عمل پودوں کے اُگنے سے پہلے مکمل کر لیں تاکہ پودے اچھی طرح پروان چڑھیں۔

Insect Control

USE modern Techniques about Sugarcane cultivation

کماد کی کاشت کے جدید اصول اپنائیں

ہماری زرعی معیشت میں کماد کی حیثیت ایک نقد آور فصل کی ہے اس وقت ہمارے پاس اچھی پیداوار دینے والی اقسام موجود ہیں، کاشت کے جدید طریقے دریافت ہو چکے ہیں ہمارے کاشت کار بھائیوں کی محنت قابل تقلید ہے لیکن کماد کی فی ایکڑ پیداوار کم ہونے کی وجہ سے مجموعی طور پر پیداوار کم ہی رہی ہے۔ فی الحال کماد کی فی ایکڑ چار سو من اوسط پیداوار ہے جس میں ایک ہزار من تک بڑھنے کی گنجائش ہے۔ کماد کی پیداوار میں اضافہ کے لئے کاشت کار بھائیوں سے گزارش ہے کہ وہ فرسودہ طریقہ ہائے کاشت کو ترک کر دیں، کھادوں کا صحیح اور مناسب استعمال کریں۔ مونڈھی فصل پر خصوصی توجہ دیں، پرانی اور کم پیداوار دینے والی کماد کی اقسام کاشت نہ کریں۔ بیماریوں کیڑوں اور جڑی بوٹیوں کے تدارک سے غفلت نہ برتیں۔

کماد کی پیداوار میں اضافہ نہ صرف ملک کو شکر کے معاملے میں خود کفیل کر دیگا بلکہ شکر کی صنعت کی ضمنی مصنوعات میں بھی اسی قدر اضافہ ہوگا۔ کماد سے شکر کی تیاری کے دوران راب اور بگاس (گنے کا پھوک) دو بڑی مصنوعات حاصل ہوتی ہیں۔ راب کا استعمال مرغیوں اور مویشیوں کی خوراک بنانے والے کارخانوں میں بھی ہوتا ہے، راب ہمارے ملک سے وافر مقدار میں برآمد کی جاتی ہے۔ بگاس کی اہمیت کی وجہ یہ ہے کہ اس میں سیلولوز شامل ہے جو کہ بیشتر مصنوعی ریشوں میں بطور بنیادی خام مال استعمال ہوتا ہے۔

زیر نظر کتابچے میں ہمارے زرعی ماہرین گنے کی نئی اقسام، طریق کاشت، کھادوں کا استعمال اور دیگر زرعی امور کی جدید سفارشات پیش کی ہیں جن پر عمل پیرا ہو کر پُرعزم کاشت کار ملک اور قوم کی زیادہ سے زیادہ خدمت کر سکیں گے۔

صادق حسین قریشی
وزیر اعلیٰ پنجاب

کماد کی کاشت

Sugarcane cultivation.

دُنیا بھر کے کماد پیدا کرنے والے ممالک میں پاکستان کماد کی فصل کے زیر کاشت رقبہ کے لحاظ سے چھٹے نمبر پر آتا ہے جب کہ بھارت، برازیل اور کیوبا کا بالترتیب پہلا دُوسرا اور تیسرا نمبر ہے لیکن یہ قابلِ تشویش بات ہے کہ فی ایکڑ پیداوار کے لحاظ سے پاکستان بیشتر ممالک سے پیچھے ہے۔ دیگر ممالک کم رقبہ زمین سے زیادہ سے زیادہ پیداوار حاصل کر کے نہ صرف اپنی ملکی ضروریات میں خود کفیل ہیں بلکہ چینی برآمد کر کے زرمبادلہ بھی کما رہے ہیں۔ ہمیں اتنے بڑے رقبے سے پیداوار کا یہ تناسب زیب نہیں دیتا کیسی بھی ملک کی معیشت بغیر کسی وجہ کے قابلِ کاشت زمین کا یوں ضائع ہونا برداشت نہیں کر سکتی۔ اس لئے ہمیں ہر ممکن طریقے سے کماد کی پیداوار بڑھانی ہوگی تاکہ کماد پیدا کرنے والے ممالک میں ہمیں بھی ایک باعزت مقام حاصل ہو سکے۔ کماد کی کاشت کے بارے میں جدید اصول ذیل میں درج کئے جاتے ہیں

Soil selection.

زمین کا انتخاب

اچھی فصل حاصل کرنے کے لئے بھاری میرا زمین کا انتخاب کرنا چاہیئے جس میں پانی کا نکاس عمدہ ہو اور نامیاتی مادہ کافی مقدار میں موجود ہو۔ سیم زدہ علاقے میں اگر تھور نہ ہو تو بھی یہ فصل کامیاب ہو جاتی ہے جس زمین میں دیر تک پانی جذب نہ ہوتا ہو اور سطح پر کھڑا رہتا ہو کماد کی فصل کے لئے موزوں نہیں ہے۔ اس فصل کی جڑیں زمین سے کافی گہرائی تک خوراک حاصل کرتی ہیں اس لئے زمین کا کم از کم ایک فٹ تک عمدہ ہونا ضروری ہے۔ اگر تین چار فٹ گہرائی تک اچھی زمین موجود ہو تو فصل اچھی طرح پروان چڑھتی ہے۔

Time of sowing

کاشت کا وقت

اس فصل کی کاشت کا موسم وسط فروری سے شروع ہو جاتا ہے اور وسط مارچ تک موزوں رہتا ہے جس وقت اس کی رُوئیدگی کے لئے درجہ حرارت موزوں ہو جائے فوراً کاشت کر دینا چاہیئے۔ کماد کی اچھی رُوئیدگی کے لئے ۸۰ سے ۹۰ درجہ فارن ہیٹ میں موزوں ہوتا ہے۔ کماد کے اگاؤ اور شگوفوں کے نکلنے کیلئے تقریباً ۳ ماہ درکار ہوتے ہیں۔ اسلئے دیر سے کاشت کرنے سے اس کی بڑھوتری کے زمانے میں کمی واقع ہو جاتی ہے۔ دیر سے کاشت کرنے میں زیادہ بیج درکار ہوتا ہے اور کیڑے بھی زیادہ حملہ آور ہوتے ہیں۔ لیہ اور ڈیرہ اسماعیل خان کے علاقہ میں کماد کی کاشت کیلئے فروری کا مہینہ موزوں ہے جبکہ شمال کی ہوتا ہے اور کیڑے بھی زیادہ حملہ آور ہوتے ہیں۔ لیہ اور دریا خان کے علاقہ میں کماد کی کاشت کے لئے فروری کا مہینہ موزوں ہے جبکہ شمال کی طرف گوجرانوالہ اور منڈی بہاؤالدین وغیرہ میں کاشت کے لئے مارچ کا مہینہ موزوں ہے۔ ستمبر کی کاشت کے لئے بھی شروع ستمبر اس لیے علاقے

Soil preparation.

زمین کی تیاری

اور شمالی علاقے کے لئے) موزوں وقت ہے۔ ستمبر کی کاشت میں یہ خیال رکھنا چاہیئے کہ سردی کا موسم شروع ہونے سے پہلے ہی اس کے پودے اپنی جڑیں اچھی طرح قائم کرلیں تاکہ کورے سے جب ان کے پتے سوکھ جائیں تو دوبارہ پھوٹنے کی پوری قوت رکھتے ہوں۔

اس فصل کی جڑیں کافی زیادہ ہوتی ہیں۔ مونڈھی فصل ہر سال نئی جڑیں نکالتی ہے۔ اگر زمین بہت سخت ہوجائے تو جڑیں مناسب طور پر نہیں پھیل سکتیں۔ اس لئے ضروری ہے کہ کھیت کی تیاری زمین کی بناوٹ کے لحاظ سے کی جائے۔ کھیت کی تیاری سردی کا موسم شروع ہوتے ہی کردینی چاہیئے دسمبر میں ایک بار گہرا ہل ضرور چلا دیا جائے جنوری۔ فروری کے مہینوں میں کم گہرائی والے ہل یا کلٹیوٹر کی مدد سے بار بار ہل اور سہاگہ چلا کر مٹی کو مناسب حد تک باریک کرلینا چاہیئے۔ کھیت کی ہمواری کا خصوصاً خیال رکھنا چاہیئے۔

Sugarcane varieties:

گنا کی اقسام

Early Season varieties

شروع موسم میں پکنے والی اقسام

(۱) سی-او-ایل ۲۹ COL-29

اس کا گنا پتلا اور رنگ میں سبزی مائل ہوتا ہے۔ پوریوں کی قوت روئیدگی کم ہوتی ہے۔ لیکن پودے شگوفے بہت زیادہ بناتے ہیں۔ بھاری زمینوں میں فصل گرجاتی ہے۔ مونڈھی فصل بہت اچھی اور اگیتی ہوتی ہے۔ اس سے گڑ اور دیسی کھانڈ زیادہ اچھی بنتی ہے۔

(۲) بی-ایل-۴ BL-4

اس کے گنے کی موٹائی درمیانی ہوتی ہے۔ رنگ ہلکا سبز ہوتا ہے۔ گنے کی پوریاں گانٹھ سے خم کھائے ہوئے ہوتی ہیں۔ پودے جھاڑ زیادہ نہیں بناتے۔ اس سے گڑ اور دیسی کھانڈ اعلٰے قسم کی بنتی ہے۔

(۳) ایل-۱۱۶-۷۳ L-116-73

یہ قسم ۱۹۷۳ء میں عام کاشت کے لئے منظور ہوئی۔ یہ قسم بہت کم گرتی ہے۔ اس کی جھاڑ بنانے کی قوت زیادہ ہے۔ اس قسم کو زیادہ گہرا نہیں بونا چاہیئے ورنہ اگاؤ بہت کم ہوتا ہے۔ مونڈھی فصل بہت اچھی ہوتی ہے اور جلد پک جاتی ہے۔ پودے سردی کا مقابلہ زیادہ بہتر طریقے سے کرتے ہیں لیکن اسے رتہ روگ کی بیماری آسانی سے لگ جاتی ہے۔ اس لئے رتہ روگ کے علاقے میں کاشت نہیں کرنا چاہیئے۔

Mid Season varieties

(ب) میانے موسم میں پکنے والی اقسام

COL-54

(۱) سی او ایل ۵۴

اس کے پتے ہلکے سبز رنگ کے ہوتے ہیں۔ پوریوں کی قوت روئیدگی اچھی ہے اور پودے جھاڑ زیادہ بناتے ہیں۔ یہ قسم پانی کا اثر بہت جلد قبول کرتی ہے۔ بھاری زمین میں کھاد اور پانی کے زیادہ استعمال سے اکثر گر جاتی ہے۔ اس قسم کو کانگیاری سے بچاؤ کے لئے دوا میں ڈبو کر بونا چاہیئے۔

B.L-19

(۲) بی-ایل ۱۹

اس قسم کے پتے پتلے سیدھے اور گہرے سبز رنگ کے ہوتے ہیں۔ پوریوں کی قوت روئیدگی اچھی ہے۔ بھاری زمینوں میں یہ قسم گر جاتی ہے۔ پودے اوسط مقدار میں جھاڑ بناتے ہیں۔ اس کے گنے میں کھانڈ اور گڑ کی مقدار سب سے زیادہ ہوتی ہے۔ اس پر سنڈی کا حملہ کم ہوتا ہے مگر کانگیاری کا حملہ زیادہ ہوتا ہے۔

Late Season varieties.

آخر موسم میں پکنے والی اقسام

COL-44

(۱) سی او ایل ۴۴

یہ دیر سے پکنے والی قسم ہے۔ بعض علاقوں میں اچھی پیداوار دیتی ہے۔ اب اسے رتہ روگ کی بیماری زیادہ نقصان پہنچا رہی ہے۔ اس لئے اب اسے کاشت نہیں کرنا چاہیئے۔ اس کا گنا دھوپ سے جلد ارغوانی رنگ کا ہو جاتا ہے۔ عام طور پر دیہاتوں میں کالا ماہ ۵ کے نام سے مشہور ہے۔

L-118

(۲) ایل ۱۱۸

یہ بہت دیر سے پکنے والی نئی قسم ۱۹۷۵ء میں عام کاشت کے لئے منظور ہوئی۔ اسے رتہ روگ کی بیماری جلدی اثر نہیں کرتی۔ گنے جلدی نہیں گرتے اور دیر سے بڑھوتری کرتے ہیں اور اکتوبر میں بھی اس کی بڑھوتری جاری رہتی ہے۔ یہ آخر موسم فروری سے اپریل کے آغاز تک اچھی طرح بوئی جا سکتی ہے۔ گنے اچھے اور سفیدی مائل زرد ہوتے ہیں۔ اس قسم کو سردی کا اثر کم ہوتا ہے۔ اس کی آنکھیں بڑی ہوتی ہیں۔ اگاؤ قدرے کم ہوتا ہے۔ اس لئے بیج کچھ زیادہ ڈالنا چاہیئے۔ مونڈھی فصل اچھی پیداوار دے جاتی ہے۔ اسے تنے کا گڑوواں کم لگتا ہے مگر چوٹی کا گڑوواں زیادہ لگتا ہے۔ جس کا تدارک جولائی سے ستمبر تک کرتے رہنا چاہیئے۔ اس قسم کو بھی کانگیاری سے محفوظ رکھنے کے لئے بیج لگانے سے پہلے دوا کے محلول میں ڈبو لینا چاہیئے۔

Method of sowing
طریقۂ کاشت

Wet sowing method
(1) وتر طریقہ کاشت

کماد کی کاشت کے دو طریقے ہوتے ہیں ۔ ۱۔ وتر طریقۂ کاشت: ۲۔ خشک طریقۂ کاشت

اس طریقۂ کاشت کو شروع موسم میں اپنانا چاہیئے کیونکہ اس طرح وتر دیر تک قائم رہ سکتا ہے ۔ زمین کی تیاری کا کام ختم کرنے کے بعد اس میں گوبر کی گلی سڑی کھاد ڈال کر ہل چلا دیں اور راؤنی ماہ فروری کے شروع میں کریں ۔ زمین وتر آنے پر ہل چلا کر کھیت کو باریک تیار کریں اور سیاڑوں میں متبادلہ بیج جو کہ کم از کم تیس ہزار دو آنکھوں والے سموں پر مشتمل ہو مناسب گہرائی میں کاشت کر دیں ۔ اگر زمین ریتلی ہو جہاں کہ وتر نسبتاً جلد خشک ہو جاتا ہے ۔ تو بیج تقریباً ۳ انچ کی گہرائی تک دبا دیں ۔ اگر زمین بھاری ہو جہاں وتر دیر تک قائم رہ سکتا ہو وہاں دو تین انچ کی گہرائی میں دبانا مناسب ہوگا ۔ گنے کے کٹے ہوئے سمے (ٹکڑے) ایک یا دو دن چونے کے پانی میں بھگونے کے بعد کاشت کریں ۔ اس طریقۂ کاشت میں سیاڑ میں جہاں بیج ڈالا جاتا ہے ۔ تیس انچ کے فاصلہ پر ایک طرف ولایتی کھاد ڈرل کر دیں ۔

Dry method sowing
(2) خشک طریقہ کاشت

یہ طریقہ پہلے طریقے سے آسان ہے ۔ کاشت کا عمل خشک تیار شدہ زمین میں ہی انجام دیا جاتا ہے ۔ کھیت تیار کر کے سہاگہ لگا دیا جاتا ہے اور مناسب فاصلے پر سیاڑ نکال کر ان میں بیج بو دیا جاتا ہے ۔ بیج کو مٹی کی ہلکی تہ سے ڈھانپ دیا جاتا ہے اور بوائی کے فوراً بعد پانی لگا دیا جاتا ہے ۔ جونہی کھیت وتر میں آتا ہے ۔ سیاڑوں کی وٹوں پر ہل چلا کر سہاگہ لگا دیا جاتا ہے ۔ اب کھیت کو روئیدگی مکمل ہونے کے بعد پانی دیتے ہیں ۔ اس دوران اسے اندھی گوڈی دے کر پڑا رہنے دیا جاتا ہے ۔ کاشت کے فوراً بعد جو پانی دیا جاتا ہے ۔ اس کے وتر کو سنبھالنا بہت ضروری ہے ۔ اس میں ذرا سی بھی کمی بیشی براہ راست روئیدگی پر اثر انداز ہوتی ہے کیونکہ نرم وتر میں اگیتا ہل چلا دینے سے سطح پر سخت سی پیپڑی بن جاتی ہے جو آنکھوں کے پھوٹنے میں مزاحمت کرتی ہے ۔ اس طرح ہل چلانے میں تاخیر کرنے سے زمین کی نمی خشک ہو جاتی ہے ۔

Seed Selection
بیج کا انتخاب

تخمی فصل کا انتخاب بھی ایسے کھیت سے کرنا چاہیئے ۔ جو کیڑے کی دستبرد سے محفوظ ہو ۔ دیمک کے متوقع حملے سے بچاؤ کے لئے کھیت میں دوا ڈالنے کے علاوہ تخمی ٹکڑوں کو کسی مناسب کرم کش دوائی جیسے ڈی ۔ ڈی ۔ ٹی یا بی ۔ ایچ ۔ سی وغیرہ کے محلول میں بھگو لینا چاہیئے ۔

کئی ایک فنگس اور وائرس قسم کی بیماریاں سموں کے ذریعے ایک فصل سے دوسری فصل کو لگ جاتی ہیں ۔ مثلاً گنے کی کانگیاری ، رتہ روگ ، چتکبری وغیرہ ۔ ہمیشہ صحت مند بیج استعمال کریں ۔ کھڑی فصل سے بیج کے لئے کھیت وہ ٹکڑا منتخب کریں ۔ جہاں بیماری موجود نہ ہو ۔ کانگیاری کی بیماری سے بچاؤ اور زیادہ پیداوار حاصل کرنے کے لئے دوائی کو ایگالال ، بنیلیٹ یا ایراٹان کے محلول میں بھگو لیں ۔

گنے کی آنکھ وہ حصہ ہے جس سے پودے کی تشکیل ہوتی ہے۔ [illegible]کے زخمی ہو کر ناکارہ ہو جانے سے اُگاؤ میں کمی آجاتی ہے۔ گنے کی آنکھیں کٹائی وچھلائی کے دوران زخمی ہو جاتی ہیں لہذا یہ کام احتیاط سے انجام دینا چاہیئے۔

Seed Rate.
شرح تخم

تیس ہزار سے چالیس ہزار دو دو آنکھوں والی پوریاں ایک ایکڑ کے لئے کافی ہوتی ہیں۔ وزن کے لحاظ سے اچھا صحت مند اور توانا بیج ۸۰ سے ۱۲۰ من فی ایکڑ شرح تخم ہے۔ وزن میں اتنا فرق کماد کی اقسام اور گنے کے موٹا اور پتلا ہونے کی وجہ سے رکھا جاتا ہے، بیج کی مقدار میں اس لحاظ سے کمی بیشی ہو سکتی ہے۔ موٹا اور لمبی پوریاں والا بیج وزن میں زیادہ استعمال ہوتا ہے۔ گنا کا موٹا یا پتلا ہونا اقسام پر بھی منحصر ہے۔

Row to Row and Set to Set distance.
سیاڑوں اور سموں کا درمیانی فاصلہ

اگیتی بوائی کے لئے تقریباً تیس ہزار اور نسبتاً دیر سے کی گئی بوائی کے لئے تقریباً ۴۰ ہزار سموں کی ضرورت ہوتی ہے۔ ہر سمہ پر دو آنکھیں ہونی چاہیئے۔ اور عام طور پر ۴۵ سے ۶۰ فیصد اگاؤ حاصل ہوتا ہے۔

بھاری زرخیز زمین میں سیاڑوں کا فاصلہ زیادہ اور نسبتاً کمزور زمین میں کم رکھنا چاہیئے۔ موٹی اقسام کے لئے فاصلہ زیادہ اور پتلی اقسام کے لئے کم فاصلہ کی ضرورت ہوتی ہے۔ عام طور پر ۲½ فٹ فاصلہ اوسط پیداوار کے لئے موزوں ہے۔ کاٹھی زمینوں میں زیادہ فاصلہ موزوں نہیں۔ اگر گندم، برسیم وغیرہ کے ساتھ نیشکر کی مخلوط کاشت کرنی ہو تو سیاڑوں کا درمیانی فاصلہ ۳ فٹ ہونا چاہیئے۔

Use of Fertilizer
کھاد کا استعمال

کھاد کا استعمال زمین کی زرخیزی اور کماد کی جو قسم کاشت کرنی ہو اس کو مدنظر رکھتے ہوئے کرنا چاہیئے۔ نامیاتی مادے کی ضرورت کو سبز کھاد یا گوبر کی کھاد، یا دونوں کو ملا کر پورا کرنا چاہیئے۔ ایک اچھی فصل کے لئے عام طور پر ۷۵، پونڈ پوٹاش، ۷۵ پونڈ فاسفورس اور ۱۵۰ پونڈ نائٹروجن کی ضرورت ہوتی ہے۔ نائٹروجن کی کھاد دو مرتبہ ڈالنی چاہیئے۔ اگر زمین ریتلی ہو یا اس کی زرخیزی کا اچھی طرح علم نہ ہو تو نائٹروجن کھاد کئی مرتبہ تھوڑی تھوڑی مقدار میں ڈالنی چاہیئے۔ ماہ جولائی سے پہلے کھاد کی مقدار پوری کر لیں۔ مناسب وقت اور مقدار میں کھاد اور پانی دینے سے گنے کی فصل حسب منشا تیار کی جا سکتی ہے۔ نائٹروجن والی کھاد زیادہ دینے سے فصل کے گر پڑنے کا خطرہ ہوتا ہے۔

To achieve the real benefit from fertilizers, the following steps be strictly adopted.

<u>کھادوں کے استعمال سے پورا پورا فائدہ لینے کے لیے ان امور پر عمل کرنا اشد ضروری ہے</u>

(۱) زمین کی تیاری اچھی طرح کرنی چاہیئے۔ ہل چلا کر زمین کو خوب نرم کر لینا چاہیئے۔ اس میں نمی کا موجود ہونا بھی نہایت ضروری ہے۔

(۲) کھاد ڈالنے سے قبل جڑی بوٹیوں کو تلف کر لینا چاہیئے۔

(۳) بیج کی اقسام مختلف علاقوں کے لئے مختلف ہیں۔ بلوں والے علاقہ اور دوسرے علاقوں میں محکمہ کی سفارش کردہ قسم کاشت کریں۔ بیج صحت مند اور اچھی قسم کا استعمال نہ کیا جائے تو اگاؤ میں کمی واقع ہو جاتی ہے اور یہ کمی کھادوں کے استعمال وغیرہ سے پوری نہیں ہو سکتی۔

Quantity of required fertilizer (in bags) per acre for sugar cane under punjab Districts.

(ا) پنجاب کے اضلاع میں گنے کے لئے فی ایکڑ کھادوں کی مطلوبہ مقدار (بوریوں میں):

نمبر شمار	نام ضلع	ذرائع آبپاشی	نائٹروجنی کھادیں: ایمونیم سلفیٹ	نائٹروجنی کھادیں: یوریا	فاسفورس والی کھاد (سپرفاسفیٹ)	پوٹاش والی کھاد (پوٹاشیم سلفیٹ)	کیفیت
۱	بہاول پور	نہری	۶½ تا ۸½	۳ تا ۴	۲½ تا ۵	۱¾	اگر ڈی۔ اے۔ پی ڈالنی ہو تو ۱ بوری سپرفاسفیٹ کے بدلے میں ½۲ بوری ڈی۔ اے۔ پی ڈالیں لیکن چونکہ اس میں نائٹروجن بھی ہوتی ہے۔ اس لئے ۲۰ پونڈ نائٹروجن فی بوری مطلوبہ مقدار سے منہا کر لینی چاہیئے۔ ڈی۔ اے۔ پی کی ایک بوری میں ۵۰ پونڈ فاسفورس اور ۲۰ پونڈ نائٹروجن ہوتی ہے۔
۲	رحیم یار خان	"	۴½ تا ۶½	۲ تا ۳	۲½	-	
۳	بہاول نگر	"	۶½ تا ۸½	۳ تا ۴	۲½ تا ۵	۱¾	
۴	ملتان	"	"	"	"	"	
۵	مظفر گڑھ	"	۴½ تا ۶½	۲ تا ۳	۲½ تا ۵	-	
۶	ڈیرہ غازی خان	"	"	"	"	-	
۷	ساہیوال	"	۶½ تا ۸½	۳ تا ۴	۲½ تا ۵	۱¾	
۸	شیخوپورہ	.	"	"	۲½	-	
۹	گوجرانوالہ	ٹیوب ویل	"	"	۲½ تا ۵	۱¾	
۱۰	سیالکوٹ	ٹیوب ویل	"	"	۲½	-	
۱۱	لائل پور	نہری	۶½ تا ۸½	۳ تا ۴	۲½	-	
۱۲	جھنگ	ٹیوب ویل	۴½ تا ۶½	۲ تا ۳	۲½ تا ۵	-	
۱۳	سرگودھا	نہری	۶½ تا ۸½	۳ تا ۴	۲½ تا ۵	-	
۱۴	میانوالی	ٹیوب ویل	۶½ تا ۸½	۳ تا ۴	۲½ تا ۵	۱¾	
۱۵	گجرات	نہری	۶½ تا ۸½	۳ تا ۴	۲½ تا ۵	-	

Insect pest Control.

کیڑوں کی روک تھام

صوبہ پنجاب میں اس فصل کا سب سے زیادہ نقصان مختلف قسم کے گڑووں کرتے ہیں۔ ان کے انسداد کے لئے مندرجہ ذیل پروگرام پر عمل کریں۔

۱۔ کیڑوں سے متاثرہ فصل سے نہ تو بیج حاصل کریں اور نہ ہی مونڈھی فصل لیں۔ بلکہ ایسی مونڈھی فصل کو فروری کے مہینے سے پہلے پہلے نکال کر جلا دیں۔

۲۔ جس مونڈھی کو بطور فصل رکھنا ہو اس کی کٹائی کے وقت جس مونڈھ میں یہ کیڑے معلوم ہوں انہیں نیچے سے کاٹ کر سنڈی تلف کر دیں۔

۳۔ فروری یا مارچ یعنی اس فصل کے موسم کاشت کے شروع میں ان کیڑوں کی پہلی کھیپ نکلتی ہے۔ ان کے انڈے اور تتلیاں صبح کے وقت تلاش کر کے تلف کر دیں۔ یہ کام گاؤں کے بچوں سے بخوبی کروایا جاسکتا ہے۔

۴۔ ماہ مارچ کے بعد فصل کھڑی نہ رکھیں۔

۵۔ کیڑوں سے پاک بیج استعمال کریں۔

۶ کیڑوں کے شدید حملہ کی صورت میں کرم کش زرعی ادویات سے مناسب روک تھام کریں ۔

Important diseases of sugarcane in Punjab
پنجاب میں نیشکر کی اہم بیماریاں

گنے کی کانگیاری کی پہچان بڑی آسان ہے۔ گنے کے انتہائی نقطہ نمو سے ایک چابک نما سیاہ رنگ کی شاخ نمودار ہوتی ہے جس میں سیاہ سفوف بھرا ہوتا ہے جو کہ بکھر کر بیماری پھیلاتا ہے۔ گنے کا رتا روگ نہایت مہلک مرض ہے متاثرہ گنے کو درمیان سے چیرا جائے تو سرخی ظاہر کرتا ہے۔ شدید حملہ کی صورت میں تنے کے ذریعہ پتوں کو پہنچنے والی خوراک اور آب رسانی متاثر ہوتی ہے۔ چتکبری بیماری کی دو قسمیں مشاہدہ میں آتی ہیں۔ (ا) معمولی چتکبری (ب) زرد چتکبری اس بیماری کی علامات پتوں پہ نمودار ہوتی ہیں۔ اس بیماری کا نام وائرس ہے۔

انسدادی تدابیر:- (ا) بیمار بیج کاشت نہ کریں (۲) بیمار فصل کا مونڈھا نہ رکھیں (۳) بیماری کے خلاف مدافعت رکھنے والی اقسام کاشت کریں (۴) بیمار گنے کو احتیاط سے نکال کر تلف کر دیں (۵) کماد کو ہر سال ایک ہی کھیت میں کاشت نہ کریں۔

کماد کے ضرر رساں کیڑے اور ان کا انسداد

Harmful insects of sugarcane and their remedy.

دیمک	ہلکے زردی رنگ کا چھوٹا سا کیڑا ہے	ماہ مارچ اور اپریل میں گنے کے سمے پر حملہ کرتا ہے۔	(۱) گوبر کی کچی کھاد استعمال نہ کریں۔ (۲) کاشت کے وقت ناکڑ دو پونڈ ایلڈرین یا ڈائی ایلڈرین اصل زہر پانی کے ہمراہ ڈالیں۔
وٹی کا گڑدواں	سنڈی کا رنگ دودھیا ہے۔ پشت کے درمیان بلے رخ پر ایک دھاری ہوتی ہے۔ پروانہ چمکدار دودھیا رنگ کا ہوتا ہے	نوزائیدہ گڑدواں کماد کی درمیانی رگ میں سرنگ بناتا ہے جس کی وجہ سے چوٹی سوکھ جاتی ہے۔ اس کو کھینچ کر آسانی سے کھینچا جا سکتا ہے۔	۱- سرک کو کھینچ کر چوٹی میں لوہے کی تار پھیریں (۲) ماہ فروری میں چوٹیاں کاٹ کر جانوروں کو کھلا دیں (۳) روشنی کے پھندے لگائیں (۴) دانے دار اینڈرین یا ڈائی سسٹان یا سالوریکس یا تھیمٹ بحساب ۳ پونڈ اصل زہر فی ایکڑ بیس دن کے وقفے کے بعد چوٹی کے گھمبے میں تین دفعہ ڈالیں
تنے کا گڑدواں	سنڈی کا رنگ خاکستری سفید یا زرد ہوتا ہے اور جسم کے اوپر بھورے رنگ کی پانچ نمایاں دھاریاں ہوتی ہیں۔ پروانہ بھورے رنگ کا ہوتا ہے اور اس کے اگلے پروں کے باہر کے کناروں پر سفید دھبوں کی ایک قطار ہوتی ہے۔	گنے کے تنے کو مارچ سے اکتوبر تک نقصان پہنچاتا ہے اپریل جون تک اس کا حملہ شدید ہوتا ہے۔ یہ کیڑا جب گنے میں گھس کر نکلتا ہے تو اسے آسانی سے کھینچا نہیں جا سکتا۔ سنڈیاں سردائی نیند مڈھوں میں گزارتی ہیں	۱- روشنی کے پھندے لگائیں ۲- فصل کی برداشت کے بعد مڈھوں کو تلف کریں۔ ۳- چوٹی کے گڑدووں کے علاج کے لئے تجویز کردہ ادویات اس کے لئے بھی مؤثر ہیں اس کے علاوہ تھائمٹ دانے دار ۳ پونڈ اصل زہر فی ایکڑ چوٹی میں ڈالیں۔
جڑ کا گڑدواں	سنڈی کا رنگ دودھیا ہوتا ہے اور جسم پر جھریاں ہوتی ہیں۔ اس کا سر زردی مائل بھورا ہوتا ہے۔ پروانہ ہلکے زردی مائل بھورے رنگ کا ہوتا ہے۔	صرف جڑوں کا ماہ مئی سے اکتوبر تک نقصان کرتا ہے۔ سنڈیاں سرمائی نیند مڈھوں میں گزارتی ہیں۔	۱- فصل کی برداشت کے بعد مڈھوں کو تلف کریں ۲- اوپر تجویز کردہ زہر میں دی گئی کیمیائی ادویہ استعمال کریں۔ یہ نہ ملیں تو اینڈرین میلاتھیان، ڈیزرکس یا ۵ پونڈ یا ڈائی میکران ۳ پونڈ اصل زہر فی ایکڑ دو ماہ کے وقفے کے بعد ۵ گیلن پانی میں ملا کر پانچ چھ دفعہ سپرے کریں

	شناخت	نقصان	[illegible]
داسیاوی گڑووا	سنڈی بادامی رنگ کی ہوتی ہے جس کے جسم پر لمبے رخ چار سرخی مائل دھاریاں ہوتی ہیں۔ پروانے کا رنگ بھورا ہوتا ہے اور اس کے اگلے پروں پر سات سیاہی مائل دھبے ہوتے ہیں۔	جون اگست تک نقصان پہنچاتا ہے اور تنے کے اندر چار دور تک لال رنگ کا ہو جاتا ہے جبکہ چھلے پر ننھی دائرہ کے قریب ٹوٹ جاتا ہے۔ سنڈیاں سرمائی نیند مڈھوں میں گزارتی ہیں	۱۔ مڈھ تلف کریں ۲۔ اگر ضرورت ہو تو کیمیائی ادویات اس کے انسداد کیلئے موثر ہیں سیون یا بیٹا کورٹ لے ایونڈ اصل زہر فی ایکڑ کا تین چار دفعہ استعمال بھی مفید ہے۔
گلابی گڑووا	سنڈی کا رنگ زردی مائل اور جوان ہو کر گلابی ہو جاتا ہے۔ پروانے کا رنگ زردی مائل بھورا ہوتا ہے۔	سنڈی گنے کی درمیانی شاخ میں داخل ہو کر اسے کھاتی ہے اور سوکے بنانے کی موجب بنتی ہے۔ اس کا حملہ اپریل سے اکتوبر تک رہتا ہے۔ سنڈیاں سرمائی نیند مڈھوں میں گزارتی ہیں۔	۱۔ مڈھوں کو تلف کریں (۲) اس کے انسداد کے لئے بھی مندرجہ بالا کیمیائی ادویات استعمال کریں۔
گنے کی گھوڑا مکھی	یہ ایک چھوٹا سا کیڑا ہے جس کے بچے اور جوان رس چوستے ہیں اور لیس دار مادہ خارج کرتے ہیں جس سے پتوں پر سیاہ پھپھوندی لگ جاتی ہے جس سے پتوں کا رنگ سیاہ دکھائی دیتا ہے۔	اپریل سے جولائی تک اس کا حملہ ہوتا ہے۔	فی ایکڑ ۱½ پونڈ بی ایچ سی اصل زہر ۵ پونڈ راکھ میں ملا کر دھوڑا کریں یا ۱½ پونڈ سوی تھیان، نکیسان یا اینڈین یا ۱½ پونڈ ڈائی میکران یا گوزا تھیان یا ڈائی زینان اصل زہر فی ایکڑ پانی کی مناسب مقدار میں دس پندرہ دن کے وقفہ پر چار یا پانچ دفعہ سپرے کریں۔
مائٹ (جوئیں)	یہ لال رنگ کا بہت چھوٹا کیڑا ہے جو خوردبین سے ہی دیکھا جا سکتا ہے۔	یہ رس چوس کر فصل کو نقصان پہنچاتا ہے اور اس کا حملہ ہر جگہ اور ہر وقت رہتا ہے۔	ایتھیک ۱ لیٹر یا ۲ پونڈ اصل زہر فی ایکڑ استعمال کریں یا ... ایتھیان ۱ پونڈ اصل زہر فی ایکڑ سپرے کرنے سے بھی جوؤں کا خاتمہ ہو سکتا ہے

Hoeing and weeding
گوڈی اور نلائی

کماد کو شروع میں اچھی گوڈی اور نلائی کی ضرورت ہوتی ہے۔ عام طور پر اندھی گوڈی کے بعد تین چار گوڈیاں دینے کی ضرورت ہے۔ موقع سے
جہاں سیاڑوں میں جڑی بوٹیاں زیادہ ہوں انہیں نلائی کے ذریعہ ختم کر دینا چاہیئے۔

Earthing
مٹی چڑھانا

جب پودے تقریباً تین فٹ اونچے ہو جائیں تو مٹی چڑھانے کا عمل مکمل کر لینا چاہیئے۔ مٹی اس طرح چڑھائی جائے کہ پانی تنوں
کے ساتھ جمع نہ ہو سکے۔ مٹی چڑھانے کے بعد جلد پانی دینا چاہیئے۔

Irrigation
آبپاشی

شروع موسم میں پانی ایک ہفتہ کے بعد اور درمیانی موسم میں دس سے پندرہ دن کے وقفے سے دینا چاہیئے۔ شروع میں پانی کی کمی پیداوار
پر بہت زیادہ اثر انداز ہوتی ہے۔ سردی شروع ہونے پر پانی کا وقفہ بڑھا دینا چاہیئے اور برداشت سے ایک ماہ قبل پانی دینا بند کر دیں۔

Harvesting
برداشت

اگیتی قسم جلد پک جاتی ہے۔ مونڈھی اور اگیتی کاشت کی ہوئی فصل بھی جلد تیار ہو جاتی ہے۔ برداشت کا بہترین موسم دسمبر سے

مارچ تک ہے۔ زیادہ جلد اور بہت دیر میں برداشت کرنے سے پودوں میں مٹھاس کم ہو جاتی ہے۔ چھوٹی کمزور فصل پر سردی کا اثر جلد ہوتا ہے۔ اس لئے ایسی فصل کو جنوری میں برداشت کر لینا چاہیئے۔ اسی طرح گری ہوئی فصل کو بھی فروری تک ضرور برداشت کر لینا چاہیئے۔

کماد کی مونڈھی فصل — Sugar Cane Ratoon crop

اچھی پیداوار کے حصول کے لئے صرف ایسی مونڈھی فصل کا انتخاب کرنا چاہیئے جو اگاؤ کے لحاظ سے عمدہ ہو اور جس پر کسی قسم کی بیماری کا حملہ نہ ہو۔ صرف اسی صورت آئندہ فصل میں پودوں کی تعداد پوری حاصل کی جا سکتی ہے۔ بیماری وغیرہ کی موجودگی نہ صرف شروع میں پودوں کی تعداد کم دیتی ہے بلکہ بعد میں بہت زیادہ تلف ہو جاتے ہیں۔ ان کا وزن کم رہتا ہے۔ اور ان میں چینی کی مقدار مناسب نہیں ہو پاتی۔ نتیجتاً پیداوار بہت کم حاصل ہوتی ہے۔

Stubble cutting
مڈھ کو کاٹنا

اچھی مونڈھی فصل اسی صورت میں لی جا سکے گی جبکہ مڈھ جسے انگریزی میں (STUBBLE) کہتے ہیں۔ پوری طرح نشوونما پائیں اور ان سے پوری تعداد میں شگوفے پھوٹ کر پودے بن سکیں۔ اسی طرح عمدہ روئیدگی کے لئے مڈھ کا زمین سے نیچے تک کاٹنا ضروری ہوتا ہے اور یہ عمل فصل برداشت ہونے کے فوراً بعد کرنا چاہیئے۔ تاخیر کی صورت میں چند شگوفے پھوٹ کر مڈھ کی طاقت کو ضائع کر دیں گے۔ اور آئندہ فصل کے لئے پودوں کی پوری تعداد حاصل نہیں ہو سکے گی۔

Time of Ratoon crop
مونڈھی فصل رکھنے کا وقت

پہلی فصل اگر موسم کے خوشگوار ہوتے ہی یعنی تقریباً فروری کے شروع میں کاٹی جائے تو اس کے بہت اچھے نتائج حاصل ہوتے ہیں۔ پودے جلد اور کافی مقدار میں پھوٹتے ہیں اور کامیاب بھی زیادہ مقدار میں ہوتے ہیں۔

Field preparation for Ratoon crop
مونڈھی فصل کیلئے کھیت کی تیاری

جب فصل برداشت کر لی جاتی ہے۔ تو زمین میں وتر عموماً بہت کم ہوتا ہے۔ اس وقت فوری طور پر پانی دیکر وتر آنے پر زمین کو اچھی طرح ہل چلا کر باریک کر دینا چاہیئے۔ مڈھ جو زمین کے اوپر ہو۔ اسے زمین کے نیچے سے کاٹ کر اس کے دونوں طرف گہرا ہل چلا دیں۔ اگر فصل کی برداشت کے وقت فروری کا مہینہ آ گیا ہو تو تقریباً ۸۰ پونڈ پوٹاش، ۸۰ پونڈ فاسفورس اور تقریباً ۵۰ پونڈ نائٹروجن گوبر کی کھاد میں ملا کر مڈھوں کے دونوں طرف گہرائی میں ڈرل کر دیں تاکہ وہ مڈھ تقریباً ۳ ۔ ۱ انچ کے فاصلہ پر زمین میں محفوظ ہو جائیں اور فصل کے بڑھنے کے کام میں آئیں۔ اگر موسم سردی کا ہو۔ دسمبر یا جنوری کو تو ہل چلا کر اس طرح سہاگہ پھیر دیں کہ تمام مڈھ زمین میں دب جائیں۔ اور اس پر ایک پلچ قائم کر دیں۔ احتیاط یہ ہونی چاہیئے کہ زمین کے مڈھ اپنی جگہ قائم رہیں تاکہ سردی سے نقصان نہ پہنچے۔ اس کام کے لئے کھوری بھی استعمال ہو سکتی ہے۔ ورنہ رنگ ٹوتھ ہیرو چلا کر یہ کام نکال لیں۔ اور موسم خوشگوار ہونے تک کھیت کو اسی طرح پڑا رہنے دیں۔ مونڈھی کو زیادہ خشک حالت میں رکھنے سے بھی سردی کا زیادہ خوشگوار اثر ہوتا ہے۔ موسم بہتر ہوتے ہی ہل چلا کر زمین اچھی طرح تیار کر لیں۔ کھادیں

ڈال دیں۔ اور جڑی بوٹیوں کی اچھی طرح تلفی کر دیں یہ عمل پودوں کے اگنے سے پہلے مکمل کر لیں تاکہ پودے اچھی طرح پروان چڑھ سکیں۔

Insect Control
کیڑوں سے بچاؤ

موسم بہار شروع ہوتے ہی کیڑوں کے حملے کا آغاز ہو جاتا ہے۔ اس لئے جس وقت فروری میں پودے چھوٹے چھوٹے ہوں ان کو کیڑوں کے حملے سے بچانا ضروری ہے۔ اس سلسلے میں دواؤں کا استعمال کیا جا سکتا ہے۔ کوشش یہ کرنی چاہیئے کہ ان کے انڈے تنوں کے نیچے سے ہی تلف کر دیئے جائیں یا تتلی کو رات میں روشنی کے پھندے لگا کر تلف کر دیا جائے۔ دواؤں سے بچ کر جو کیڑے پودے میں داخل ہو جاتے ہیں ان کی وجہ سے بھی پودا خشک ہونے لگتا ہے۔ ان کیڑوں سمیت اس پودے کو درانتی سے کاٹ کر نکال دینا چاہیئے جانوروں کو کھلا دیں۔ اگر زہر پڑا ہوا ہو تو اسے جلا دیں۔ تاکہ جو سنڈی اس تنے میں نیچے موجود ہوتی ہے تلف ہو جائے گی۔

Fertilizer use
کھاد کا استعمال

پہلے جس وقت مونڈھی فصل کو کھاد دی جاتی ہے۔ وہ زمانہ فروری کے شروع کا ہوتا ہے، جب مونڈھی ابھی چھوٹی نہیں ہوتی۔ اس وقت سیاڑوں کے دونوں طرف ہل چلا کر ۸ پونڈ پوٹاش، ۸ پونڈ فاسفورس اور ۵ پونڈ نائٹروجن بذریعہ ڈرل دے دیں۔ اس طرح پودے زیادہ نہیں گے اور جلدی بڑھیں گے جلد بڑھنے سے ان کو کیڑے بھی زیادہ نقصان نہیں پہنچاتے اور فصل بھی جلد تیار ہو جاتی ہے۔

Earthing.
مٹی چڑھانا

مونڈھی فصل کو مٹی پودوں کی بڑھوتری کا خیال رکھتے ہوئے چڑھائی جائے اور اس طرح چڑھائی جائے کہ پودے خشک جگہ پر رہ سکیں۔ اور پانی نالیوں کے ذریعہ ان کو ملتا ہے۔ اس طرح فصل گرنے سے بچ جاتی ہے۔ اور اس میں نخاس بھی بہت زیادہ پیدا ہوتی ہے۔

عام اقسام میں ایک کھیت میں تقریباً ۵۰ ہزار پودے اچھی طرح پکنے چاہئیں۔ اگر کھیت میں پودوں کی تعداد کم ہو تو مٹی دیر سے چڑھانی چاہیئے اور کوشش کرنی چاہیئے کہ شگوفے اور زیادہ جھوئیں شگوفے پھوٹنے کے موسم میں ہلکی مٹی چڑھائیں اور پودوں کے قریب کی زمین کی گوڈی اس طرح کریں کہ مڈھوں تک ہوا کا گزر ہو سکے۔ یہ عمل زیادہ شگوفے حاصل کرنے کے لئے بہت مفید ہے۔

زیادہ پیداوار حاصل کرنے کے لئے پودوں کی مناسب تعداد بہت ضروری ہے۔ جہاں بھی ایک فٹ سے زیادہ حصہ سیاڑ کا خالی ہو۔ زیادہ یا اسی عمر کے مڈھ دوسرے کھیت سے یا اسی کھیت کے ایک طرف سے جو خالی کرنا مقصود ہو لے کر لگالیں تاکہ جگہ پر ہو جاتے۔ اور یہ عمل پودوں کے اگنے سے پہلے خالی جگہ دیکھ کر پر کر لینا چاہیئے۔ تاکہ کھیت میں پودے ایک ساتھ اگیں۔ اگر چند جگہوں پر دیر سے پودے اگیں گے۔ تو ان پر دوسروں کا سایہ زیادہ ہوگا۔ تو یہ پودے کمزور ہو جائیں گے۔

شعبہ مطبوعات محکمہ زراعت حکومت پنجاب لاہور

امید پرنٹرز ۲۳۶ بی راوی پارک لاہور

Subject: FODDER CROPS

Trainer Agronomist
Class Room 2 hours
Field 0 Days

OBJECTIVES

To make the trainees familiar with the fodder crops and their cultivation, making use of important production factors involved.

MATERIALS NEEDED

1 - Sketches of implements used in cultivation.

2 - Seeds of various fodders for identification.

TRAINING MATERIALS

1 - Slides on oat production

2 - Urdu publication "Rabi Fodder", 1 per trainee

INTRODUCTION

Fodder crops are grown for their vegetative parts rather than their seed and are fed to livestock. They are, however, an important indirect source of food. In general, fodder crops have not received the same attention from Agronomists as cereals. Problems of production have not been studied in a comparable way. Fodder crops are also considered essential part of a crop rotation employed to increase the yield of cereals. Their feeding value under proper care and management, however, justifies their consideration as crops in their own rights.

PRESENTATION

Trainees shall be exposed to the information on various production factors.

According to their growing season, fodders are classified into 2 categories, that is "Rabi" fodders and "Kharif" fodders. The recommendations for each category are presented on the following pages.

BERSEEM CLOVER

Berseem clover, a winter annual, is the least winter hardy of the cultivated clovers. It exhibits an erect growth habit, hollow stems, narrow leaflets, and yellowish white flowers borne on a typical clover head. It commonly produces more winter forage than other legumes if it is not damaged by low temperatures. Berseem clover is the most widely grown forage crop in Pakistan.

Since Berseem is a winter annual, it can be incorporated into a "double crop" system. Legumes are a valuable rotation crop due to their symbiotic nitrogen fixing capacity which provides the nitrogen needed by the Berseem and is reported to have added to the yields of rice, maize, cotton and sorghum. Rotations that are recommended follows:

1. Cotton, Berseem, Maize, Berseem
2. Rice, Berseem
3. Maize, Berseem, Cotton, Wheat
4. Wheat, Cowpeas, Berseem, Maize
5. Wheat, Cotton, Berseem, Maize

Berseem is highly nutritious for green forage for milk production and for hard-working animals such as bullocks (30 to 40 pounds of green feed per day). The green forage of Berseem contains 85-90% moisture. It must, therefore, be fed in combination with dry forage to avoid compaction and bloat problems. On a dry matter basis, it is high in minerals and crude protein (up to 20-30%). Details of the recommended cultural practices are given in Table 1. Additional considerations are given below.

Soil, Water and Climatic Requirements

Berseem is a cool weather crop although it will not persist at temperatures below about 20-25°F. The Punjab, with it's long cool winters, is considered to have the optimum climate for this crop. It isadapted to a wide variety of soils, but medium loam soils are considered best. Sandy soils which may be drouthy are generally not suitable for Berseem. Berseem is moderately tolerant to salt, a characteristic which makes it an excellent rotational crop with rice on mildly saline lands.

Seedbed Preparation

Like all small-seeded crops, Berseem requires a well-prepared, firm seedbed. When animal power is utilized with primitive equipment, 3 to 4 plowings and 2 to 3 harrowings are recommended. The land must be level to prevent ponding and allow for even distribution of water.

Seeding

Berseem is a legume. The presence and the activity of rhizobial bacteria is important. Innoculation of the seed is recommended if berseem has not been grown upon the land for more than three years. Nodules on the berseem roots indicate rhizobial activity.

There are over 200,000 Berseem clover seeds in a pound. Theoretically, if the seed germinates at 90% and if half of the seedlings develop into producing plants, a four pound per acre planting rate should result in a population of 8 plants per square foot. When nonprecision planting methods are used, however, enough seed must be applied to insure a good stand. Eight to ten seers of seed per acre is usually adequate.

TABLE 1. Summary of recommended cultural practices for fodder production.

Name	Land preparation	Sowing Time	Fertilizer	Seed Rate and Sowing Method	Irrigation	Harvesting
Rabi Fodder						
Berseem (No. 4/11, Laila)	3-4 ploughings + planking. Precise leveling. Fields of kanal area.	Last week of Sept. to 1st week of Oct.	1½ bags TSP + 1 bag A/S before planting	8-10 seers/acre Broadcasting in standing water or immediately followed by irrigation water	After every 10 days in summer and 15 days in winter	1st cutting last week of Nov., subsequent cuttings every 30-45 days
Lucern (No. 8, No. 9) Sarsa	3-4 ploughings 15 CL of FYM well drained loamy soil most suitable	Round the year Mid Oct. to mid Nov. is the best sowing time	33 lbs. N + 75 lbs. P_2O_5 + 15 CL of FYM.	3-4 seers/acre, 1-1½ inch deep in lines 1-1½ feet apart	1st irrigation 2-3 weeks after sowing subsequent irrigation after every 10 days	1st cutting in March, subsequent 30-45 days
Oats (JII. Albehrin) Alya	3-4 ploughings + planking leveling	1st week of Oct. to mid of Dec. 15 Nov. best	15-20 CL of FYM before sowing	24-30 seers/acre by drills or broadcast	2-3 irrigations	March-April, start
Kharif Fodder						
Sorghum	3-4 ploughing + planking	May to June	1 bag Urea, ½ at sowing and ½ at 1st irrigation	20-25 seers/acre Broadcasting in "Wattar" condition	3-4 irrigations after 1½ months after sowing every 15 days	
Maize	3-4 ploughing + planking	March to Aug.	2 bag Urea + 1 bag TSP. N at sowing and at 2nd irrigation	16-20 seers/acre Broadcasting	3-4 irrigations after every 10 days	1½ months after sowing
Bajra	2-3 ploughing + planking	June to 1st week of July	Nil	2-2½ seers/acre Broadcasting	Usually grown under "Barani" conditions 1-2 irrigations in irrigated areas	Month of Aug. depending upon the condition of crop.

The seed must be placed in contact with moist soil, otherwise it will not germinate. A common recommendation is to apply a two-inch irrigation prior to broadcasting the seed. It is also common practice to broadcast Berseem seed into rice paddies or into maize or cotton just before the final irrigation. This allows the new seedlings the protection provided by the mature crop plants during their formative stages and at the same time helps to shade out competitive weeds.

Fertility Requirements

Like other legumes, Berseem is a heavy phosphorus feeder. Mixing the phosphate with 10 to 12 cartloads of barnyard maure is a good practice. After spreading manures, a light irrigation should be applied to germinate weeds so that they will be eliminated as the soil is prepared for planting. If no manure is used, 1 bag of ammonium sulfate should be applied before sowing.

The basic fertilizer recommendation is given in Table 1.

Irrigation

Berseem, an annual crop, should never have to "wait" for water is satisfactory yields are to be realized. Frequent light irrigation is preferred to less efficient heavy applications of water.

The application of a preplant irrigation to allow the plant to establish itself is a good practice, since the berseem seed is small and requires extra care during the establishment period. The crop may be irrigated lightly soon after germination if crusting is a problem. It will use about 3" of water in December, 3" in January, 4.5" in February, 6" in March and 8" in April in the Northern Punjab and about two more inches per month in the Southern Sind. The consumptive use water requirement for the season is shown in Figure 1. Variations in the irrigation schedule to take advantage of rainfall during the

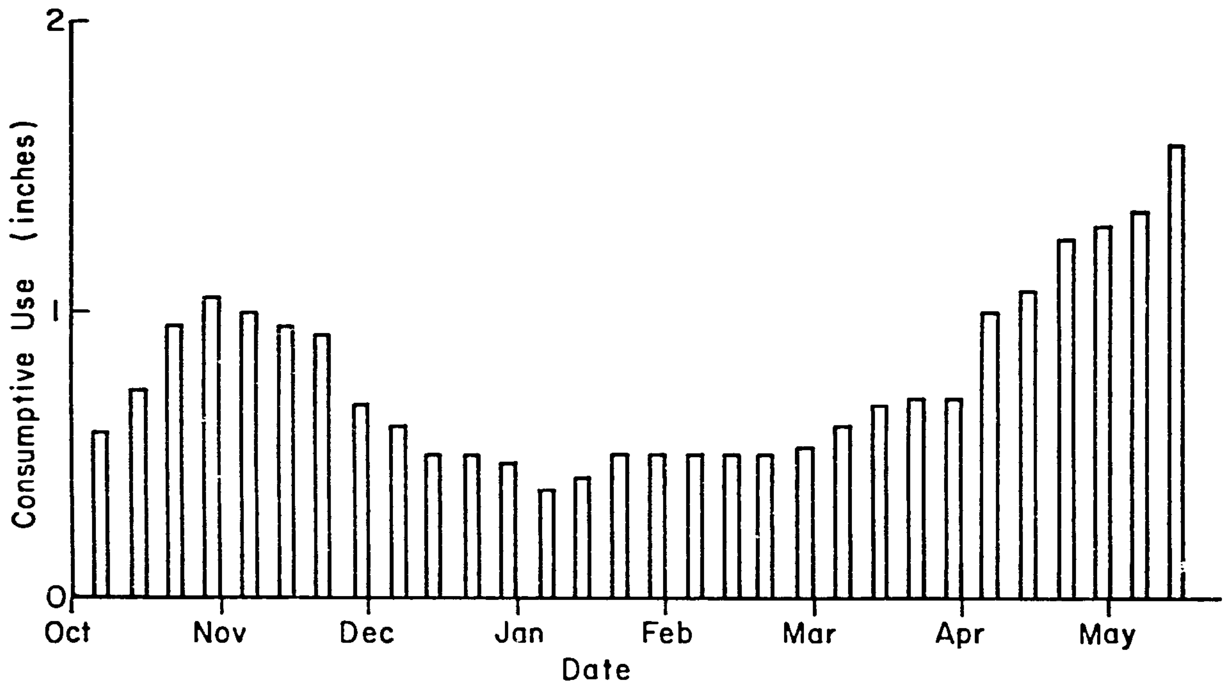


Figure 1. The Weekly Consumptive Use of Water for Berseem.

growing season or of water which might be available from the water table must be determined in the field.

For seed production, the crop should be kept on the dry side until the seed has set. Vegetative growth reduces seed production. After the seed has set, however, regular irrigation schedules may be resumed to allow the seed to fill and mature.

Utilization

Berseem should be harvested about once a month. It should be cut 3 inches above the ground to encourage basal tillering and fine-stemmed forage. The first cutting is normally light (1500 to 8000 lbs. per acre) with succeeding yields increasing until the third cutting when yields of green forage up to 16,000 lbs. per acre may be expected. Proper attention to fertility maintenance and irrigation efficiency can result in 4 to 6 cuttings from December to May and a total yield of up to 60,000 to 80,000 pounds of green forage per acre.

If a seed crop is to be produced, no forage should be harvested after February (usually the 2nd or 3rd cutting). Later forage harvests will result in seed sets during the adverse warmer weather. . .and in poor yields and low quality seed. Thinner stands are usually saved for seed production since the extra light intensity and the lower interplant competition for moisture and fertility stimulates seed sets. Four hundred pounds or more seed per acre is considered a good crop.

The cultural practices for Berseem are given in Table 1. It is also an excellent forage and can be a good source of animal feed. Details are given in the Urdu publication on Fodder production.

OATS

Oats is a nonlegume crop which can be grown either for forage or for grain and which offers versatility to a forage production program. The oat crop is particularly desirable in that, compared to other grain crops, it is relatively easily planted and pleasant to handle, harvest and feed. Oat forage is of high quality. If the crop is allowed to mature for grain, it threshes easily and the straw is superior for either bedding or feed.

The oat plant is an annual grass plant which may grow to heights of from 2 to 6 feet, depending upon the variety and its adaptation. Its root system is fiberous and may penetrate to a depth of about four feet, although the primary root feeding area is within the top foot of soil. The plant usually develops from about three to six or seven hollow stems, 1/8 to 1/4 inch in diameter, topped by a spreading panicle type inflorescence. The seed is usually a long, narrow caryopsis to which the hull remains attached.

Seedbed Preparation

Cultural practices for oat production are given in Table 1.

Following a cultivated row crop such as maize or cotton with oats eliminates the need for intensive seedbed preparation. Oats will emerge when planted as much as 2 inches deep in loamy soils. This allows for relatively deep planting, or for broadcasting and discing or harrowing to help get the seed down into moist soil. If, however, the previous crop has depleted soil moisture, a preplant irrigation, may be required.

Seeding

Oats are commonly a winter crop. They may be multiple cropped to produce 2 to 3 cuttings per year. They may be planted following a cultivated row crop such as corn or cotton. Oats may be drilled or broadcast and worked into the soil. Drilling is more satisfactory because the seed is distributed more uniformly and placed at a more uniform depth but not often practical. Seeding rates will vary slightly with the seed size and planting method. If a good drill is available, about 3-4 seers/A live seed per acre should suffice.

Irrigation

Oats use little moisture during the seedling stage, but moisture for germination and establishment is necessary. The average water requirement for oats under temperate climatic conditions is about 13 to 16 inches. While oats will use somewhat less water than some other crops, it will produce most efficiently when it doesn't have to "wait" for water. Saturation of the soil, however, excludes air from the roots and quickly smothers them and damages the crop.

Oats are commonly seeded in the latter part of October as indicated in Table 1.

Actual irrigation needed to supplement rainfall will depend on the rainfall received, the initial water content of the soil, extent of crop cover and whether the farmer wishes to leave his soil with or without moisture reserves at the time of harvest.

Oats commonly root to depths of 3 or 4 feet and if that whole soil reservoir is filled to field capacity at the beginning of the season (as it probably is in September in the mid-Punjab if monsoon rains have been normal and a 4" preplant irrigation has been applied) this reservoir of 5 to 8" water of available may be drawn upon during the season. Normally, this reservoir should not be depleted by more than about 2" during the first month of the growing season, when the plan roots are still shallow. However, during the second month, depletions of 3" are reasonable and after the second month the whole reservoir is generally tapped by the roots and the total 5" to 8" can be considered as available.

The farmer can fill this reservoir during the latter part of the season if he has the water and wants to carry it over for use by the following crop.

On the other hand, if he needed his water for use on other crops growing at the same time as the oats, the last irrigation can be eliminated.

Fertilization

Oats are not considered to be a heavy user of plant foods. The general recommendations are given in Table 1.

Utilization

In order to attain maximum benefit from oat forage, it should be allowed to grow to moderate maturity before it is cut, which will be about March or April. Maximum nutrition per acre is realized when the oat forage crop is cut at the soft dough stage. It is at this stage that the grain has developed a good proportion of its carbohydrate value, but the vegetation still retains its leaves and its forage values. Oat forage, when mowed green may be used as a food or feed additive. It is very high in chlorophyl and vitamin A.

SORGHUM

Sorghum is a warm weather crop which has many advantages as a forage producer. Since it grows best when the mean temperature is about 80 degrees, it fills a need for forage during the warm weather when many of the other forage crops are in the resting (loafing) stage.

Sorghum root system is highly efficient in its ability to remove water from the soil. Sorghum seems to have the capability to "wait" for moisture without appreciable damage to the crop. Sorghums will produce well when temperatures are high enough to wilt terminal leaves of corn (top-wilt). Sorghums' tolerance to salt is also superior to corn and they normally produce more than corn when grown on salt-affected soils.

Is is a coarse, annual grass plant which may grow to heights of from 2 to 12 feet, depending upon the type, variety and adaptation. Forage sorghums are tall and leafy. Many of them have sweet, juicy stalks and produce highly platable fodder. Leaves form from each node on the stem as well as from crown nodes which may be located at or below the surface of the soil. Seed is borne in a dense to loose head or panicle.

Many improved soghum varieties and hybrids are avaibable now. They merit evaluation. Reports indicate that, to date very little varietal evaluation of sorghum varieties has been conducted in Pakistan.

Seedbed Preparation

Sorghum, being a small seeded crop, requires a compact well-prepared level seedbed. The usual practice is to plow the land 3 to 4 times and plank once or twice (Table 1). The soil must be warm if the seed is to germinate satisfactorily. A temperature of 65° is the minimum at which the sorghum plant will grow, and 80° is considered optimum. Moisture must be available for germination and emergence. The sorghum seedling is not a good competitor, so the practice of preirrigation of the seedbed and preplant cultivation for weed control is a good one.

Seeding

Sorghum for forage should be drilled in 30 to 36 inch rows about 1 inch deep (but it is usually broadcast). A seeding rate of 16-20 seers/acre pure live seed should be sown.

Irrigation and Drainage

Sorghum is extremely efficient in the removal of moisture from the soil system. Sorghum will produce most if it always has adequate water. However, timeliness of rain or of irrigation scheduling is not as critical as with other crops. It has the ability to "stand still" when dry, then to quickly utilize moisture when it is received. Thus, in an area where the season is long and reasonably warm, over 65 degrees mean temperature, yields are not as critically effected as are those of other crops when short, dry periods are encountered during the growing season.

When possible, a preplant irrigation and a cultivation to control weeds during the critical seedling stage of the sorghum plant is recommended. This will also help to warm the soil and encourage quicker germination and development. The water consumption of the sorghum plant, like other plants, increases until the leaf canopy intercepts all the sunlight. From then until the crop begins to mature (i.e., the leaves begin to dessicate) the water use will be practically equal to the potential evapotranspiration. After that water is not needed but evapotranspiration will continue as long as the foliage is green.

When the leaves turn dark and tend to roll, and do not unroll in the evening, the sorghum crop needs water. Sorghum will need water at least once every two to three weeks during its heavy use period (Table 1). More frequent irrigations should be applied if the plant shows the water stress symptoms indicated above. . .if the farmer has the water. If, however, the farmer needs the water for other crops, sorghum can best survive.

Sorghum is generally more tolerant to wet soils than maize and consequently produced better yields than maize when the monsoon rains leave water standing in the fields for more than a day.

Utilization

The maximum amount of nutrition per acre can be realized if the forage is cut at about the soft dough stage. At this time, growth is about complete, but leaves are still present and they are green and platable.

For forage, of course, it should be cut earlier (1½ months after sowing). If so, however, it is lower in dry matter and higher in water content. . .

it requires more of it to produce the same amount of nutrition. Sorghum forage which is cut very early needs to be used cautiously. Sorghums, as a family have the capability of producign hydrocyanic (prussic) acid in the very young leaves, particularly in second growth following unfavorable growing conditions which may have stunted the plant. Hydrocyanic acid is extremely toxic. One-half gram can kill a cow. Any danger, however, has been bypassed when the plant reaches a height of about 2 feet. As the plant matures, the nitrogen materials in the leaves are converted to proteins and the hazzard eliminated. Maize and Baj a are also good kharif season fodders. Their general cultural practice recommended are given in Table 1. Details are also given in the Urdu publication on fodder production.

APPLICATION

1 - Each trainee will examine and identify the seeds of various fodders.

2 - Each trainee will learn the production practices of the forages.

QUESTIONS

1 - What is the importance of fodder crops and what role they play in human nutrition?

2 - What is the seed rate of Berseem and Maize for fodder?

3 - Prepare a planting and harvesting plan to supply fodder to a farmer year around.

Fodders CPG-5

Rabi Fodders.

ربیع کے چارے

پاکستان میں چارے کی فصلوں کی اہمیت اس لیے زیادہ ہے۔کیونکہ چارے مویشیوں کے لیے بطور غذا استعمال ہوتے ہیں۔ پاکستان میں مویشیوں کی تعداد کافی ہے لیکن ان کو سبز چارہ اور متوازن خوراک پوری مقدار میں مہیا نہیں ہوتی۔ جس کی وجہ سے ان سے گوشت۔ مکھن۔ دودھ اور دیگر اشیاء کی پیداوار کم مقدار میں حاصل ہوتی ہے۔ انسان کی بڑھتی ہوئی آبادی کا معیارِ زندگی اور صحت کو برقرار رکھنے کے لیے مویشیوں سے گوشت۔ دودھ۔ مکھن اور دیگر اشیاء کی زیادہ پیداوار تب ہی حاصل کی جا سکتی ہے جبکہ ان کو متوازن چارے اور خوراک بروقت مہیا کی جائے۔ مویشیوں سے انسانی خوراک زیادہ حاصل کرنے کیلئے یہ ضروری ہے کہ چارے کی ایسی فصلیں یا ترقی دادہ اقسام زیرِ کاشت لائی جائیں جن سے سبز چارہ کی کم سے کم رقبہ سے زیادہ سے زیادہ پیداوار حاصل کی جا سکے۔ موسم سرما میں ربیع کے چارے مثلاً برسیم۔ لوسرن۔ جئی خاص طور پر چارے کے لیے کاشت کیے جاتے ہیں۔ ان فصلوں کو بطور چارہ کاشت کرنے کے لیے ضروری ہدایات درجِ ذیل ہیں :-

برسیم

Burseem

اہمیت :

Importance

برسیم موسم سرما کا ایک مفید اور مقوّی چارہ ہے۔ زیادہ تر اس کو سبز حالت میں جانوروں کو کھلایا جاتا ہے۔ اس کا خشک چارہ بھی اچھا بنتا ہے۔ جو بوقت ضرورت استعمال میں لایا جا سکتا ہے۔ اس کی آخری کٹائی سبز کھاد کے طور پر استعمال کی جا سکتی ہے۔ جو زمین کی زرخیزی بحال کرتی ہے۔ جو زمیندار ۱۵ مارچ کے بعد برسیم کی فصل بیج کے لیے چھوڑ دیتے ہیں ان کے لیے یہ ایک نفع بخش فصل ہے۔

موسمِ ربیع میں جو چارہ آبپاش علاقوں میں بویا جاتا ہے۔ اس کا ۷۵ فیصد رقبہ برسیم پر مشتمل ہوتا ہے۔ یہ اپنی اعلیٰ خصوصیات کی وجہ سے چاروں کا بادشاہ کہلاتا ہے۔ اس کے پودوں میں چونکہ فاسفورس ۲ر۸ فی صد اور کیلشیم ۲ر۶ فی صد مقدار میں پائے جاتے ہیں۔ اس لیے جن گائیوں اور بھینسوں کو برسیم کا چارہ ڈال دیا جاتا ہے ان کے دودھ کی پیداوار بڑھ جاتی ہے۔ اس میں لحمی مادہ کی مقدار ۱۸ر۲۳ فی صد ہے۔ اس لیے اس کا چارہ بہت مفید اور زود ہضم ہوتا ہے۔ اس کے پتے اور شاخیں نرم ہوتی ہیں۔ اس لیے یہ تمام جانوروں کی دل پسند خوراک ہے۔ صوبہ پنجاب میں تقریباً ۱۵ لاکھ ایکڑ کے لگ بھگ رقبہ پر برسیم کی کاشت کی جاتی ہے۔

برسیم کے پودے میں اپنے دوران نشوونما بار بار پھوٹنے کی صلاحیت بدرجہ اتم پائی جاتی ہے۔ اور ایک کٹائی دینے کے بعد یہ دوبارہ پھوٹ آتا ہے۔ اس طرح نومبر سے لے کر مئی تک سبز چارہ مسلسل بہم پہنچاتا ہے۔ اسکی پیداوار بھی ربیع کے دوسرے چاروں سے زیادہ ہے۔ اس میں وہ تمام خوبیاں پائی جاتی ہیں جو ایک مثالی چارہ میں ہونی چاہئیں۔ اس لئے اس نے آبپاش علاقوں میں ربیع کے دوسرے چاروں کی جگہ لے لی ہے۔ ذیل میں دی گئی

Fertilizer ۴

ہدایات پر عمل کرنے سے برسیم کی سبز چارہ کی زیادہ پیداوار حاصل کی جاسکتی ہے۔

زمین : Soil

اس کی کاشت کے لیے بھاری میرا زمین جس میں پانی کا نکاس اچھا ہو۔ بہت مناسب ہے۔ ہلکی زمینوں پر جن میں نمی محفوظ کرنے کی طاقت ہو یہ معیاری پیداوار دیتا ہے۔ یہ درمیانے درجے کی کلراٹھی زمین پر بھی اگایا جاتا ہے۔ یہ کلر والے علاقے میں چاول۔ برسیم ردّو بدل (ROTATION) میں کثرت سے بویا جاتا ہے اور زمین درست کرنے میں معاون ثابت ہوتا ہے۔ یہ ۴۰ء ۵۰ فی صدی تک کلر برداشت کرسکتا ہے۔

کھاد :

برسیم کو ۱۰ تا ۱۲ گڈے گلی سڑی گوبر کی کھاد بوائی سے پہلے دینے سے سبز چارہ کی اچھی پیداوار مل جاتی ہے۔ لیکن تجربات سے ثابت ہوا ہے کہ برسیم کی زیادہ پیداوار لینے کے لیے فاسفورس کھاد بہت ضروری ہے۔ اور تھوڑی بہت نائٹروجن بھی ڈالنی چاہیئے۔ چند ایک تجربات کے نتائج نیچے دیئے جاتے ہیں ان سے ثابت ہوجائے گا کہ فاسفورس کھاد برسیم کی کاشت کے لیے کتنی ضروری ہے۔

۷۶-۱۹۷۵ء میں زمینداروں کے کھیتوں میں کیئے گئے تجربات جن میں ۱۰۰ پونڈ فاسفورس اور ۲۰ پونڈ نائٹروجن استعمال کی گئی نتائج درج ذیل ہیں۔

Burseem varieties and yield kg/A

اقسام برسیم پیداوار کلوگرام فی ایکڑ

نام کاشتکار	۴/۱۱ بغیر کھاد	۴/۱۱ کھاد سے	امپورٹیڈ بغیر کھاد	امپورٹیڈ کھاد سے	لوکل بغیر کھاد	لوکل کھاد سے
۱۔ چوہدری پرویز بشیر چک نمبر ۲۶۷/ ر ب لائلپور	۲۸۰۱۰	۳۶۴۴۴	۳۲۵۰۶	۴۵۴۵۵	۲۱۱۴۵	۲۷۶۸۷
۲۔ راؤ پرویز یاسین تقی پور۔ لاہور	۲۲۸۴۷	۳۳۷۴۷	۲۳۲۱۹	۴۴۱۸۵	۱۸۸۳۶	۲۶۵۹۴

اس کے علاوہ ایسے ہی اور تجربات زرعی تحقیقاتی ادارہ لائلپور پر کیے گئے جن سے یہ بات ثابت ہوگئی ہے کہ برسیم کی فصل کو ۲۰ پونڈ نائٹروجن اور ۱۰۰ پونڈ فاسفورس بوائی سے پہلے دینے سے سبز چارہ کی زیادہ سے زیادہ مقدار حاصل کی جاسکتی ہے۔

آب وہوا : climate

اس کے لئے معتدل آب و ہوا درکار ہوتی ہے۔ جس میں نہ زیادہ گرمی ہو اور نہ سخت سردی ہو۔ کسی حد تک یہ گرم آب و ہوا میں بھی کاشت کیا جاسکتا ہے لیکن سخت سردی میں اس کی نشوونما بہتر نہیں ہوتی۔

تیاری زمین : Soil Preparation

برسیم کی کاشت کے لیے تین چار دفعہ دیسی ہل چلا کر زمین کو نرم اور بھربھرا کر لینا چاہیئے دو تین دفعہ سہاگہ بھی ضروری ہے اور زمین کا ہموار ہونا اشد ضروری ہے اور کھیت میں جڑی بوٹیاں بھی نہیں ہونی چاہئیں۔ جب کھیت اچھی طرح تیار ہوجائے تو اسے ایک ایک کنال کے ٹکڑوں میں تقسیم کرلینا چاہیئے۔ تاکہ بوائی کے وقت آبپاشی میں آسانی ہو۔

برسیم کو ٹیکہ لگانا : Burseem Injection

برسیم ایک پھلی دار فصل ہے اور اس کی جڑوں پر جراثیم کی گھنڈیاں ہوتی ہیں جو ہوا سے نائٹروجن حاصل کر کے پودے کو مہیا کرتی ہیں۔ جس کھیت میں برسیم کی پہلی دفعہ کاشت کرنی ہو اس میں جراثیم آلود مٹی اس کھیت سے لاکر جس میں پچھلے سال برسیم کاشت کیا گیا ہو ملانی چاہیئے۔ ورنہ اس کھیت سے سالِ اوّل برسیم کی فصل اچھی نہ ہوگی۔ اگر جراثیم آلود مٹی دستیاب نہ ہو تو زرعی تحقیقاتی ادارہ لائل پور سے

برسیم کے بیج کا ٹیکہ ایک ڈبہ کی شکل میں مل سکتا ہے۔ اس ڈبہ میں برسیم کی کاشت کے لیے ضروری جراثیم والی مٹی بند کی ہوئی ہوتی ہے۔ اسے ۱۰ فیصد گڑ یا شکر کے ½ کلوگرام محلول میں ملا لیا جاتا ہے۔ فرش یا ایک بوری پر برسیم کے بیج کی ڈھیری لگائی جاتی ہے۔ اور اس پر یہ محلول چھڑکا جاتا ہے۔ اور دونوں کو اچھی طرح ملا لیا جاتا ہے۔ اس کے بعد بیج کی ایک پتلی تہہ بچھائی جاتی ہے اور اسے سایہ میں خشک کر لیا جاتا ہے۔ ٹیکہ لگائے ہوئے برسیم کے بیج کو ۲۴ گھنٹے کے اندر اندر کاشت کر دینا چاہیئے ورنہ ٹیکے کا اثر زائل ہونے کا احتمال ہے۔

ترتیب کاشت: Crpping pattern

کل رقبہ جو برسیم کے زیر کاشت ہوتا ہے اس کا ۵۰-۶۰ فیصد خالی زمینوں پر بویا جاتا ہے۔ باقی ۵۰-۶۰ فی صد رقبہ اول بدل (ROTATION) میں مکئی کپاس، چاول اور جوار کے بعد کاشت کیا جاتا ہے۔ خالی زمینوں میں کاشت کی ہوئی فصل مخلوط کاشت سے زیادہ پیداوار دیتی ہے۔ مندرجہ ذیل فصلوں کا ادل بدل بہت اچھا رہتا ہے اس سے زمین کی زرخیزی بحال ہو جاتی ہے اور برسیم کے بعد آنے والی فصل اچھی پیداوار دے جاتی ہے۔

۱۔ گندم۔ چری۔ گوارہ۔ برسیم۔ کپاس
۲۔ مکئی۔ برسیم۔ کماد۔ کماد۔
۳۔ چاول۔ برسیم۔ چاول۔
۴۔ برسیم۔ کپاس۔
۵۔ برسیم۔ جوار
۶۔ برسیم۔ کپاس۔ گندم

وقت کاشت: Time of Sowing

تاریخ وار کاشت کے تجربات سے ثابت ہوا ہے کہ برسیم کی ستمبر کے آخری ہفتہ اور اکتوبر کے پہلے ہفتہ کے درمیانی وقفہ میں کاشت کرنے سے فصل اچھی اور زیادہ پیداوار دیتی ہے۔ گرم علاقوں میں موسم کے مطابق کاشت ذرا دیر سے کی جا سکتی ہے لیکن پچھیتی کاشت کی صورت میں سردی زیادہ ہو جانے کی وجہ سے پودوں کی نشوونما رک جاتی ہے اور پہلی کٹائی دیر سے حاصل ہوتی ہے۔

شرح بیج: Seed Rate برسیم کے لیے ۸ سے ۱۰ کلوگرام تک بیج فی ایکڑ کافی رہتا ہے۔ خیال رکھنا چاہیئے کہ بیج جڑی بوٹیوں خصوصاً کاسنی اور شفتل کے بیج سے صاف ہو۔ برسیم کے بیج کو ان پودوں کے بیج سے صاف کرنے کے لیے برسیم کے بیج کو ۵ فیصد کھانے والے نمک کے محلول میں بھگو دینا چاہیئے۔ بھگونے سے کاسنی اور شفتل وغیرہ کے بیج وزن میں ہلکے ہونے کی وجہ سے پانی کے اوپر رہ جائیں گے اور برسیم کا بیج نیچے بیٹھ جائے گا۔

طریقہ کاشت: Sowing method

زمین کو ہموار اور اچھی طرح تیار کر کے اس میں ایک ایک کنال کے کیارے بنا لینے چاہئیں۔ پھر کھیت میں پانی لگا کر کھڑے پانی میں بیج کا چھٹا دینا چاہیئے کھیت میں چھٹا ایک دفعہ لمبائی کے رخ اور دوسری بار چوڑائی کے رخ دینا چاہیئے تاکہ کھیت میں کوئی جگہ بھی بیج کے بغیر نہ رہ جائے۔ برسیم کے بیج کی بوائی شام کے وقت کرنی چاہیئے تاکہ دھوپ میں بوائی کرنے سے سورج کی گرمی کا بیج کی روئیدگی پر برا اثر نہ پڑے۔ برسیم کی پہلی کٹائی سے عام طور پر سبز چارہ کی کم مقدار حاصل ہوتی ہے۔ اس لیے پہلی کٹائی کی پیداوار میں اضافہ کرنے کے لیے برسیم میں جئی کی اگیتی قسم فلسطینی یا رایا اور سرسوں یا رائی گھاس کی مخلوط کاشت کرنی چاہیئے۔

آبپاشی: Irrigations

برسیم کی فصل کو پہلے تین چار پانی سات آٹھ دن بعد لگانے چاہئیں۔ جب فصل کا اگاؤ اچھی طرح قائم ہو جائے تو پانی پندرہ دن کے بعد بھی دیا جا سکتا ہے۔ زیادہ سردی کے دنوں میں خاص کر جنوری۔ فروری میں ہفتہ وار پانی لگاتے رہنا چاہیئے۔ اس سے فصل کی بڑھوتری نہیں رکتی اور کورے کا اثر کم ہوتا ہے۔ برسیم کو کل ۱۴ تا ۱۵ آبپاشیوں کی ضرورت ہوتی ہے۔

پیداوار: Yield

اگیتی کاشت کردہ برسیم کی فصل سے سبز چارہ کی پہلی کٹائی نومبر کے آخری ہفتہ میں تیار ہو جاتی ہے۔ جبکہ دوسری کٹائیاں ۳۰ یا ۴۵ دن کے وقفہ کے بعد لینے سے سبز چارہ کی پیداوار میں خاصہ اضافہ ہو سکتا ہے۔ فصل کو جلدی جلدی اور کم وقفے سے کاٹنے سے برسیم کے پودے کمزور ہو جاتے ہیں اور مجموعی پیداوار پر برا اثر پڑنے کا احتمال ہو سکتا ہے۔ مشاہدات سے یہ بات بھی ثابت ہو چکی ہے کہ برسیم کی فصل کو زمین کی سطح کے قریب سے کٹائی کرنے سے زیادہ

پیداوار حاصل ہوتی ہے۔ ایک ایکڑ برسیم کی فصل سے ۴ تا ۵ کٹائیاں لی جاتی ہیں۔ جن سے مجموعی اوسط پیداوار ۲۰۰ ۲ کلوگرام سے ۲۴۵۶۰ کلوگرام فی ایکڑ سبز چارہ کی مقدار حاصل ہو سکتی ہے۔

High yielding varieties of Berseem

برسیم کی ترقی دادہ اقسام:

برسیم کی دو اقسام سقاوی اور پشاوری عام طور پر مشہور ہیں۔ پنجاب میں اگیتی اقسام نمبر ۱۱/۲ نے سب سے زیادہ سبز چارہ کی پیداوار دی ہے۔ اس قسم کے کاشت کرنے سے سبز چارہ کی پہلی کٹائی میں برسیم کی قسم پشاوری سے کہیں زیادہ پیداوار حاصل ہوئی ہے۔ اور مئی کے وسط تک سبز رہتی ہے۔ پشاوری قسم پچھیتی ہونے کی وجہ سے پہلی کٹائی دیر سے دیتی ہے اور زیادہ عرصہ یعنی جون تک سبز رہتی ہے۔

پنجاب زرعی تحقیقاتی ادارہ لائل پور اور سرگودھا کے شعبہ چارہ جات میں تحقیقات کے بعد برسیم کی مندرجہ ذیل اقسام دریافت کی گئی ہیں جو سبز چارہ کی پیداوار زیادہ دیتی ہیں اور چارہ بھی اعلیٰ معیار کا ہوتا ہے۔ برسیم کی قسمیں اور ان کی خصوصیات مندرجہ ذیل ہیں:-

(۱) ۱۱/۲: یہ برسیم کی اگیتی قسم ہے اور دسمبر تا فروری خاص طور پر چارہ کی زیادہ پیداوار دیتی ہے اور مئی کے پہلے ہفتہ تک چارہ مہیا کرتی ہے۔ 4/11

Lyallpur Late

(۲) لائل پور لیٹ:

یہ برسیم کی ایک نئی پچھیتی قسم ہے جو سبز چارہ کی مجموعی پیداوار ۱۱/۲ کے برابر ہی دیتی ہے۔ لیکن مئی اور جون کے پہلے ہفتہ تک چارہ فراہم کرتی رہتی ہے اس وقت کاشتکار گندم کی کٹائی میں معروف ہوتے ہیں اور چارہ کی بڑی قلت ہوتی ہے اس لیے یہ پچھیتی ہونے کی وجہ سے دیر تک چارہ مہیا کرنے میں بڑی مفید ثابت ہوئی ہے۔

۱۱/۲ اور لائل پور لیٹ دونوں اگیتی اور پچھیتی اقسام کا بیج ملا کر تجربات کئے گئے تاکہ پتہ لگ سکے کہ دونوں قسموں کی مخلوط کاشت سے چارہ کی مسلسل اور زیادہ پیداوار حاصل ہوتی ہے یا نہیں۔ اس سلسلے میں نتائج حوصلہ افزا ثابت ہوئے ہیں لیکن اس پر ابھی اور تحقیق کرنا باقی ہے۔

(۳) ۴/۷۳: یہ برسات کی اگیتی قسم ہے۔ جس نے شعبہ چارہ جات سرگودھا 3/73 پر ۱۱/۲ کے مقابلے میں سبز چارے کی زیادہ پیداوار دی ہے۔ اس کی سب سے بڑی خصوصیت یہ ہے کہ فصل چارہ کی کٹائی کے لیے ایک ہفتہ پہلے تیار ہو جاتی ہے۔ اور اس سے چارہ کی کل کٹائیاں قسم ۱۱/۲ کی نسبت زیادہ لی جا سکتی ہیں۔

ان قسموں کے علاوہ ایک نئی قسم (MULTIFOLIATE) مصر سے منگوائی گئی ہے جو کہ ابھی زیر مشاہدہ ہے۔ اس کی خصوصیت یہ ہے کہ اس کے پودوں میں پتیوں کی تعداد تین سے زیادہ یعنی چار یا پانچ ہوتی ہے۔

Producing Berseem Seed

برسیم کا بیج پیدا کرنا

برسیم کی فصل چارہ کی بہت زیادہ پیداوار دینے اور لگاتار کٹائیاں دینے کی صلاحیت رکھنے کی وجہ سے زمینداروں میں بہت پسند کی جاتی ہے۔ اس لیے اس کے بیج کی ملک میں ربیع کے دوسرے سب چاروں سے زیادہ مانگ ہوتی ہے۔ اس کا خالص، صحت مند و چمکدار اور صاف ستھرا بیج پیدا کرنا بہت اہمیت کا حامل ہے۔

کچھ عرصہ پہلے یہ خیال کیا جاتا تھا کہ پنجاب کی آب و ہوا میں برسیم کے بیج کی اچھی پیداوار حاصل نہیں ہوتی۔ اس لیے مصر و سرحد سے کافی بیج پنجاب لایا جاتا تھا۔ اس ضرورت کو پورا کرنے کے لیے شعبہ تحقیق چارہ جات سرگودھا میں برسیم کا اچھا بیج پیدا کرنے کے لیے بڑے تفصیلی تجربات کئے گئے جن سے یہ ثابت ہوا کہ برسیم کی فصل کی مناسب دیکھ بھال اور صحیح وقت پر فصل کو بیج کے لیے چھوڑنے پر اچھا اور صحت مند بیج پیدا کیا جا سکتا ہے جس سے کاشتکار چارہ لینے کے علاوہ اضافی آمدنی بھی حاصل کر سکتا ہے۔

سرگودھا میں تجربات کے نتائج درج ذیل ہیں جس پر عمل کرنے سے برسیم کے بیج کی فی ایکڑ زیادہ سے زیادہ پیداوار لی جا سکتی ہے۔

۱۔ برسیم کی فصل جب بیج کے لیے چھوڑی گئی ہو تو اس وقت پھول آنے پر شہد کی مکھیوں اور دوسرے کیڑوں کی مدد سے اختلاط نسل بڑی حد تک ضروری ہے۔ اس وقت شہد کی مکھیوں کے چھتے برسیم کے کھیت میں رکھنے سے بیج کی زیادہ پیداوار حاصل کی جا سکتی ہے۔

۲۔ چارے کے لیے فصل کو بار بار کاٹنے سے بیج کی پیداوار کم ہو جاتی ہے۔ اس لیے برسیم کی فصل سے زیادہ بیج لینے کے لیے ضروری ہے کہ برسیم کی فصل سے صرف دو تین کٹائیاں لی جائیں۔

Lucern cultivation

۳۔ تجربات سے معلوم ہوا ہے کہ اگر پندرہ فروری کے بعد چارہ کے لیے کٹائی نہ کی جائے تو بیج کی پیداوار بہت اچھی حاصل ہوتی ہے۔ لیکن چارہ کی کم مقدار ملتی ہے اس لیے ضروری ہے کہ برسیم کی فصل کو برائے بیج یکم مارچ اگیتی اقسام کے لیے اور پندرہ مارچ کو پچھیتی اقسام کے لیے چھوڑا جائے۔ اس طرح چھوڑی ہوئی فصل سے بیج کی بہت اچھی پیداوار حاصل ہوتی ہے۔

۴۔ بیج کے لیے چھوڑی ہوئی برسیم کی فصل پر پھول نکلنے سے پہلے اینڈرین یا ڈائی کران یا کسی زہر کا ایک سپرے کرنا چاہیئے۔ کیونکہ اس وقت لشکری سنڈی کے حملے کا خطرہ ہوتا ہے۔ اگر ڈائی تھین ایم ۴۵ بھی ساتھ ملا لی جائے تو پھپھوندی کے حملے کا خطرہ بھی ٹل جاتا ہے۔ لشکری سنڈی کے حملہ کی وجہ سے برسیم کے بیج میں کافی کمی واقع ہو جاتی ہے۔ اس لیے اس کا بروقت تدارک کرنا بہت ضروری ہے۔

۵۔ برسیم کی فصل کو پھول نکلنے کے بعد کسی صورت میں پانی کی کمی نہیں آنے دینی چاہیئے۔

۶۔ برسیم کے بیج کے لیے پچھیتی کاشت وسط دسمبر سے وسط جنوری تک کپاس مکئی۔ جوار۔ چاول کی فصلیں کاٹ لینے کے بعد اچھی رہتی ہے۔ اس سے زمیندار کو اچھا بیج بھی مل جاتا ہے اور اس کی زمین کی زرخیزی بھی بحال ہو جاتی ہے۔

۷۔ برسیم کی فصل سے جڑی بوٹیوں۔ ریوالڑی شینفتل۔ باتھو۔ کرنڈ وغیرہ کو تلف کر دینا چاہیئے۔ ان بوٹیوں کا خالص برسیم پیدا کرنے کے لیے تلف کرنا بہت ضروری ہے۔ خیال رہے کہ جڑی بوٹیوں کو پھول آنے سے پہلے ہی نکال دینا چاہیئے۔

۸۔ بیج کے لیے چھوڑی ہوئی برسیم کی فصل مئی کے آخر اور جون کے شروع میں پک کر تیار ہو جاتی ہے۔ جب فصل کی ڈوڈیاں اچھی طرح خشک ہو جائیں اس وقت فصل کو کاٹ کر فوراً گہائی کر لینی چاہیئے۔ کیونکہ ان دنوں بارش طوفان وغیرہ کا بڑا خطرہ ہوتا ہے۔ اچھی پکی ہوئی فصل ۲۹۸ تا ۳۰۷ کلو گرام بیج برسیم فی ایکڑ دے جاتی ہے۔

لوسرن کی کاشت

لوسرن دائمی نوعیت کا ایک پھلی دار چارہ ہے۔ اور اس کے چارے کو مقوی اور لذیذ ہونے کی وجہ سے دوسرے پھلی دار چاروں میں ایک امتیازی حیثیت حاصل ہے۔ لوسرن کے چارہ میں لحمی مادہ۔ حیاتین۔ چونا۔ میگنیشیم اور دوسری معدنیات بھی زیادہ مقدار میں ہوتی ہے۔ لوسرن کے پودے کی جڑیں زمین میں کاشت کے بعد کافی گہرائی تک چلی جاتی ہیں اور اس طرح نیچے سے پانی حاصل کر کے خشک حالات کا مقابلہ کر سکتا ہے۔ لوسرن کے پودا میں یہ بھی خصوصیت ہے کہ ہر قسم کی زمین اور آب و ہوا سے مطابقت پیدا کر لیتا ہے اسے امریکہ میں "چارے کی ملکہ" کے نام سے پکارا جاتا ہے۔

لوسرن ایک ایسا چارہ ہے جو ہمارے ملک میں ربیع اور خریف کے دونوں موسموں خاص طور پر مئی جون اور اکتوبر نومبر میں جانوروں کے لیے سبز چارہ فراہم کرتا ہے۔ لوسرن کو زیادہ تر گھوڑوں اور خچروں کی خوراک کے طور پر استعمال کیا جاتا ہے۔ اس لیے اس کی زیادہ تر کاشت بڑے شہروں کے آس پاس اور ملٹری کے گھوڑوں کے فارموں پر کی جاتی ہے۔ لوسرن کی کامیاب کاشت کے متعلق تفصیلی ہدایات مندرجہ ذیل ہیں۔

زمین : Soil

لوسرن کی کاشت نیم خشک آب و ہوا والے علاقوں میں کلراٹھی زمینوں کے سوا اچھے پانی کے نکاس والی ہر قسم کی زمین پر کی جا سکتی ہے۔ اگرچہ لوسرن کی فصل زرخیز میرا قسم کی اچھے نکاس آب والی زمین پر جس میں چونے کی بہتات ہو سبز چارے کی زیادہ پیداوار حاصل کرنے کے لیے موزوں ترین خیال کی جاتی ہے۔

آب و ہوا : Climate

ویسے تو پاکستان کے چاروں صوبوں میں لوسرن کی کاشت بخوبی کی جا سکتی ہے لیکن بروقت پانی کی فراہمی کرنے پر ملک کے گرم اور خشک آب و ہوا والے حصے اس کی کاشت کے لیے نہایت موزوں ثابت ہوئے ہیں۔ لیکن مرطوب علاقوں میں گرمی اور ہوا کی نمی کا باہمی اثر لوسرن کی فصل کے لیے مضر ثابت ہوتا ہے۔ سردیوں کے موسم میں لوسرن کے چارے کی بڑھوتری رک

جاتی ہے۔ اور موسم گرما کی نسبت سردیوں میں سبز چارہ کی پیداوار فی ایکڑ کم ہو جاتی ہے۔

تیاری زمین: Soil preparation

لوسرن چونکہ ایک دوامی قسم کی فصل ہے اس لیے زمین کی تیاری پر خاص توجہ دینی چاہیے۔ فصل کی کاشت سے کم از کم ڈیڑھ ماہ پہلے زمین خالی رکھی جائے اور اس میں مٹی پلٹنے والا ہل اور بعد میں تین چار دفعہ دیسی ہل اور سہاگہ چلا کر مٹی خوب باریک کر لینی چاہیے۔ بوائی سے پہلے کھیت کو ہموار کرنا بھی ضروری ہے کیونکہ ناہموار زمین کے نشیبی حصوں میں پانی ٹھہرنے سے فصل کو نقصان پہنچتا ہے۔

کھاد: Fertilizer

لوسرن چونکہ ایک پھلی دار فصل ہے اس لیے نائٹروجن کی بیشتر ضروریات اپنی جڑوں میں موجود جراثیم کی مدد سے ہوا سے حاصل کر لیتا ہے۔ کاشت سے ڈیڑھ یا دو ماہ پہلے ۱۵ تا ۲۰ گڈے گوبر کی گلی سڑی کھاد زمین میں ساوی طور پر ملا دینی چاہیے۔ اس سے زمین میں مختلف غذائی مادوں کے علاوہ نامیاتی مادے کی مقدار بھی بڑھ جاتی ہے جو لوسرن کی فصل کے لیے بہت ضروری ہے دوسرے پھلی دار پودوں کی طرح لوسرن کی فصل کو فاسفورس والی کھاد دینے سے کافی فائدہ پہنچتا ہے۔ تجربات سے یہ بات ثابت ہوئی ہے کہ لوسرن کی فصل کو ۲۰ پونڈ نائٹروجن اور ۵۰ سے ۱۰۰ پونڈ فاسفورس فی ایکڑ بوائی سے پہلے دینے سے سبز چارہ کی پیداوار میں کافی اضافہ ہو جاتا ہے۔

وقت کاشت: Time of sowing

لوسرن کی کاشت ویسے تو سارا سال کی جاسکتی ہے۔ لیکن وسط اکتوبر سے وسط نومبر تک کاشت کی ہوئی فصل سے چارا کی زیادہ پیداوار حاصل کی جاسکتی ہے۔ لوسرن کی اکتوبر میں کاشت شدہ فصل زیادہ پیداوار دیتی ہے۔

شرح بیج اور طریقہ کاشت: Seed rate and sowing method

لوسرن کا بیج چونکہ دوسرے چارے کے بیجوں کی نسبت چھوٹا ہوتا ہے اس لیے ۴ تا ۵ کلوگرام بیج فی ایکڑ کافی ہے چونکہ لوسرن کا پودا دائمی نوعیت کا ہوتا ہے اس لیے اس کی بوائی ۴۵ سنٹی میٹر کے فاصلے پر لائنوں میں کرنی چاہیے۔ لائنوں میں کاشت شدہ فصل میں جڑی بوٹیوں کی تلفی اور گوڈی باسانی کی جاسکتی ہے۔ بوائی بذریعہ ڈرل وتر زمین میں کرنی چاہیے۔ بیج کو ۵ ۲/۱ سنٹی میٹر تا ۴ سنٹی میٹر سے زیادہ گہرا نہیں بونا چاہیے۔

عام طور پر زمیندار لوسرن کو برسیم کی طرح کھڑے پانی میں بذریعہ چھٹا کاشت کرتے ہیں۔ چونکہ فصل کئی سال تک کھیت میں رہتی ہے۔ اس لیے چھٹا سے بوئی ہوئی فصل میں جڑی بوٹیاں آسانی سے تلف نہیں کی جاسکتیں اور پیداوار میں کافی کمی واقع ہو جاتی ہے۔

آب پاشی: Irrigations

لوسرن کی فصل کو پہلا پانی بوائی سے تقریباً تین ہفتہ بعد دیا جاتا ہے۔ اور بعد میں سردیوں کے موسم میں ۱۵ تا ۲۰ دن کے وقفہ سے اور موسم گرما میں ہر ۱۰ تا ۱۵ دن بعد پانی دیتے رہنا چاہیے۔

فصل کی نگہداشت اور نلائی Crop care and hoeing

موسم برسات میں لوسرن کی فصل میں جڑی بوٹیوں اور کھبل گھاس کی بہتات ہو جاتی ہے۔ جو زمین کی خوراک کو استعمال کر کے لوسرن کی فصل کو کمزور کر دیتی ہیں اس لیے قلبہ رانی کے ذریعے ان جڑی بوٹیوں کی تلفی ضروری ہے۔ اگر فصل میں قلبہ رانی نہ کی جائے تو لوسرن کی فصل چھ سات سال کی بجائے تین چار سال بعد ختم ہو جاتی ہے۔ اس لیے قطاروں کے درمیان کئی بار ہل چلا کر جڑی بوٹیوں کو تلف کر کے چارہ کی زیادہ سے زیادہ پیداوار حاصل کرنی چاہیے۔

کٹائی فصل Crop cuttings

موسم سرما میں لوسرن کے پودے کی بڑھوتری معمولی نوعیت کی ہوتی ہے۔ اس لیے پہلی کٹائی کاشت کے تین ماہ بعد بطور چارہ کرنی چاہیے، بعد کی کٹائیاں ۵ تا ۶ ہفتہ کے وقفہ سے لی جاتی ہیں۔ اور ان کا انحصار خاص طور پر زمین کی زرخیزی اور فصل کو پانی کی فراہمی کے درمیان وقفوں پر ہوتا ہے۔

فصل کو بطور چارہ اس وقت کاٹنا چاہیے جب اس میں ۱۰ تا ۱۵ فی صد حصے میں پھول نکل آئیں۔ پنجاب میں چارہ کے لیے بوئی ہوئی فصل سے سال بھر میں ۶ تا ۸ کٹائیاں لی جاتی ہیں اور ہر کٹائی سے ۵۵۰۰ تا ۷۴۰۰ کلوگرام فی ایکڑ چارہ

حاصل ہوتا ہے۔ Lucern varieties

اقسام لوسرن:

لوسرن کی اچھی قسم کی یہ خصوصیت ہونی چاہیئے کہ زیادہ دیر تک زندہ رہے اور سبز چارہ کی پیداوار بھی زیادہ دے۔

لوسرن کی اقسام نمبر ۸، نمبر ۹ بلحاظ پیداوار پنجاب میں بہت مشہور ہیں۔ قسم نمبر ۸ میں شاخوں کی تعداد زیادہ ہوتی ہے اور پودوں کی بڑھوتری کی رفتار بھی زیادہ ہوتی ہے۔ اس کے پتے نسبتاً چوڑے ہوتے ہیں اور بیج بھی زیادہ بنتا ہے۔ قسم نمبر ۹ کے پودے اگنے کے بعد کم مرتے ہیں اور اس کی عمر قسم نمبر ۸ سے زیادہ ہوتی ہے۔ اس کے پتے کم چوڑے۔ پودا گہرے سبز رنگ کا اور تنا نسبتاً باریک ہوتا ہے۔ ان کے علاوہ لوسرن کی بہت سی اقسام بیرونی ممالک سے منگوا کر ان پر تجربات کیے گئے لیکن کوئی قسم بھی نمبر ۸، نمبر ۹ سے سبز چارہ کی فی ایکڑ پیداوار زیادہ نہیں دے سکی۔ تاہم بیرونی اقسام میں سے میرا، سرسا اور سنورا اچھی ثابت ہوئی ہیں۔

پنجاب کے تمام اضلاع میں زمینداروں کے کھیتوں سے لوسرن کے دو ہزار سے زائد پودے اکٹھے کیے گئے ہیں اور زیر مشاہدہ ہیں۔ ان میں سے پنجاب سلیکشن اور نمبر ۱۸ اچھی معلوم ہوتی ہیں اور ابھی تجربات کے مراحل سے گزر رہی ہیں۔

Harmful insects

نقصان رساں کیڑے:

لوسرن کی فصل کو سب سے زیادہ نقصان دہ کیڑوں میں تیلہ اور لشکری سنڈی قابل ذکر ہیں۔ جس فصل پر تیلے کا حملہ ہو وہ نہ تو جانوروں کو کھلائی جا سکتی ہے اور نہ ہی ان میں اچھی طرح بیج بن سکتا ہے۔ اس لیے اس کا بروقت تدارک ضروری ہے۔ لشکری سنڈی فوج کی شکل میں فصل پر حملہ آور ہوتی ہے۔ اور سبز پتے اور نرم شاخیں بھی چٹ کر جاتی ہے۔ یہ کیڑا عموماً فروری، مارچ میں حملہ آور ہوتا ہے اور فصل میں بیج پیدا کرنے کی صلاحیت ہی ختم ہو جاتی ہے۔ BHC اور اینڈرین کی سپرے کرنے سے اس کی روک تھام کی جا سکتی ہے۔

Diseases

بیماریاں:

لوسرن کی فصل پر کنگی، بلائٹ اور جڑوں کی سڑن کے علاوہ اکاس بیل کا حملہ بہت مہلک ہوتا ہے جس سے لوسرن کا سارا کھیت اس مرض کی زد میں آ جاتا ہے۔ اور چارہ جانوروں کے کھانے کے قابل نہیں رہتا۔ اس سے بچاؤ کا طریقہ یہ ہے کہ جب بھی یہ بیل نظر آئے اسے بمعہ حملہ شدہ پودے کاٹ کر جلا دیا جائے۔ تاکہ اس کا بیج نہ بن سکے۔ حملہ شدہ فصل پر مٹی کا تیل چھڑکنے سے بھی اسے روکا جا سکتا ہے۔ سب سے بہتر علاج یہ ہے کہ لوسرن کا صاف ستھرا بیج کاشت کیا جائے۔

Producing Seed

بیج پیدا کرنا:

لوسرن میں تسلی بخش طور پر بیج بنانے کے لیے ہمارے صوبے کے موسمی حالات موزوں نہ ہونے کی وجہ سے بیج کی فی ایکڑ پیداوار بہت کم یعنی ۴ تا ۱۰ کلوگرام فی ایکڑ ہوتی ہے۔ موافق موسموں میں ۱۵۰ تا ۳۰۰ کلوگرام بیج فی ایکڑ بھی حاصل ہو جاتا ہے۔

پنجاب میں جب مارچ اور اپریل کے مہینوں میں موسم خوشگوار ہوتا ہے اور زیادہ گرمی نہیں پڑتی تو لوسرن میں بیج اچھا بنتا ہے۔ لیکن جب ان دو مہینوں میں موسم زیادہ گرم ہوتا ہے تو بیج کم بنتا ہے۔ لوسرن کے بیج کی پیداوار پر مختلف عوامل اثر انداز ہوتے ہیں جن پر چارہ کے تحقیقاتی مرکز سرگودھا اور لائل پور میں تجربات کئے گئے ہیں جن کے نتائج درج ذیل ہیں۔

۱۔ نیم خشک علاقوں میں ماسوائے بیج کے لیے لوسرن کی فصل شاذ و نادر ہی بوئی جاتی ہے۔ مرطوب علاقوں میں ماسوائے خشک موسمی حالات کے کم بیج پیدا ہوتا ہے۔

۲۔ تجربات سے یہ ثابت ہوا ہے کہ لوسرن کے بیج کی پیداوار میں قطاروں کا درمیانی فاصلہ ایک اہم عنصر ہے۔ ایک میٹر پر بوئی ہوئی قطاروں میں فصل کو پھول نکلنے کے بعد تین بار پانی دینے سے بیج کی پیداوار میں اضافہ ہو جاتا ہے۔ لوسرن کے پودے دور دور بونے سے چونکہ پودوں کو سورج کی روشنی زیادہ حاصل ہوتی ہے اس لیے قریب قریب بوئے ہوئے پودوں کے مقابلہ میں اول الذکر میں پھلیاں زیادہ بنتی ہیں۔ اور زیادہ مقدار میں بیج بنتا ہے۔

۳۔ قدرتی حالات میں لوسرن [illegible] میں ۸۰ تا ۹۰ فیصد اختلاط نسل واقع ہوتا ہے۔ اور مختلف پودوں کے اختلاط نسل سے بیج کی پیداوار میں ۳۰ فی صد اضافہ ہو جاتا ہے۔ اس لیے لوسرن کی فصل میں تسلی بخش بیج

بنانے کے لیے فی ایکڑ شہد کی مکھیوں کے تقریباً چار چھتے مہیا کرنے کا انتظام کرنا چاہیئے۔ یہ مکھیاں جب پھولوں پر بیٹھتی ہیں تو پھولوں کا کھلنے کا عمل نہایت عمدگی سے انجام پاتا ہے۔ مکھیوں کے جسم کے نچلے حصے میں زرد دانے لگ جاتے ہیں اور جب وہ دوسرے پھولوں پر جاکر بیٹھتی ہیں تو وہ زرد دانے دوسرے پھول کی کلغی پر چھوڑ جاتی ہیں اور اختلاط نسل عمل میں آجاتا ہے۔

۴۔ اکثر برسیم بوئی ہوئی فصل سے پہلے سال چارہ کی کوئی کٹائی نہیں لی جاتی بلکہ اسے بڑھنے اور بیج بننے کے لیے چھوڑ دیا جاتا ہے۔ مئی کے مہینے میں جب بیج کی فصل پختہ ہو جاتی ہے تو کاٹ لی جاتی ہے۔ موسمی حالات موافق ہوں تو ماہ مئی میں بیج کے لیے ایک مرتبہ کاٹ لینے کے بعد دوبارہ پھوٹی ہوئی شاخوں میں پھر بیج تیار ہو جاتا ہے۔ لوسرن کی جس فصل سے بیج لینا درکار ہو اس کو جنوری کے تیسرے ہفتہ کے بعد چارہ کے لیے نہیں کاٹنا چاہیئے۔ نئی بوئی ہوئی فصل پرانی فصل کے مقابلے میں بیج کی زیادہ پیداوار دیتی ہے۔ کیونکہ پرانی فصل میں شاخیں اور پتے کثرت پیدا ہو جاتے ہیں جس سے یہ فصل کافی گھنی ہو جاتی ہے۔ اور اس طرح اس کی بیج کی پیداوار میں کمی واقع ہو جاتی ہے۔

جئی

Barley

جئی موسم سرما کا ایک مفید چارہ ہے جسے سبز حالت میں مویشیوں کو بطور چارہ کھلایا جاتا ہے۔ یہ دودھ دینے والے جانوروں کے لیے بھی اچھا چارہ ہے اور جانور اسے خوش ہو کر کھاتے ہیں۔ جئی کے چارے میں لحمی مادے، حیاتین اور قابل ہضم شکریات کی کافی مقدار پائی جاتی ہے۔ جئی خشک حالت میں بیج دانے بڑے شہروں کے نزدیک بھی فروخت ہوتی ہے۔ گھوڑوں، خچروں کی من بھاتی خوراک ہے۔ اس لیے جئی کی کاشت پنجاب میں بڑے شہروں کے گردونواح خاص طور سے لاہور، گوجرانوالہ اور سیالکوٹ میں ہوتی ہے۔ جئی کا شمار دانے والی اجناس میں بھی ہوتا ہے۔ اس کا دانہ گھوڑوں کے لیے موزوں خیال کیا جاتا ہے۔ جئی کا بھوسہ بھی دوسرے بھوسوں سے اچھا ہوتا ہے۔

جئی کو عموماً برسیم کے ساتھ ملا کر کاشت کرنے سے برسیم کی پہلی کٹائی کی پیداوار زیادہ حاصل کی جا سکتی ہے۔

مندرجہ ذیل باتوں پر عمل کرنے سے جئی سے چارہ کی فی ایکڑ زیادہ سے زیادہ پیداوار حاصل کی جا سکتی ہے۔

زمین:

Soil

جئی کے لیے میرا زمین بہت مفید خیال کی جاتی ہے جو اپنے اندر نمی برقرار رکھ سکتی ہو اور پانی کی نکاسی کا انتظام اچھا ہو۔ نشیبی زمین جس میں پانی کھڑا ہو جائے اس کی کاشت کے لئے اچھی نہیں رہتی۔ اسے نسبتاً ایسی زمینوں میں اچھی طرح کھاد دے کر کاشت کیا جا سکتا ہے۔ بشرطیکہ یہ اپنے اندر نمی محفوظ رکھ سکیں۔

آب و ہوا:

Climate

گرم مرطوب آب و ہوا اس کے لیے بہت اچھی ہے۔ یہ خشکی کو برداشت نہیں کر سکتی۔ یہ گرم آب و ہوا کو پسند نہیں کرتی۔ یہی وجہ ہے کہ اس کی بوائی کرتے وقت اگیتی۔ درمیانی اور پچھیتی اقسام کا بہت خیال کرنا پڑتا ہے۔

تیاری زمین:

Soil Preparation

اس کے لیے زمین گندم کی طرح تیار کی جاتی ہے۔ پہلے کھیت میں مٹی پلٹنے والا ہل چلایا جاتا ہے۔ پھر تین چار دفعہ ہل چلا کر اور سہاگہ دے کر زمین کو باریک تیار کر لینا چاہیئے۔ اس بات کا بھی خیال رکھنا چاہیئے کہ کھیت میں بڑی بڑی ڈھیلیاں نہ ہوں۔ جتنی اچھی زمین تیار ہو گی اتنی ہی فصل اچھی ہو گی۔ یہ بھی خیال رکھنا چاہیئے کہ زمین اچھی طرح ہموار ہو۔

کھاد:

Fertilizer

پندرہ (۱۵)، بیس (۲۰) گڈے گلی سڑی گوبر کی کھاد ایک ماہ پہلے کھیت میں ڈالنی چاہیئے۔ اس کو مساوی مقدار میں تمام کھیت میں پھیلانا چاہیئے اور ہل چلا کر زمین میں ملا دینا چاہیئے۔ اگر گوبر کی کھاد میسر نہ ہو تو نائٹروجن اور فاسفورس والی کھاد بوائی کے وقت دینی چاہیئے۔ فاڈر ریسرچ سٹیشن سرگودھا اور لائل پور کے کھاد کے تجربات سے یہ نتیجہ اخذ کیا گیا ہے کہ جئی کی فصل کو ۹۰ پونڈ نائٹروجن اور

۲۵ پونڈ فاسفورس فی ایکڑ دینے سے چارہ کی زیادہ سے زیادہ مقدار حاصل کی جا سکتی ہے۔ نائٹروجن کی آدھی مقدار اور فاسفورس کی ساری مقدار بوائی سے پہلے دینی چاہیئے۔ اور باقی نائٹروجن پہلی یا دوسری آبپاشی کے ساتھ فصل کو ڈال دینی چاہیئے۔ بھاری اور زرخیز زمینوں پر فصل کو کھاد کی ضرورت نہیں ہوتی۔ اور اگر کھاد دی جائے تو فصل کے گر جانے کا احتمال ہوتا ہے۔ جس سے چارہ کی کوالٹی خراب ہو جاتی ہے۔ اور چارہ کی پیداوار بھی کم ہو جاتی ہے۔

وقتِ کاشت : Time of sowing.

جئی کو اکتوبر کے شروع سے لے کر وسط دسمبر تک کاشت کیا جاتا ہے۔ شہروں کے نزدیک اس کو ستمبر کے آخر میں کاشت کر کے کامیاب فصل لی جاتی ہے۔

طریقہ کاشت : Method of sowing

جئی کو اچھی طرح زمین تیار کر کے گندم کی طرح بذریعہ پورہ یا کیرا کاشت کرنا چاہیئے۔ اس طرح فصل کاشت کرنے سے چارہ کی زیادہ پیداوار حاصل ہوتی ہے۔ یہاں اس کو برسیم یا لوسرن کے ساتھ کاشت کرنا ہوتا ہے۔ اس کو سوکھے کھیت میں چھٹا دے کر ہل چلا کر ملا دیا جاتا ہے اور چھوٹے کیارے بنا کر پانی لگا کر کھڑے پانی میں برسیم یا لوسرن کا چھٹا دیا جاتا ہے۔ شہروں کے گرد و نواح میں زمیندار عموماً جئی کو بذریعہ چھٹا کاشت کرتے ہیں جو ایک اچھا طریقہ نہیں ہے۔ جئی کو بذریعہ کیرا وتر زمین میں صرف اتنی گہرائی پر بویا جائے کہ بیج کے ارد گرد مٹی نم ہو۔ عام طور پر ۲.۵ سینٹی میٹر تا ۵ سنٹی میٹر گہرائی بیج کے لیے کافی ہوتی ہے۔

شرح بیج : Seed rate

غلے کی فصل کے لیے ۲۲ تا ۳۰ کلوگرام بیج فی ایکڑ کافی ہے لیکن چارہ کی فصل کے لیے ۳۰ تا ۳۸ کلوگرام بیج فی ایکڑ استعمال کرنا چاہیئے۔

آبپاشی : Irrigations.

جئی کی فصل کو پہلی آبپاشی بوائی کے تین چار ہفتے بعد دینی چاہیئے سردیوں میں فصل کو کچھ زیادہ پانی درکار نہیں ہوتے۔ اگیتی اقسام تین پانی سے تیار ہو جاتی ہیں۔ پانی دینے سے یہ خوب پھلتی پھولتی ہے۔ پچھیتی اقسام کو اپریل مئی میں زیادہ پانی کی ضرورت ہوتی ہے۔ جو فصل دانے کے لیے رکھی جاتی ہے اس کو سٹے نکلنے پر ایک پانی دینا بہت ضروری ہے۔

جڑی بوٹیوں کی تلفی : Weed eradication

جڑی بوٹیاں فصل کی خوراک، نمی اور روشنی چوری کر کے پیداوار گھٹا دیتی ہیں۔ اس لیے فصل کی نلائی کر کے جڑی بوٹیوں کا تلف کرنا بڑا ضروری ہے۔ گوڈی کرنے سے وتر بھی محفوظ ہو جاتا ہے۔ اور جڑی بوٹیاں بھی ختم ہو جاتی ہیں۔ کیرے سے بوئی ہوئی فصل میں آسانی سے گوڈی یا نلائی ہو جاتی ہے۔

جئی کی اقسام : Barley varieties

جئی کی اقسام کو پختگی کو پہنچنے کی مدت کے لحاظ سے تین درجوں میں تقسیم کیا جاتا ہے۔

۱۔ اگیتی ۲۔ درمیانی ۳۔ پچھیتی

ان تمام اقسام کی جئی ہمارے حالات میں کامیاب ثابت ہوئی ہے۔

۱۔ اگیتی اقسام : Early varieties

یہ اقسام گندم کے ساتھ پک کر تیار ہو جاتی ہیں۔ اگیتی اقسام میں فلسطینی اور کولمبیا سپرنگ خاص طور پر قابل ذکر ہیں جو چارہ کی زیادہ پیداوار دیتی ہیں۔ اکتوبر میں بوئی ہوئی فصل مارچ میں چارہ کے لیے تیار ہو جاتی ہے۔

۲۔ درمیانی اقسام : Mid-season varieties

جئی ڈیلیٹن نمبر ۱۱ درمیانی پکنے والی قسم ہے جس پر کانگیاری کا حملہ بہت ہوتا ہے۔ درمیانی اقسام جئی ایون (AVON) اور نل گرین نئی دریافت کی گئی ہیں جو چارہ اور دانے دونوں کی پیداوار زیادہ دیتی ہیں۔ اور کانگیاں کا حملہ بھی ان پر نہیں ہوتا۔ درمیانی اقسام کی نومبر میں بوئی ہوئی فصل اپریل میں چارے کے لیے تیار ہو جاتی ہے۔

۳۔ پچھیتی اقسام : Late varieties

جئی کی پچھیتی اقسام موسم کے لحاظ سے مئی سے وسط جون تک سبز حالت میں رہتی ہیں۔ پچھیتی

اقسام کی نشو ونما تسلی بخش ہوتی ہے اور چارہ کی وافر مقدار میں پیداوار دیتی ہیں۔ لیکن جب ان میں بیج بننے کا وقت آتا ہے اس وقت موسم زیادہ گرم ہو جاتا ہے۔ جس کی وجہ سے ان کی دانے کی پیداوار بہت کم ہوتی ہے۔ پچھیتی اقسام جئی اُس وقت مئی اور جون کے اوائل میں چارہ مہیا کرتی ہیں جبکہ موسم ربیع کی دیگر فصلاتِ چارہ ختم ہو چکی ہوتی ہیں۔ پچھیتی اقسام میں الجیرین اور ایک نئی قسم سرگودھا سلیکشن قابلِ ذکر ہیں۔ اس کے علاوہ جئی کی نئی اقسام جو زیرِ مشاہدہ زیادہ پیداوار دے رہی ہیں وہ یہ ہیں۔

۱۔ جوا لاہوری ۲۔ ویوان (VEVON)

۳۔ پی ڈی ۲ ایل وی 65 ۴۔ گولڈن رین ۵۔ فورک ڈیر۔

Harmful insects and Diseases

نقصان رساں کیڑے اور بیماریاں :

کبھی کبھار تنے کی مکھی اور تیلہ مکھی کا حملہ فصل پر ہو جاتا ہے۔ اس کے بچاؤ کے لیے اینڈرین یا کسی اور دوائی کا محکمہ زراعت کے توسیعی عملہ سے مشورہ کرکے سپرے کرانا چاہیے۔

...er Smut of barley

جئی کی کھلی کانگیاری :

اس سے فصل کو بچانے کے لیے جئی کو کاشت کرتے وقت گرینوسن ایم وائی محکمہ زراعت کے توسیعی عملہ سے نگرانی چاہیئے۔ جس کھیت میں کھلی کانگیاری کا حملہ ہو اس سے بیج نہیں رکھنا چاہیئے۔ کھلی کانگیاری کا حملہ جئی کی قسم ویسٹرن نمبر ۱۱ پر بہت ہوتا ہے۔

Cutting Time and yield

وقت برداشت اور پیداوار :

جئی کی فصل کو بطور چارہ سبز حالت میں مویشیوں کو کھلانے کے لیے اس وقت کاٹنا چاہیئے جب پودوں میں پھول نکل آئیں۔ اگر اس کے بعد دیر سے کاٹا جائے تو ریشہ اور خشک مادہ کھانے کے زیادہ قابل نہیں رہتا۔

خشک چارے کی تیاری کے لیے فصل کو سِٹہ نکالنے کی حالت میں کاٹنا چاہیئے۔ خمیرہ چارہ تیار کرنے کے لیے جئی کے دانوں میں دُودھ بننے کی حالت تک کاٹا جا سکتا ہے۔

— عام حالات میں جئی کی فصل سے ۱۸۵۰۰ کلوگرام سے ۲۲۲۰۰ کلوگرام فی ایکڑ سبز چارہ حاصل کیا جا سکتا ہے اور غلے کی فصل سے ۷۴۰ کلوگرام تا ۱۴۸۰ کلوگرام دانہ فی ایکڑ حاصل ہو جاتا ہے۔

ڈاکٹر محمد حسین چوہدری، محمد سلیم، محمد رفیق، اصغر حیدر اوپل

شعبۂ تحقیقات چارہ جات سرگودھا

شائع کردہ شعبۂ مطبوعات محکمہ زراعت حکومت پنجاب لاہور تاریخ اشاعت ستمبر ۱۹۷۷ء

اتحاد پرنٹرز ۲۳۶ بی راوی پارک ...

Subject: MAIZE PRODUCTION GUIDELINES

Trainer Agronomist
Class Room 1 hour
Field 0 Days

OBJECTIVES

To enable the trainees to carry out the cultivation of maize independently making use of important production factors involved.

MATERIALS NEEDED

1 - Charts of implements to be used.

2 - Seeds of various varieties for identification.

TRAINING AIDS

1 - Slides on the cultivation of maize crop with slide projector. Material for developing new slides.

2 - Urdu publication "Modern Techniques of Corn Cultivation", one per trainee.

INTRODUCTION

Indian corn, or maize, is a native of the American Continents where it was cultivated by the Indians long before the arrival of Columbus. In Pakistan, it is one of the edible grain crops which produces high grain yields. In addition to being consumed as chapati or roasted grains, it is used for manufacturing oil, starch, alcohol, and breakfast food, primarily corn flakes. Agricultural scientists have developed hybrid varieties which have a very high yield potential. The optimum response from this potential can only be realized if the attention is given to the following recommendations.

PRESENTATION

Trainees shall be made familiar with the following production factors. More details are given in the Urdu publication "Modern Techniques of Corn Cultivation". The following important points are given.

1. Selection of Land

Heavy loamy soils with good natural drainage are best suited for the corn cultivation. Cultivation should not be done on sandy waterlogged and saline soils.

2. Preparation of Land

From 4-6 ploughing with 2-4 planking should be done to prepare a good seedbed. If possible, the first ploughing should be done with a mould-board plough so that the weeds are uprooted and buried in the soil. If possible, 10-15 cartloads of FYM/acre should be added one month before sowing. Finally, the field should be precisely leveled.

3. Time of Sowing

From last week of July to 10th of August is the ideal time for planting for grain production. About 12 seers/A should be seeded.

4. Varieties

1. Kelam: This variety can successfully grow in different ecological regions. It is a synthetic variety and yields good returns in rich soils. It matures in 90-100 days. This variety has been exported to Middle East. If crop protection techniques are applied this variety proves the highest yielder.

2. Agaiti 72: This variety has been approved since 1924. The time of maturity is 70-80 days, therefore, it can be sown some late uptil 25 August. It can be sown in areas where water availability is restricted. It is also recommended for the Barani area. The period of formation of seed from

the flowers in this variety is short, therefore, can be successfully grown in the spring season. This variety is recommended for the following areas.

I. Sialkot-Guiranwala: This crop should be grown in between two crops of potato and yields higher than local variety.

II. In Barani Tracts.

III. In Hazro where cropping intensity is high.

IV. In Canal Colonies: This crop should be sown late, i.e. from August 8-25. If sown early, the crop matures early and bird feeding problems arise.

V. This variety is highly suitable for spring cultivation. The grain formation occurs before intense hot season. A cotton crop can be sown after spring maize.

3. Akbar: This variety has been recently introduced. It matures from 90-100 days. This is a synthetic maize and more varieties have been used in the evolution of this maize. The merit of this variety is that it can maintain its yield potential for much longer period as compared tih Neelum. This variety resembles desi variety in color. This variety is gaining wide popularity among farmer masses for grain and animal stalk.

5. Method of Cultivation

Corn should be planted in rows with the help fo single row cotton drill. Line to line distances should be maintained 2¼ feet. When the germination is completed, the crop should be thinned out to 9" plant to plant distance.

6. Fertilizer

One hundred fifty pounds nitrogen and 75 lbs P_2O_5 are taken as sufficient for application to corn crop. The timing of application is given below.

Time of Application	Amount	Carrier
At sowing time:	75 lbs P_2O_5	½ bag DAP or 1½ bag TSP
	50 lbs N	1 bag urea or 2 bags A/Sulphate
1½-2 feet height	*50 lbs N	1 bag urea or 2 bags A/Sulphate
At flowering	50 lbs N	1 bag urea or 2 bags M/Sulphate

* Don't add this if the soil has a high native fertility.

7. Irrigation

A lot of research work has been done on irrigation requirements of maize crop. However, the irrigation requirements differ in Kharif and spring season. In Kharif season, the crop is sown in the monsoon season (July) and the water x requirement of maize is less as compared to the spring season. In spring season the crop is shown in February when the temperature is not high and is harvested in May/June when air temperature is high. The rate of evapotranspiration is also high. In this period, the water requirement of the maize crop is high. The consumption use of spring and Kharif corn is shown in Figures 1 and 2.

Corn is highly sensitive to irrigation shortages. Excessive water stress for maize fields are dried up for two days has been shown to decrease yields by 25% and 8-10 days. The reduction in yield may be 50%.

During the kharif crop it should be irrigated after 10-15 days of germination. If germination is poor only light irrigation should be done and resowing ar ungerminated hills should be done with 'Khurpa' in valter condition. The other irrigation should be applied depending upon rainfall. It is seen that if the plants look wilted in the afternoon, the field should be irrigated. Usually irrigation should be applied every 12-15 days. When the grains attain 40 percent moisture, no further irrigation should be done.

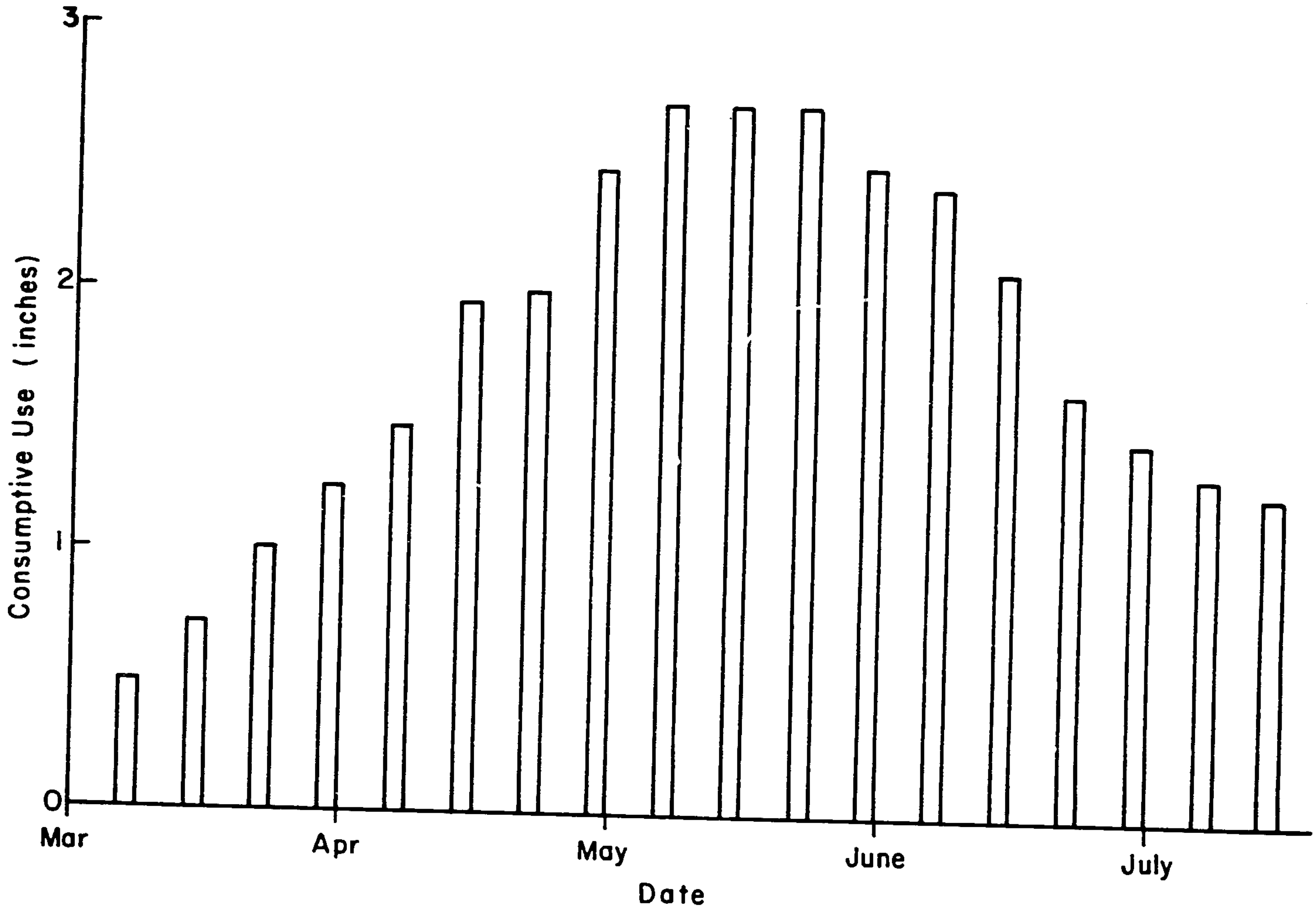


Figure 1. The Weekly Consumptive Use of Rabi Season Corn (120-day variety).

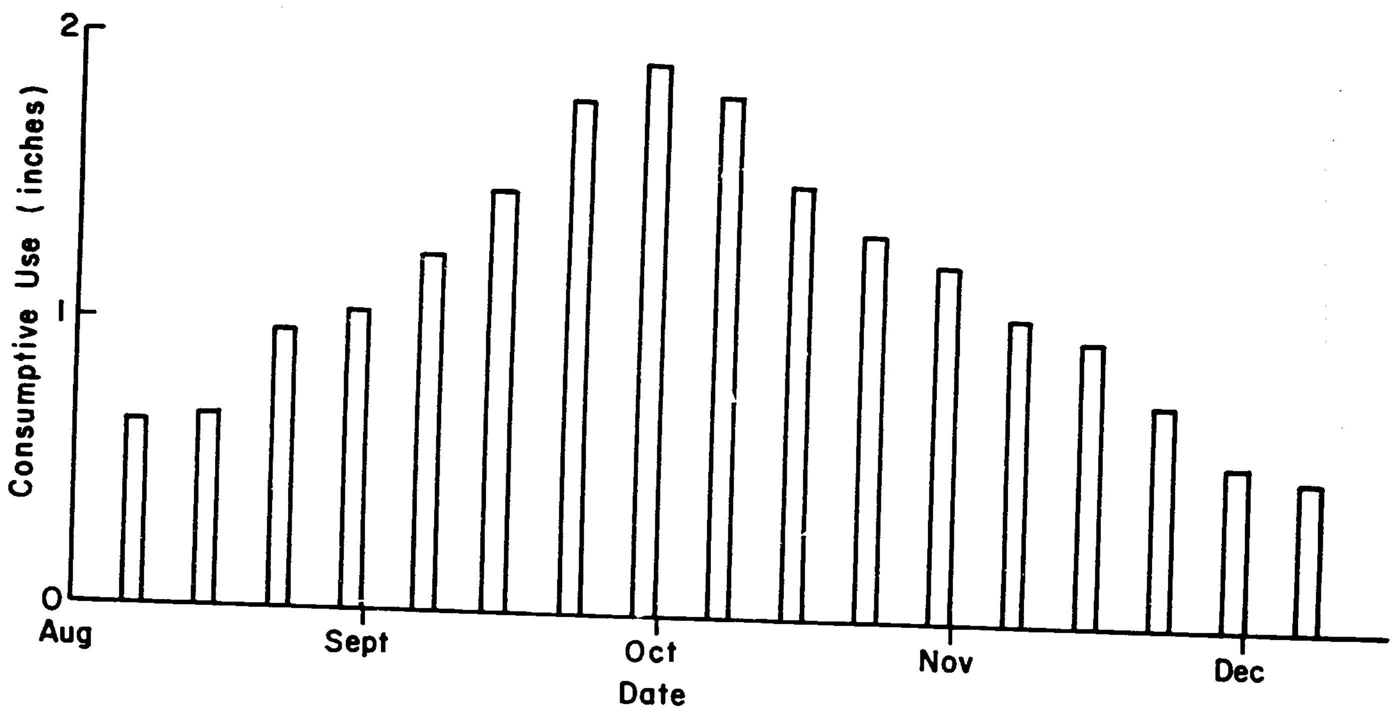


Figure 1. continued

The spring crop needs frequent irrigations as compared to Kharif. The water should be applied every 12-15 days in the beginning but later on when the air temperature rises the crop should be irrigated after every 10 days or so. Special care should be taken at the grain filling stage. An inadequate supply of irrigation water at this stage will lead to the disruption of the translocation of plant nutrients and the grain formation process will be hampered. The grain therefore will be shrivelled and light in weight. The irrigation application should be stopped at "CHABBU" stage

8. Hoeing

Hoeing should be done after every irrigation. The first 2 hoeings, when the crop is small can be even carried out with the help of "Tarphali". The last hoeing should be done a little prior to the flowering. Earthing up should also be done at this stage, so that the plant doesn't lodge.

9. Harvesting

Cobs should be picked when they become dry. They should be spread on an elevated platform for drying. Choose the healthy and big cobs for seed for the next crop.

10. Protection from Insects

a. To eradicate the corn borer, the crop should be sprayed immediately after germination with 8-10 oz "Endrine" in 45 gallons of water. This solution would be sufficient for spraying one acre.

b. After this, granules of "Seven" G-20 should be used two times at 15 days interval for killing the insect. Dizinon and Endrine can also be used if G-20 is not available.

See the publication "Modern Techniques of Corn Cultivation" for more details.

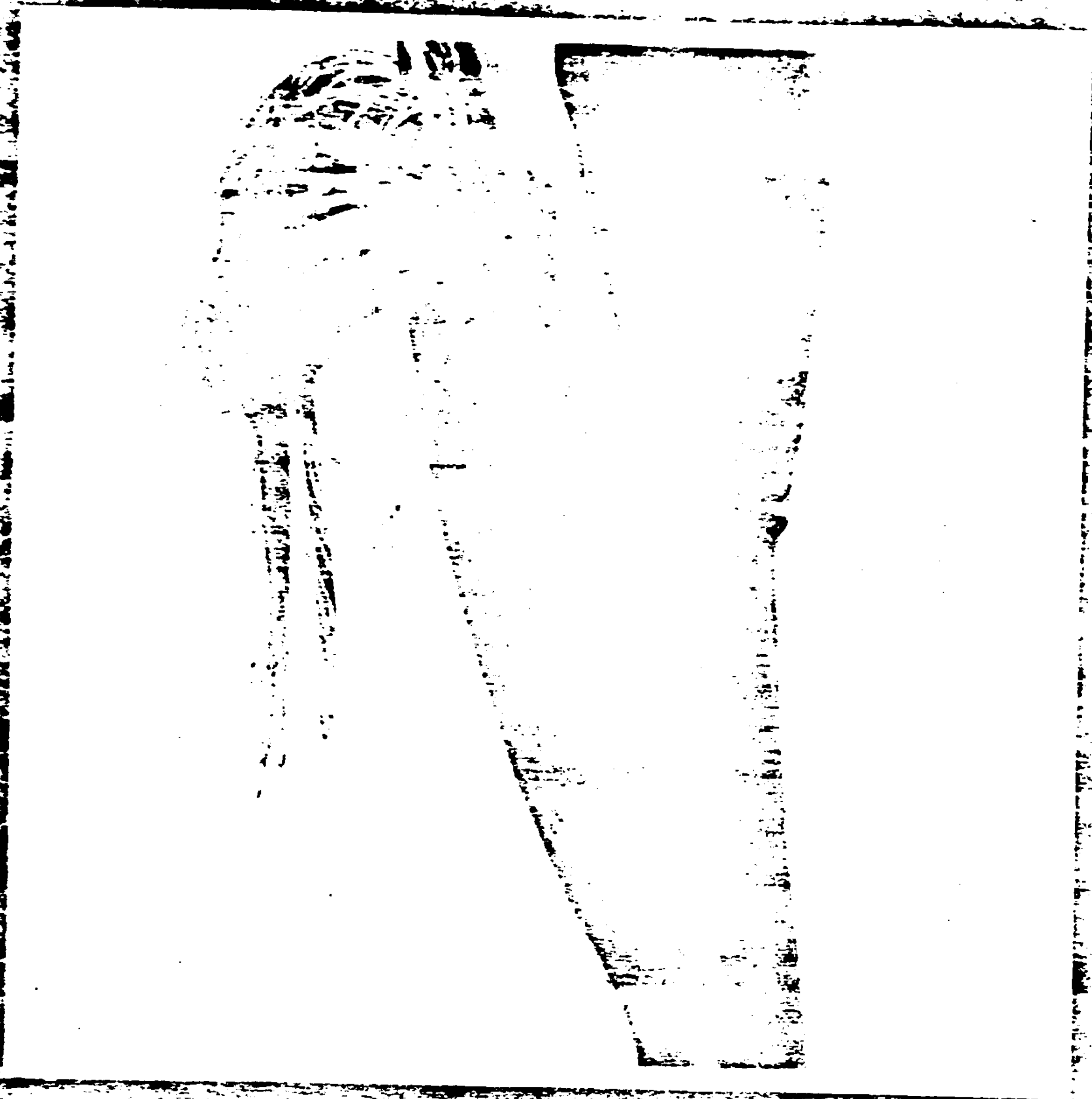
APPLICATION

1. Each trainee will examine and identify the seed of different varieties.

2. Each trainee will learn the agronomical steps involved in maize production.

QUESTIONS

1. What should be the rate of seed and irrigation for maize cultivation?
2. What is the amount of fertilizers and at what stages should they be applied?
3. What are the recommended central measures for stem borer?



Salient Steps for Corn cultivation.

مکئی کی کاشت کے چیدہ چیدہ نکات

ترقی دادہ اقسام (Improved varieties)
(۱) نیلم (۲) اکبر (۳) اگیتی ۷۲ (۴) صدف (۵) ...

وقتِ کاشت (Time of Sowing)
موسم خریف (پہاڑی علاقے) اپریل - مئی - (نہری علاقے)
وسط جولائی تا اگست کا آخری ہفتہ
موسم بہار ملتان و بہاولپور ڈویژن ۱۰ فروری تا ۲۵ فروری
سرگودھا ڈویژن ۱۵ فروری تا ۷ مارچ
راولپنڈی ڈویژن (ماسوائے پہاڑی علاقے) ۲۵ فروری تا ۲۰ مارچ

زمین کی تیاری (Soil preparation)
دو تین بار ہل اور سہاگہ چلا کر جب زمین بھربھری ہو جائے تو مکئی کاشت کریں

کاشت کا طریقہ (Method of Sowing.)
فصل کو کپاس بونے والی ڈرل کے ساتھ کاشت کیا جائے۔ قطاروں کا فاصلہ سوا دو فٹ تا اڑھائی فٹ اور پودوں کا درمیانی فاصلہ ۹ انچ رکھیں

مصنوعی کھاد (Artificial fertilizer)
بوائی کے وقت ۵۰ پونڈ فاسفورس اور ۵۰ پونڈ نائٹروجن زمین میں بکھیر کر زمین کی تیاری کریں۔ کیمیاوی کھادیں علی الصبح یا سہ پہر کو ڈالیں اور اس کے ساتھ ہی بوائی جلد ختم کر لیں۔

شرح تخم (Seed rate)
موسم خریف (جولائی اگست) کی کاشت کیلئے ۱۵ سیر مکئی یا ۱۲ سیر دانے
موسم بہار (فروری، مارچ) کی کاشت کیلئے ۲۰ سیر مکئی یا ۱۵ سیر دانے

پودوں کی تعداد (plant population)
پچیس ہزار سے پینتیس ہزار ہونا لازمی ہے۔

چھدرائی (Thinning.)
چھدرائی کے وقت پودوں کی اونچائی ۹ انچ سے زیادہ نہ ہو۔ چھدرائی کے بعد پودوں کا درمیانی فاصلہ ۹ انچ تک رکھیں۔

مکئی کے ضرر رساں کیڑوں کا انسداد (Remedy of harmful insects)
مکئی کے ضرر رساں کیڑوں میں گڑووا (MAIZEBORER) تنے کی مکھی اور چست تیلہ فصل کو زیادہ نقصان پہنچاتے ہیں ان کے انسداد کے لیے باسوڈین، بیون۔ فیوراڈان یا ڈائی سسٹان میں سے کوئی ایک پانچ چھ کلوگرام ۱۰ فی صد دانہ دار زہر فی ایکڑ مقامی زرعی عملہ کے زیر نگرانی استعمال کریں۔

نلائی اور جڑی بوٹیوں کی تلفی (Weed control)
مکئی کے کھیت میں سے دو دفعہ جڑی بوٹیوں کو تلف کرنا ضروری ہوتا ہے۔ پہلی بار آب پاشی کے بعد اور دوسری مرتبہ جب پودے تقریباً تین فٹ اونچے ہو جائیں۔ جب فصل دو فٹ اونچی ہو جائے تو ٹریکٹر سے کھیلیاں بنا دیں۔

آب پاشی (Irrigation)
مکئی کی کامیاب فصل حاصل کرنے کے لیے چھ سے آٹھ دفعہ پانی لگانے کی ضرورت ہوتی ہے۔ بہاریہ موسم میں جب فصل پر پھول آ رہے ہوں تو پانی کا خاص خیال رکھنا چاہیئے۔

برداشت (Harvesting)
مکئی کی فصل اس وقت برداشت کرنی چاہیئے جب چھلی کے ... قدرے خشک اور سفید ہو جائیں اور دانوں میں ناخن نہ چبھیں۔

اگلی فصل کے لیے بیج کا چناؤ (Seed Selection for next crop.)
اچھے اچھے پودے جو بیماریوں سے محفوظ اور تندرست ہوں، کٹائی کے وقت ان سے چھلیے توڑ کر علیحدہ دھوپ میں سکھا کر بوریوں میں بھر کر ہوادار کمرے میں آئندہ سال کے لیے بیج کے طور پر محفوظ رکھیں۔

Corn cultivation

مکئی کی پیداواری صلاحیت کو مدنظر رکھتے ہوئے پاکستان [illegible]

[illegible] وقت یہ پیداواری عمل [illegible]

[illegible] حاصل کرنے کے لیے جدید طریقوں [illegible]

[illegible] بہت ضروری ہے۔ تجربات سے ثابت ہو چکا ہے [illegible]

جدید طریقے [illegible] کاشت کے جدید طریقوں سے [illegible]

Neelum — [illegible]

[illegible] تقریباً ۱۲۰ دن لگتے ہیں [illegible] پیداواری صلاحیت [illegible]

[illegible] کا رنگ [illegible] ہے۔

۲۔ گوہر — [illegible]

[illegible] کے بعد [illegible]

[illegible]

[illegible] کاشت کی جا سکتی ہے۔

Sohrab — ۳۔ [illegible]

[illegible] دن لگتے ہیں۔ [illegible]

[illegible] کا رنگ [illegible] ہے۔

Sultan — ۴۔ سفید [illegible] علاقوں میں [illegible] کاشت [illegible] کیا جاتا ہے۔

[illegible] اوسط پیداوار ۵۰ تا [illegible] من فی [illegible] کامیابی کے ساتھ کاشت

[illegible] ہو سکتی ہے۔

۵۔ نمبر ۵۵ — [illegible] کاشت کے لیے [illegible] ۹۰ دن

میں [illegible] تیار ہو جاتی ہے۔ [illegible] کے بعد [illegible] استعمال ہو سکتا ہے۔

اچھے حالات [illegible] پیداوار دیتی ہے۔

Time of / Area — Spring Season — Time of sowing — Kharif Season

(موسم بہار) — (موسم خریف)

اوقات کاشت	علاقہ جات	اوقات کاشت	علاقہ جات
(ا) جولائی کا آخری پندرھواڑہ تا اگست کا پہلا ہفتہ۔ نیلم۔ اکبر اور صدف اقسام کاشت تاکہ ۹۵ تا ۱۰۰ دن میں فصل پک کر تیار ہو جائے	نہری علاقے	(ا) ۱۰ فروری تا ۲۵ فروری	رحیم یار خاں، بہاولپور، ملتان
(ب) اگست کے دوسرے ہفتے کے آغاز سے تیسرے ہفتے تک جلد پکنے والی اقسام اگیتی ۳، اور نمبر ۱۵۵ کاشت کریں	نہری علاقے	(ب) ۱۵ فروری تا ۱ مارچ	ساہیوال، فیصل آباد، جھنگ، سرگودھا
(ج) اپریل مئی۔ کوئی بھی زیادہ پیداوار دینے والی قسم کاشت کی جا سکتی ہے۔	پہاڑی علاقے جہاں سردیوں کا دور مختصر ہو	(ج) ۲۰ فروری تا ۱۵ مارچ	لاہور، سیالکوٹ، گوجرانوالہ
(د) مطابق مون سون	دامن کوہ اور بارانی علاقوں میں جہاں بارش زیادہ ہوتی ہو وہاں نیلم اکبر اور صدف کاشت کریں۔ کم بارش علاقوں میں اگیتی ۲، اور نمبر ۱۵۵ کاشت کے لیے موزوں ہیں۔	(د) ۲۵ فروری تا ۲۰ مارچ	راولپنڈی و مغربی (ماسوائے پہاڑی علاقہ)

اگر مقررہ وقت پر مکئی کی اقسام نیلم یا اکبر کاشت نہ کی جا سکیں تو مزید ۱۵ دن کے اندر اندر جلد پکنے والی اقسام اگیتی ۲، یا نمبر ۱۵ کاشت کی جا سکتی ہیں۔

نوٹ:۔ جن علاقوں میں آلو کی بہاریہ فصل کاشت کی جاتی ہے۔ وہاں پر آلوؤں کی فصل کی برداشت کے بعد مکئی کی جلد پکنے والی اقسام اگیتی ۲، اور نمبر ۱۵۵ کاشت کی جا سکتی ہیں۔

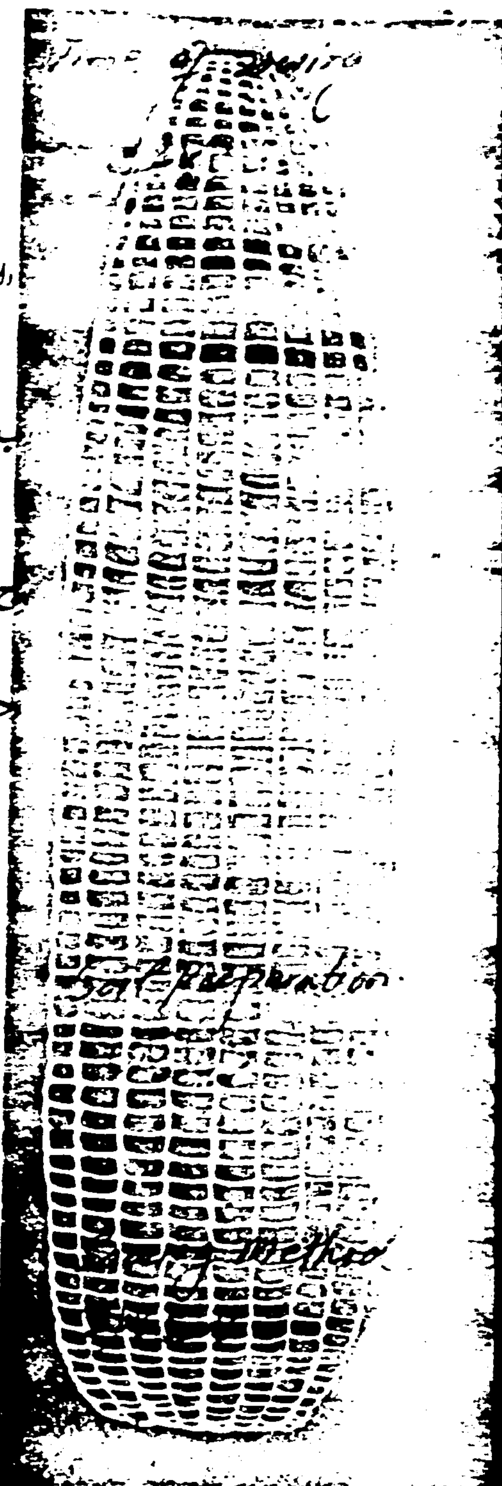
Soil Preparation

سابقہ فصل کی برداشت کے فوراً بعد دو دفعہ ہل چلائیں تاکہ جڑی بوٹیاں تلف ہو جائیں۔ سابقہ فصل کے مڈھوں کو دبا دینا بہت ضروری ہے۔ اس کے لیے مٹی پلٹنے والے ہل کا استعمال بہتر ثابت ہوگا۔ کھیت کو چار یا پانچ حصوں میں تقسیم کر کے علیحدہ علیحدہ آبپاشی کریں۔ جب زمین وتر کی حالت میں ہو تو ہل چلانے سے پہلے دوہرا سہاگہ جس کو کرمبر یا میرا کہتے ہیں۔ ضرور چلایا جائے۔ اس کے بعد حالات کے مطابق ہل اور سہاگہ چلا کر مکئی کاشت کریں۔ یہ خیال ضرور رکھیں کہ زمین بھربھری ہو۔

Sowing Method

فصل کو کاشت کرتے وقت مندرجہ ذیل باتوں کا خیال رکھیں۔

۱۔ زمین کو تیار کرتے وقت فاسفورسی کھاد کی تمام مقدار اور نائٹروجنی کھاد کی ۱/۳ مقدار ڈالیں۔ کیمیاوی کھادیں بوائی کے



ساتھ زمین کی تیاری کے دوران یا تو تیسرے پہر ڈالیں یا صبح سویرے ڈالیں اور جتنی جلد ہو سکے بوائی ختم کریں۔

۲۔ فصل کو مندرجہ ذیل طریقہ سے قطاروں میں کاشت کریں۔

الف۔ دیسی ہل کے ذریعے ایک سیدھا سیاڑ نکالیں۔ اگر لائنوں کا فاصلہ ۳۰ انچ رکھنا ہو تو بیل کو پہلے سیاڑ کے کنارے کنارے ساتھ ساتھ چلائیں۔

ب۔ سیاڑ نکالنے کے فوراً بعد بیج ڈالنا شروع کر دیں۔ ایک فٹ کے فاصلے کے اندر تقریباً چار بیج ضرور ڈالیں۔ بیج کو فوراً پاؤں سے مٹی ڈال کر ڈھانپ دیں۔ ڈھانپنے کے لیے ہلکا سہاگہ چلانا بھی کافی ہے۔ یہ احتیاط ضروری ہے کہ سہاگے کے اوپر کوئی آدمی نہ بیٹھے۔ اگر کاشت کے لیے تمام کھیت میں ہل چلا دیا گیا ہو تو ہر تیسرے سیاڑ میں بیج ڈالیں۔ اگر سیاڑ کو بیج ڈال کر زیادہ دیر کھلا چھوڑ دیا جائے تو زمین خشک ہو جائے گی اور اگاؤ بہت ناقص ہو گا۔ اگر ڈرل دستیاب ہو تو وہ بھی استعمال کر سکتے ہیں۔ ۱۲ سے ۱۵ سیر بیج فی ایکڑ کافی ہے۔ تاکید ہے کہ بیج ڈالنے کے فوراً بعد ہلکا سہاگہ ضرور چلائیں تاکہ زمین کی نمی ضائع نہ ہو۔ اگر موسم زیادہ گرم اور خشک ہو اور بوائی کے دوران نمی تسلی بخش نہ ہو تو کاشت کے تین دن بعد کھیت کو ہلکا سا پانی لگا دیں تاکہ روئیدگی مکمل اور یکساں حاصل ہو۔ اگر روئیدگی کے لیے مناسب نمی نہ ہو تو پودوں کی تعداد فی ایکڑ کم ہو جائے گی اور پوری پیداوار حاصل نہ ہو سکے گی۔ کپاس بونے والی ڈرل کو بوائی کے لیے استعمال کریں۔ قطاروں کا فاصلہ سوا دو فٹ اور پودوں کا فاصلہ ۹ انچ رکھیں۔ بارش یا آب پاشی کے بعد زمین میں کرنڈ بن جائے تو وتر کی حالت میں بار ہیرو کے ذریعے اسے ضرور توڑ لینا چاہیے۔

۱۵ سیر بھٹے یا ۱۲ سیر دانے برائے کاشت موسم خریف (جولائی، اگست) ۲۰ سیر بھٹے یا ۱۵ سیر دانے برائے کاشت موسم بہار (فروری، مارچ) مکئی کی فصل میں پودوں کی صحیح تعداد حاصل کرنا نہایت ضروری ہے۔ پودوں کی تعداد میں کمی بیشی پیداوار کو متاثر کرتی ہے۔ فی ایکڑ پچیس سے پینتیس ہزار پودے ہونا لازمی ہیں۔

اگر حسب ہدایات مکئی کو قطاروں میں کاشت کیا گیا ہو تو مطلوبہ مقدار سے زائد پودے کھیت میں ہوں گے۔ زائد پودوں کو چھدرائی کے ذریعے نکال دیں۔ چھدرائی کے وقت پودوں کی اونچائی ۹ انچ سے زیادہ نہ ہو۔ چھدرائی کے بعد پودوں کا باہمی فاصلہ ۹ انچ تک رکھیں۔ اگر فصل میں دانہ دار زہر استعمال کی گئی ہو تو چھدرائی سے نکالے گئے پودوں کو مویشیوں کو نہ ڈالیں سوائے ان پودوں کے نکالیں جن پر سنڈی کا حملہ ہو چکا ہو۔

مکئی کا سب سے نقصان دہ کیڑا اس کا گڑوواں (MAIZE BORER) ہے جو کہ سردیوں میں مکئی کی فصل کے ٹھڈوں میں سرمائی نیند سوتا ہے۔ گرمیوں میں اس کی چار سے پانچ نسلیں ہوتی ہیں۔ یہ کیڑا سنڈی کی حالت میں تنے میں داخل ہو کر اس کی کونپل کو خشک کر دیتا ہے۔ فصل کا معائنہ جاری رکھیں، بہاریہ اور موسم خریف کی مکئی کے پودوں میں جب چار یا پانچ پتے نکلنے کی حالت میں اس کی درمیانی کونپل سوکھ جائے پودے کی بڑھوتری رک جاتی ہے ایسی حالت میں ضرورت پڑنے پر پانچ یا چھ کلوگرام ۱۰ فیصد دانہ دار زہر فی ایکڑ استعمال کریں۔ ان زہروں میں باسوڈین

(BASODINE) سیون (SEVEN) یا فیوراڈان (FEURADON) زیادہ مؤثر ہیں۔ دوائی ڈالتے وقت کونپل میں زہر کے دانوں کا گرنا ضروری ہے بعد میں آبپاشی کر دیں۔

چست تیلہ: (JASSID) یہ کیڑا بہاریہ اور خریف کی فصل پر حملہ آور ہوتا ہے۔ شدید حملہ کی صورت میں پتے سفید ہو جاتے ہیں اور فصل کی پیداوار متاثر ہوتی ہے۔ اس کے انسداد کے لیے جب پتوں پر ۱۰ - ۸ کیڑے فی پتہ دیکھنے میں آئیں تو فوراً میلاتھیان ایک لیٹر یا ڈائی میکران نصف لیٹر یا گوزاتھیان نصف لیٹر یا تھایوڈان ایک لیٹر کا سپرے کریں۔ مندرجہ بالا گڑواں کے انسداد کے لیے دی ہوئی دانے دار زہروں کے استعمال سے بھی اس کیڑے پر قابو پایا جا سکتا ہے۔

تنے کی مکھی (STEM FLY) اس مکھی کا بہاریہ فصل پر زیادہ حملہ ہوتا ہے جو کہ فصل اُگنے کے بعد ایک مہینہ تک رہتا ہے۔ اس کے انسداد کے لیے دانے دار کرم کش مرکبات مثلاً ڈی سسٹان (DISYSTON) یا فیوراڈان (FEURADON) ۱۰ فیصد بحساب ۶ - ۵ کلوگرام فی ایکڑ مفید رہتا ہے۔ اگر فصل میں گوڈی، کھاد اور پانی کا صحیح اور برمحل استعمال ہو تو اس کیڑے کے انسداد کیلئے کرم کش ادویات کی ضرورت نہیں۔ بغیر ماہرانہ مشورہ کے زہروں کے استعمال سے پرہیز کرنا چاہیئے۔

کھیتوں میں نائٹروجن کی عموماً کمی پائی جاتی ہے۔ لیکن اکثر علاقوں میں فاسفورس کھادوں کا بہت اچھا ردِ عمل ہوا ہے۔ اگر فاسفورس اور نائٹروجن کھاد ایک اور دو کی نسبت سے ڈالی جائے تو بہت اچھے نتائج برآمد ہوں گے۔ زمیندار خود فصل کی حالت کو دیکھ کر مقدار کم یا زیادہ کر سکتا ہے۔ اگر گوبر کی کھاد استعمال کی گئی ہو تو پھر کم کیمیاوی کھاد کی ضرورت ہے بھرپور پیداوار حاصل کرنے کے لیے مندرجہ ذیل سفارشات پیش کی جاتی ہیں۔

کھاد ڈالنے کا طریقہ	غذائی عناصر کی پیداوار	قسم کھاد
(۱) بوائی کے وقت	۷۵ پونڈ فاسفورس ۵۰ پونڈ نائٹروجن	ڈیڑھ بوری ڈی۔ اے۔ پی یا ڈیڑھ بوری ٹی۔ ایس۔ پی ایک بوری یوریا نائٹرو فاس یا دو بوری امونیم سلفیٹ اگر ڈی۔ اے۔ پی استعمال کی گئی ہو تو یوریا یا امونیم سلفیٹ کی مقدار نصف ہوگی۔

ایک دفعہ خالی کھیت میں ہل چلا کر کھاد بکھیر دیں اور پھر ہل چلا کر بوائی کر دیں۔

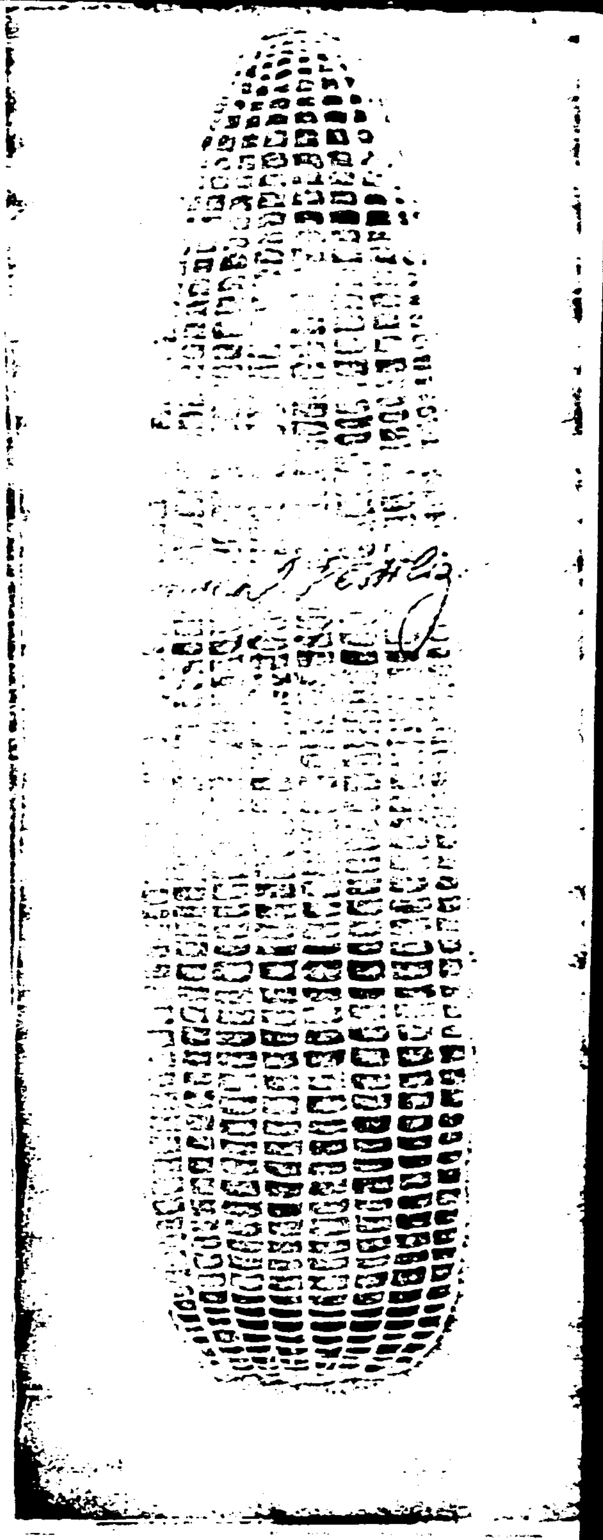
کھاد ڈالنے کا طریقہ	غذائی عناصر کی پیداوار	قسم کھاد
(۲) ڈیڑھ یا دو فٹ کی بلندی پر	۵۰ پونڈ نائٹروجن ؎	ایک بوری یوریا نائٹروفاس یا دو بوری امونیم سلفیٹ۔

قطاروں کے درمیان پانی سے پہلے بکھیر دیں اور پانی دے دیں۔ کھاد پتوں پر نہ پڑے۔

کھاد ڈالنے کا طریقہ	غذائی عناصر کی پیداوار	قسم کھاد
(۳) پھول آنے سے قبل	۵۰ پونڈ نائٹروجن	ایک بوری یوریا یا دو بوری امونیم سلفیٹ

؎ اگر زمین زرخیز ہو اور فصل گہرے سبز رنگ کی ہو تو یہ مقدار نہ ڈالیں۔

بارانی علاقوں میں نہ[illegible] علاقوں کے مقابلے میں کیمیاوی کھاد کی نصف مقدار ا[illegible] کریں اور تمام کھاد بوائی کے وقت کھیت میں ڈالنی چاہیئے۔



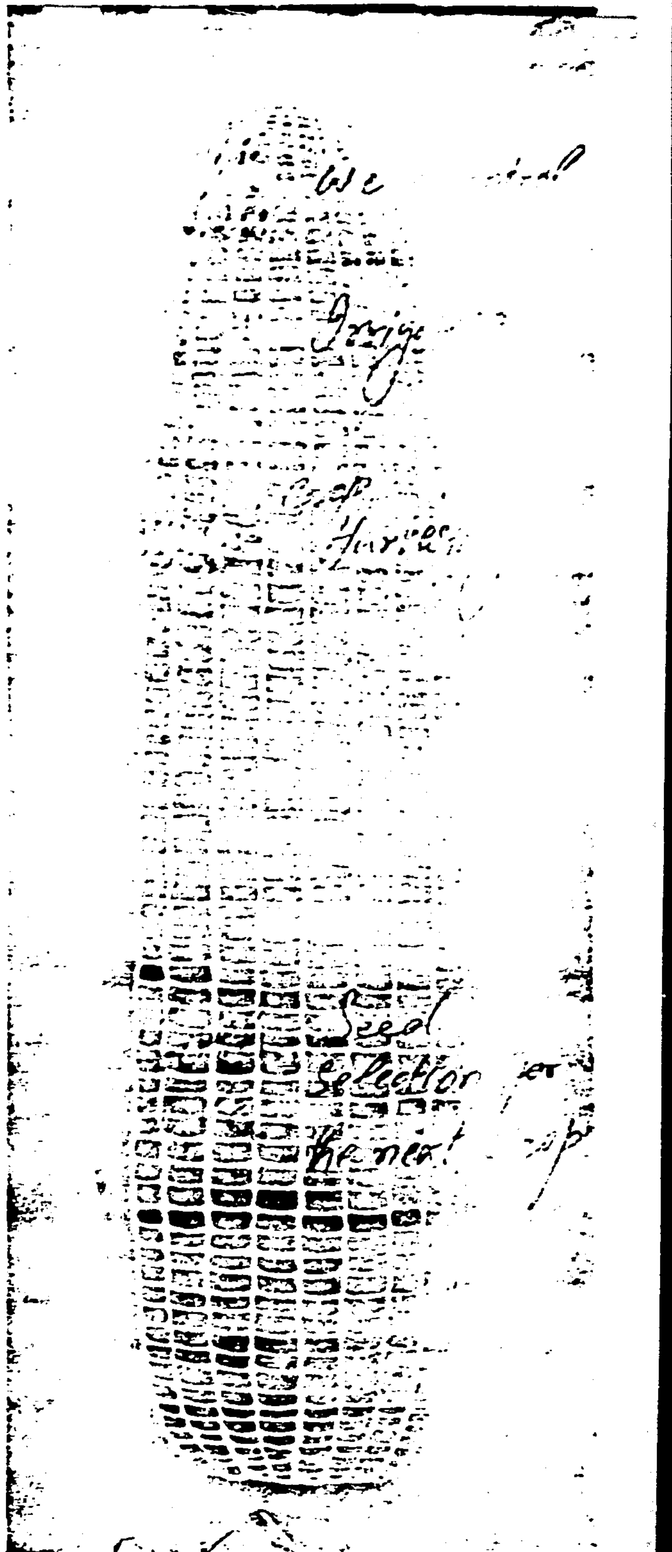
عام طور پہ دو دفعہ مکئی کی فصل میں جڑی بوٹیوں کو تلف کرنا ضروری ہوتا ہے۔ پہلی بار پہلی آبپاشی کے بعد زمین کے وتر آجانے پر اور دوسری دفعہ جب پودے تقریباً تین فٹ اونچے ہو جائیں۔ بہتر ہوگا۔ جب فصل تقریباً دو فٹ اونچی ہو جائے۔ تو مٹی چڑھا کے کھیلیاں بنا دیں۔ ان سے پودے گرنے سے بچ جاتے ہیں اور پانی کی بھی بچت ہوتی ہے۔

مکئی کی کامیاب فصل حاصل کرنے کے لیے چھ سے آٹھ دفعہ پانی کی ضرورت ہے۔ بہاریہ موسم میں جب مکئی پھول نکال رہی ہو اور گرم ہوائیں مئی میں چلنا شروع ہو جائیں تو پانی کا خاص خیال رکھیں۔ پھول نکلنے سے دانہ بننے تک تر وتر رہے اس کے لیے کم از کم تین پانی لگا تار دیتے چاہئیں۔ بہاریہ مکئی وہ کاشتکار بوئیں جن کے پاس اپنا ٹیوب ویل ہو اس کے علاوہ اگر پہلے پہر کھیت میں پودے کملاتے نظر آئیں تو پانی ضرور دینا چاہیئے۔

مکئی کی فصل کو اس وقت تک برداشت کرنا چاہیئے جب یہ اچھی طرح پک جائے۔ تین طریقوں سے فصل کے پکنے کا فیصلہ کیا جا سکتا ہے۔

۱۔ دانے کو دانت سے دبانے پہ جب یہ آواز کے ساتھ ٹوٹے تو فصل کٹائی کے لیے تیار ہے۔
۲۔ ملک میں رائج اقسام عموماً اس وقت پک کر تیار ہوتی ہیں جب چھلی کے پردے خشک ہو کر سفید ہو جائیں۔
۳۔ جب دانے کی پرورش مکمل ہو جاتی ہے تو ہر ایک دانے کے اگنے والے حصے کے نیچے ایک سیاہ تہہ نمودار ہوتی ہے اس کے بننے کے چند دن بعد برداشت کریں تو بہتر ہے۔ کیونکہ اس وقت ٹانڈوں کی نمی بھی کم ہو جائے گی۔ برداشت کے بعد چھلیوں کو صاف جگہ پر رکھ کر اچھی طرح خشک کر لیں تاکہ گودام میں کیڑوں وغیرہ سے نقصان نہ ہو۔ جب چھلیاں اچھی طرح خشک ہو جائیں تو دانے الگ کر لینے چاہئیں اور انہیں مزید خشک کر کے صاف اور خشک گودام میں محفوظ کر لیا جائے۔ جس میں چوہوں وغیرہ کے حملے کا خطرہ نہ ہو۔

مکئی کی تمام ترقی دادہ اقسام کا بیج اسی طرح رکھا جا سکتا ہے۔ جس طرح کاشتکار دیسی مکئی کا بیج رکھتے ہیں۔ اچھے اچھے پودے جو بیماریوں سے محفوظ اور تندرست ہوں۔ ان کی کٹائی سے پہلے نشان دہی کر لی جائے۔ کٹائی کے وقت ان سے بھٹے توڑ کر علیحدہ دھوپ میں سکھائیں اور ہوادار کمرے میں بوریوں میں بھر کر رکھیں۔ اگلے سال اس بیج کے استعمال سے فصل اور بہتر ہونے کی توقع ہے۔



Broadcast = Rs-79/bag or 35kg (2-8kg/A)

Fill rider = Rs 61-51/35kg (10kg)/A

Seven [illegible]

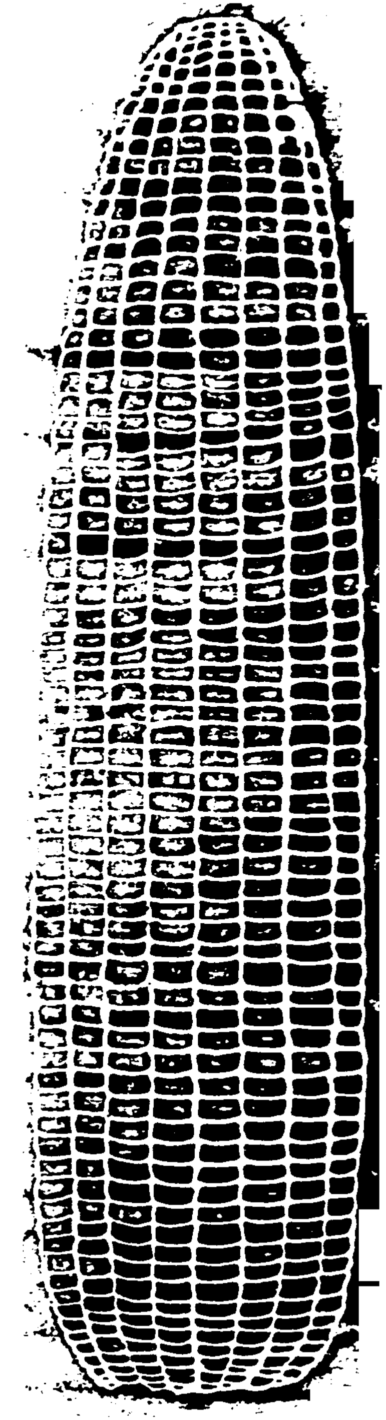
modern technique for corn cultivation - 1978

مکئی کی کاشت کے جدید اصول ۱۹۷۸ء

مکئی کا سب سے نقصان دہ کیڑا اس کا گڑواں (MAIZEBORER) ہے جو کہ سردیوں میں فصل کے مڈھوں میں سرمائی نیند سوتا ہے۔ گرمیوں میں اس کی چار سے پانچ نسلیں ہوتی ہیں۔ یہ کیڑا سُنڈی کی حالت میں تنے میں داخل ہو کر اس کی کونپل کو خشک کر دیتا ہے۔ جس سے پودا تباہ ہو جاتا ہے۔ بہاریہ اور خریف مکئی کے پودوں میں جب چار پانچ پتے نکلنے کی حالت میں پودا کیف کی شکل اختیار کر لے تو اس میں پانچ یا چھ کلوگرام دس فیصد دانے دار زہر فی ایکڑ استعمال کریں۔ ان زہروں میں باسوڈین (BASODINE) سیون (SEVIN). ڈایازینان (DIAZINON) زیادہ مؤثر ہیں۔ دوائی ڈالتے وقت کونپل میں زہر کے دانوں کا گرنا ضروری ہے۔ بعد میں آبپاشی کر دیں۔ فصل کا معائنہ جاری رکھیں۔ اگر ضرورت ہو تو ۲۰/۲۵ دن کے بعد دانے دار دوائی پھر استعمال کریں۔

یہ کیڑا بہاریہ اور خریف کی فصل پر حملہ آور ہوتا ہے۔ شدید حملہ کی صورت میں پتے سفید ہو جاتے ہیں۔ اور فصل کی پیداوار متاثر ہوتی ہے۔ اس کے انسداد کے لیے جب پتوں پر ۸-۱۰ کیڑے فی پتہ دیکھنے میں آئیں تو فوراً ڈائی میکرون نصف لٹر یا گوزاتھیان نصف لٹر یا تھایوڈان ایک لیٹر کا سپرے کریں۔ مندرجہ بالا گڑواں کے انسداد کے لیے دی ہوئی دانے دار زہروں کے استعمال سے بھی اس کیڑے پر قابو پایا جا سکتا ہے۔

اس مکھی کا بہاریہ فصل پر زیادہ حملہ ہوتا ہے۔ جو کہ فصل اُگنے کے بعد ایک مہینہ تک رہتا ہے۔ اس کے انسداد کے لیے دانے دار کرم کش مرکبات مثلاً فیوراڈان یا ڈائی سسٹون مفید رہتا ہے۔ اگر فصل میں گوڈی۔ کھاد اور پانی کا صحیح برمحل استعمال ہو تو اس کیڑے کے انسداد کے لیے کرم کش مرکبات (PESTICIDES) کی ضرورت نہیں ہوتی۔ بغیر ماہرانہ مشورہ کے زہروں کے استعمال سے بہرحال پرہیز کرنا چاہیئے۔



امید پرنٹرز ۲۳۶ بی راوی پارک

ادارہ زرعی مطبوعات حکومت پنجاب سمن آباد لاہور (۱۵ مئی ۱۹۷۸ء)

Subject: OIL SEEDS

Trainer Agronomist
Class Room 1 hours
Field 0 Days

OBJECTIVES

To learn the importance and production factors of oilseeds and to enable them to carry out the sowing of these independently.

MATERIALS NEEDED

Sketches and seeds of various oilseeds for identification.

TRAINING AIDS

Slides of various oil seed cultural practices.

INTRODUCTION

"Raya" and "Sarsoon" are the most important oil seeds of this region. Raya, sarsoon and other oil seeds are grown on large areas of Rawalpindi division, but the production of these commodities do not meet the requirements of the country. A huge amount of foreign exchange is spent on the import of edible oil every year. It is, therefore, of paramount importance to concentrate on increasing the production to meet the country requirements satisfactorily.

PRESENTATION

The information on the production factors will be given putting more emphasis on the following points.

1. Climate and Soil

Light, sandy and saline soils are not suitable for Raya and Sarsoon cultivation. Loamy soils which have good waterholding capacity and frequent drainage are thought to be the best. In Rawalpindi division where the winter rainfall is from 4-5 inches, these crops can be grown successfully.

2. Preparation of Land

Rain water should be conserved in the field and the field should be prepared by applying 2-3 ploughings followed by planking to get the fine seedbed. To get the good germination, emphasis must be given to the following points.

a. Precise leveling to get the uniform distribution of rain water.

b. "Wattar" should not be dry at the time of sowing, rather it should be sufficiently moist.

c. In case of dry "wattar", keep the soil in wet soil for one night.

d. Add equal amount of earth in the seed before broadcasting.

e. Seed should not go too deep in the soil.

f. Use new seed every year.

g. Don't use more seed than recommended.

h. Break the crust if the rain is received immediately after sowing.

3. Time of Sowing and Seed Rate

The most suitable sowing time is from October 1st-20th. Late sowings result in decreased yields. Use the seed at the rate of 2-2½ seers per acre. Increase the seed rate slightly in case of less "Wattar" or late sowing.

4. Method of Sowing

To harvest the crop, it should be sown in lines 1-1½ feet apart and weak plants may be uprooted later to keep plant distance from 5 to 6 inches. Sowing depth should be from 1¼-1½ inches. Sowing may also be done by broadcasting in certain cases.

5. Fertilizer

Usually no commercial fertilizers are applied to these crops. However, application of super phosphate and ammonium sulphate at the rate of one bag each per acre will increase the yield up to 40%.

6. Insect and Diseases

In case of a moisture stress in the soil, the crop is attacked by white ants, BHC should be added to the soil for control. Another problem may be the attack of Jassids in case of rain or high humidity in the atmosphere. Plants can be protected from Jassids by the use of DDT, Melathion or other poisons.

NOTE: Recently, cultivation of caslor is also recommended in some areas.

APPLICATION

Each student will examine and identify the seeds of different oil seeds and discuss the production practices.

QUESTIONS

1. What is the importance of oil seeds?
2. Why should a higher rate seeding be used in low moisture conditions and late sowings?
3. In which areas is the cultivation of oil seed recommended?
4. What should be done in case of Jassid attack on the crop?
5. What should be the sowing depth in oil seed?

Subject: ORCHARD

Trainer Agronomist
Class Room 1 hours
Field 0 Days

OBJECTIVES

To acquaint the trainees with important factors involved in growing of fruit trees. To develop an understanding of the economic importance of orchards.

MATERIALS NEEDED

Charts and sketches of gardening and different layout methods.

TRAINING AIDS

Slides of orchards and field problems encountered in the production of orchard crops.

INTRODUCTION

Fruit trees, in addition to increasing income, play an important role in maintaining the health of human beings. Fruits are a major source of supplying mineral and vitamins, an essential part of human nutrition. The present supply of fruits is not enough to meet the demand and all out efforts are therefore needed to grow the fruit trees on more scientific lines adopting the available technology.

PRESENTATION

Trainees will be given information on some important fruit trees.

1. Mango

Mango is one of the most important fruits of Pakistan. "Sanji", "Shaftal", Gram or Berseem should be grown in mango garden in the month of

October. It adds N to the garden in addition to supplying the fodder. For establishing a new garden, mango trees can be planted up to October. Small plants should be covered with straw to save the plants from the ill effects of cold weather. In the month of February, plant should be fertilized with ammonium sulphate and hoes and irrigated and uncovered. New plants should be planted in the beginning of March after thorough preparation and proper lay-out of the field.

2. Citrus Fruits

Citrus fruits are second in importance in the fruit industry of Pakistan. New plants can also be introduced in the month of October. To increase the fertility of the soil and to get an additional income, Gram, Berseem and "Sanji" can be grown in the garden. Wheat can also be grown successfully if the trees are small. The dry branches of the trees should be cut in the month of December and January. There should be no water stress so that the fruit is plump and premature dropping of the fruits does not occur.

3. Grapes

Cold and dry climate is best suited to this plant. It is therefore, grown successfully in the Quetta Division. Plants should be supplied with FYM at the rate of 15 seers/plant in the months of December and January. As the new branches are mainly responsible for producing fruits, the old branches should be cut in January and February to get the proper fruiting.

4. Banana

Banana is an important fruit of Hyderabad and Khairpur divisions. Its cultivation can be done in both the spring and autumn seasons. They start to fruit after one year and need rather larger amounts of fertilizer and water. In December and January, FYM should be applied and followed by frequent hoeing and irrigation water. In the month of October, the unnecessary flowers and small fruits should be cut so that the standard and high quality fruit is obtained.

APPLICATION

1. Each trainee will learn the importance of fruit trees and proper intercropping techniques.
2. On one of the next field trips, several orchards will be visited.

QUESTIONS

1. What is the importance of orchards in your district?
2. How are fruits essential for human health?
3. What crops can be grown in the garden in intercropping techniques?
4. Why are mango and citrus trees covered with straw in winter?
5. What are the constraints in increasing the areas under fruit production?

Subject: IMPLEMENTATION OF A RICE, COTTON OR WHEAT PLANTING AND/OR FERTILIZER DEMONSTRATION IN THE FIELD

Trainer Agronomist
Class Room 2 hours
Field 3 Days

OBJECTIVES

1 - To provide an opportunity to the trainees to do some important agricultural operations by themselves.

2 - To provide an opportunity to the trainees to work with the farmer and to develop a cooperative relationship.

3 - To prepare demonstration plots.

MATERIALS NEEDED

Seed, fertilizer, drill, etc., depending upon the

TRAINING AIDS

None

INTRODUCTION

There is no short cut to experience. The best way to understand a thing is to do it practically. The trainees will have the opportunity to get in tough with the farmer and work with him on establishing a demonstration plot.

PRESENTATION

Trainees will be taken to the Thikriwaia project area and establish a fertilizer or planting test/demonstration plot on rice, wheat or cotton crops, depending on the season. The exact treatments will be determined in the classroom in cooperation with the trainer to satisfy the test demonstration needs that exist at that time.

APPLICATION

The trainees must have this experience in order to ensure they are confident of their ability in establishing field demonstrations and working with farmers. The OFWM field team agricultural officer in the area should be included in this project so he can ensure that the plots are taken to harvest and the results shared with the farmers in the area. The Farm Power and Machinery Department Trainer should cooperate in the exercises so the latest available machinery will be demonstrated to the farmer.

QUESTIONS

1 - What was the major constraint you encountered in carrying out this project?

2 - What was the best method to overcome it?

Subject: FIELD TRIP TO THE COTTON RESEARCH CENTER AT MULTAN

Trainer Agronomist
Class Room 0 hours
Field 1 Days

OBJECTIVES

1 - To familiarize the trainees with the Cotton Research Center, its functions and personnel.

2 - To show the trainees the recommended practices for cotton production and to identify some of the problems of cotton production under field conditions.

MATERIALS NEEDED

Transportation.

TRAINING AIDS

None

INTRODUCTION

The lesson on "Cotton Production Guidelines" has taught you the major points regarding cotton production. Now you need field experience in order to put these basic principles to use.

PRESENTATION

The trainees will take a field trip to the Cotton Research Institute in Multan. Along the way they will stop and visit two cotton farmers and briefly discuss their concepts of problems of cotton production. At the Cotton Research Institute, the Director will present an introductory lecture on "Cotton Production in Pakistan--practices and problems." Following this, the scientist in charge of cultural practices, pest management, physiology, fertility and irrigation will present lectures regarding their research areas and recommended practices.

APPLICATION

The trainees and Institute staff will tour the research plots on the farm. The trainees will discuss with the staff some of the problems mentioned by the farmers visited earlier.

QUESTIONS

1 - How can the Cotton Research Institute by of service to you once you have been posted at your field assignment?

2 - What are the three major production problems as envisioned by the farmer and the Institute staff? How do they differ and why?

Subject: MAIZE RESEARCH CENTER AT YOUSAFAWALA

Trainer Agronomist
Class Room ______
Field 1 Days

OBJECTIVES

To acquaint the trainees as to the function of the Maize Research Center, Yousafawala and explain to them the research activities and achievements of the Center. Trainees will also be involved in a general discussion of the production problems and constraints in maize cultivation.

APPLICATION

1 - Learning the problems of maize production and their solutions.

2 - Broaden the vision of the trainees about practical problems involved in mazie cultivation.

QUESTIONS

1. What is the most limiting factor for top maize yields?
2. What is the recommended varieties for your area?
3. What is the fertilizer recommendations for each variety?

Subject: FIELD TRIP TO THE PUNJAB AGRICULTURAL RESEARCH INSTITUTE (PARI) AT FAISALABAD

Trainer Agronomist
Class Room 0 hours
Field 1 Days

OBJECTIVES

1 - To familiarize the trainees with the functions and personnel of PARI.

2 - To show the trainees the recommended practices for wheat production and identify some of the problems under field conditions.

MATERIALS NEEDED

Transporation.

TRAINING AIDS

None.

INTRODUCTION

Wheat production has been discussed at great lengths in class and every trainee should be familiar with all the cultural practices and recommendations. Field experience is needed in order to be able to put the knowledge you have to practical use.

PRESENTATION

The trainees will be taken to PARI on a field trip. The Director will be asked to present an introductory lecture on "Wheat Production in Pakistan--Practices and Problems" after which the Institute scientists in charge of cultural practices, breeding, fertility, pest management and soil salinity will be asked to lecture on their "Research Programs and Production Recommendations."

APPLICATION

The trainees and Institute staff will visit the research farm and observe the various production experiments that are in progress.

QUESTIONS

1 - How can PARI be of service to you once you have been posted at your assignment?

2 - What are the major problems of wheat production and how can they be overcome?

Subject: NIAB AT FAISALABAD

Trainer Agronomist
Class Room ______ hours
Field 1 Days

OBJECTIVES

Trainees will be taken to the Nuclear Institute of Agriculture and Biology and lectures by heads of various sections will be arranged. Their research area will also be visited and problems of practical nature will be discussed.

APPLICATION

1 - Learning of the facilities available at NIAB.

2 - Broaden the vision of the trainees as to various aspects of agricultural research and production.

QUESTIONS

1. How could NIAB help you in the field?

Subject: RICE RESEARCH INSTITUTE, KALA SHAH KAKU

Trainer Agronomist
Class Room ______ hours
Field 1 Days

OBJECTIVES

To have a field trip to the Institute and the adjoining rice growing areas. Show them different methods of raising and transplanting rice seedlings.

Lectures emphasizing the practical problems will be delivered by the director of the Institute and his staff. Some farmers of the area may also be visited and the farmers views of rice production discussed.

APPLICATION

1 - Learn the problems of rice production from farmers.

2 - Broaden the vision of the trainees as to agricultural research on rice.

QUESTIONS

1 - What facilities at the Rice Research Institute could be of benefit to you once you are in the field?

Subject: SOIL SCIENCE TERMINOLOGY

Trainer Soil Scientist
Class Room 1 hour
Field 0 Days

OBJECTIVES

An agricultural field worker must be able to understand the terms used in soil conservation, improvement and management of soils; management of water; interpretation of results and crop production or in short, diagnosis, improvement and management of soils. This will enable him to analyze the situation in the field and make proper evaluations and recommendations.

MATERIALS NEEDED

Slide projector if slides are available.

TRAINING AIDS

Slides assisting in explaining different terms like salt affected soils, waterlogged soils, drains, etc.

PRESENTATION

Absorption: The process by which a substance is taken into and included within another substance, i.e., intake of water by soil or intake of gases, water, nutrients, or other substances by plants.

Adsorption: The increased concentration of molecules of ions at a surface, including exchangeable cations and anions on soil particles.

Aggregate: A group of soil particles cohering so as to behave mechanically as a unit.

Aggregation: The act or process of forming aggregates, or the state of being aggregated.

Alkali (sodic) Soils: A soil that contains sufficient exchangeable sodium to interfere with the growth of most crop plants and does not contain appreciable quantities of soluble salts. The exchangeable sodium percentage is greater than 15 and the electrical conductivity of the saturation extract is less than 4 millimohos per centimeter (at 25 C). The pH reading of the saturated soil paste is between 8.5 and 10.0.

Alkaline: A chemical term referring to basic reaction where the pH reading is above 7, as distinguished from acidic reaction where the pH reading is below 7.

Alkalization: The process where by the exchangeable sodium content of a soil is increased.

Bulk Density: The ratio of the mass of water free soil to its bulk volume. Bulk density is expressed in pounds per cubic foot or grams per cubic centimeter and is sometimes referred to as "apparent density", when expressed in grams per cubic centimeter, bulk density is numerically equal to apparent specific gravity or volume weight.

Cation Exchange: The interchange of a cation in solution with another cation on a surface-active material.

Cation Exchange Capacity: The total quantity of cations which a soil can adsorb by cation exchange, expressed as milliequivalent (me) per 100 grams. Measured value of cation exchange capacity dependent somewhat on the method used for the determination.

Dispersed Soil: Soil in which the clay readily forms a colloidal soil. Dispersed soils usually have low permeability. They tend to shrink, crack and become hard on drying and to salake and become plastic on wetting.

Drainage: 1. The process of the discharge of water from an area of soil by sheet or stream flow (surface drainage) and the removal of excess water from within soil by downward flow through the soil (internal drainage).

2. The means for effecting the removal of water from the surface of soil and from within the soil, i.e., sloping topography or stream channels (surface drainage) and open ditches, underground tile lines, or pumped wells (artificial drainage).

Drainage Requirements: Performance and capacity specifications for a drainage system, i.e., permissible depths and modes of variation of the water table with respect to the root zone or soil surface, and the volume of water that the drains must convey in a given time.

Electrical Conductivity: The reciprocal of the electrical resistivity. The resistivity is the resistance in ohms of a conductor, metallic or electrolytic, which is 1 cm long and has a cross-sectional area of 1 cm. Hence, electrical conductivity is expressed in reciprocal ohms per centimeter or mhos per centimeter. The terms "electrical conductivity" and "specific electrical conductance" have identical meaning.

Equivalent per Million: An equivalent weight of an ion or salt per 1 million g of solution or soil. For solutions, equivalents per million (e.p.m.) and milliequivalents per liter (me/l) are numerically identical if the specific gravity of the solution is 1.0.

Exchange complex: The surface-active constituents of soil (both organic and inorganic) that are capable of cation exchange.

Exchangeable Cation: A cation that is adsorbed on the exchange complex and which is capable of exchange with other cations.

Exchangeable Sodium Percentage: The degree of saturation of the soil exchange complex with sodium. It may be calculated by the formula:

$$ESP = \frac{\text{Exchangeable sodium (me/100 g soil)}}{\text{Cation exchange capacity (me/100 g soil)}} \times 100$$

Field Capacity: The moisture content of soil in the field 2 or 3 days after a thorough wetting of the soil profile by rain or irrigation water. Field capacity is expressed as moisture percentage on dry weight basis.

Leaching: The process of removal of soluble material by the downward passage of water through soil.

Leaching Requirement: The fraction of the water entering the soil that must pass through the root zone in order to prevent soil salinity from exceeding a specified value. Leaching requirement is used primarily under steady-state or long time average conditions.

Milliequivalent: One thousandth of an equivalent.

Milliequivalent per liter: A milliequivalent of an ion or a compound in liter of solution.

Moisture Percentage: 1. Dry weight basis. The weight of water per 100 units of weight of material dried to constant weight at a standard temperature. 2. Depth basis. The equivalent depth of free water per 100 units of depth of soil. Numerically, this value approximates the volume of water per 100 units of volume of soil.

Osmotic Pressure: The equivalent negative pressure that influences the rate of diffusion of water through a semipermeable membrane. Its direct experimental value for a solution is the pressure difference required to equilize the diffusion rates between the solution and pure water across a semipermeable membrane.

Particle Density: The average density of the soil particles. Particle density is usually expressed in grams per cubic centimeter and is sometimes referred to as "real density" or "grain density".

Percolation: A qualitative term applying to the downward movement of water through soil. Especially, the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of one or less.

Permeability: 1. Qualitative. The quality of state of a porous medium relating to the readiness with which such a medium conducts or transmits fluids. 2. Quantitative. The specific property governing the rate or readiness with which a porous medium transmits fluids under standard conditions. The equation used for expressing the flow should take into account the properties of the fluid so that proper measurements on a given medium give the same permeability value for all fluids that do not alter the medium. The physical dimensions of the permeability unit are determined by the equation used to express the flow.

Porosity: The fraction of the soil volume not occupied by soil particles, i.e. the ratio of the sum of the volumes of the liquid and gas phases to the sum of the volumes of the solid, liquid and gas phases of the soil.

Potassium Adsorption Ratio: A ratio for soil extract and irrigation waters used to expressed the relative activity of potassium ions in exchange reactions with a soil.

$$PAR = \frac{K}{\sqrt{Ca^{++} + Mg^{++} / 2}}$$

where the ionic concentrations are expressed in milliequivalents per liter.

Reclamation: The process of removing excess soluble salts or excess exchangeable sodium from soils.

Saline Alkali Soil: A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts. The exchangeable sodium percentage is greater than 15, and the electrical conductivity of the saturation extract is greater than 4 mmhos per centimeter (at 25 C). The pH reading of the saturated soil is usually less than 8.5.

Salination: The process of accumulation of soluble salts in soil.

Saturated Soil Paste: A particular mixture of soil and water. At saturation, the soil paste glistens as it reflects light, flows slightly when the container is tipped and the paste slides freely and cleanly from a spatula for all soils except these with high clay content.

Saturation Extract: The solution extracted from a soil at its saturation percentage.

Saturation Percentage: The moisture percentage of saturated soil paste, expressed on a dry weight basis.

Semipermeable Membrane: A membrane that permits the diffusion of one component of a solution but not the other. In biology, a septum which permits the diffusion of water but not of the solute.

Sodium Adsorption Ratio: A ratio for soil extracts and irrigation waters used to express the relative activity of Na ions in exchange reactions.

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{++} + Mg^{++}) / 2}}$$

Where the ionic concentrations are expressed in milliequivalents per liter.

Soil Extract: The solution separated from a soil suspension of a soil at a particular moisture content.

Soluble Sodium Percentage: A term used in connection with irrigation waters and soil extracts to indicate the proportion of sodium ions in solution in relation to the total cation concentration. It may be calculated by the formula:

$$SSP = \frac{\text{Soluble sodium concentration (meq/l)}}{\text{Total cation concentration (meq/l)}} \times 100$$

Specific ion Effect: Any effect of salt constituent in the substrate on plant growth that is not caused by the osmotic properties of the substrate.

Specific Surface: The surface area, per unit weight of soil, commonly expressed as square meters per gram of soil (m^2/gm).

Water Table: The upper boundary for ground water. The upper surface of the locus of points at which pressure in the ground water is equal to atmospheric pressure.

Agencies for Soil Testing:

1. Department of Soil Science, U.A., Faisalabad.
2. Agri. Chemist (Soils), AARI, Faisalabad.
3. Directorate of Soil Fertility, AARI, Faisalabad.
4. Directorate of Land Reclamation, Lahore.
5. Assistant Agri. Chemist at divisional headquarters, Lahore, Multan, Bahawalpur, Rawalpindi.
6. Agri. Chemist at Tarnab (N.W.F.P.), Tandojam (Sind) and Quetta (Baluchistan).

Criteria for Soil Evaluation:

a. Saline Soils

$EC_e \times 10^3 > 4$ mmhos/cm at 25 C

ESP < 15%   pH < 8.5

b. Alkali Soils (Sodic soils)

$EC_e \times 10^3 < 4$ mmhos/cm at 25 C

ESP > 14

pH = 8.5 to 10

c. <u>Saline Alkali Soils (Saline sodic soils)</u>

$EC_e \times 10^3 > 4$ mmhos/cm at 25 C

ESP > 15

pH may or may not be 8.5

APPLICATION

These terms will be application in soil testing, soil analysis interpretation and water management.

QUESTIONS

Differentiate the following terms:

1. Alkali, sodic and alkaline soil.
2. SAR and RSC.
3. Percolation and infiltration.
4. Waterlogging and drainage.
5. Soil water and ground water.
6. Texture and structure of soil.

Subject: SOIL OF PAKISTAN

Trainer Soil Scientist
Class Room 2 hours
Field 1 Days

OBJECTIVES

For the effective, efficient and judicious use of a soil, one must know its origin, formation, development, capability and physico-chemical characteristics.

MATERIALS NEEDED

Spade, knife, set for determining pH, EC, magnifying glass, dilute HCl or H_2SO_4.

TRAINING AIDS

1. Visit to salt affected soils, texture determination by feel method and study of soil profile.
2. Slide set "Our Living Soil" by the Potash Institute.

PRESENTATION

I. Origin of Soil Materials as Related to Geology of the Region

A. Geology and geologic materials dictate the kinds of materials that soils form in.

1. In Pakistan, these materials originated mainly from sedimentary and metamorphic rocks of the Himalayas mountain ranges which were formed by a huge uplift of the earth's surface. Adjacent to this uplife, there was a depression created. Today, this depression is known as the Indo-Gangetic basin. For several thousands of

years following this uplift, natural or geologic erosion has provided sediments that have partially filled the great Indo-Gangetic vall. The thickness of these sediments (alluvium) has been recorded by tubewell borings and exceeds 200 to 300 feet in places. This vast area of alluvial deposits has provided the most extensive kind of parent material for soils in Pakistan. Alluvial sediments are extremely variable as to coarseness or fineness, color, and suitability toward crop production.

2. Within hilly and mountainous regions the weathered bedrock layers have provided the parent material for the formation of soils. These materials remain in place and are derived from shales, schists, limestone, sandstone and other kinds of rocks. Because these parent materials are not transported they are collectively called residual. The weathering or breakdown of bedrock is a slow process and as a result, soil thickness in these upland areas ranges from shallow to deep.

3. Scattered throughout northern Pakistan, a third kind of parent material is common. This is the wind blown silt size material known as loess. During climatic cycles, wet periods (centuries) contributed toward more rapid rate of erosion and sedimentation in certain areas and greater glacial activity in other regions. In both of these cases, the wetter climates created silty sediments in the beds of glacial lakes and river valleys. A change in climate from wet to dry left large arid areas of these silty sediments exposed to prevailing strong winds that carried this material to nearby leeward areas. The thickness of loess deposits in Pakistan ranges from 1 to 16 feet. Usually, the thicker

deposits are nearer the source, but it is not uncommon to find two feet thick deposits 40 to 80 miles distant from a river or glacial lake bed that contained the original silty sediments.

B. Land forms and their occurance in Pakistan.

1. In the first part of this section, the geologic parent materials common to Pakistan were discussed. The different kinds of materials make up specific land forms. For example, alluvial material occurs as recent floodplains to very old materials on high terrace land forms.

   Soil Scientists classify soils on the basis of their (the soil's) properties. Some of these properties are controlled by the land form and material that comprise the land form.

2. The four kinds of land forms that are derived from alluvium can be distinguished by the following:

   a. Piedmont - Usually a nearly level to gently sloping broad plain that has received a deposit of water transported sediments from local or nearby hills and low mountains. A part of the outer rim of the basin known as the peshawar vale consists of piedmont terraces. It is usually evident that this land form has a deposit of old alluvium. This is an old land surface considerably higher in elevation than present day stream beds and floodplains. Because of its position on the landscape soils occurring on the piedmont are usually well drained and may be subject to accelerated erosion and gully formation.

b. River terraces are the next oldest alluvial land form in Pakistan and are often associated with the last ice age or Pleistocene period. They usually lie adjacent to present and past stream valleys. These terraces are considerably higher in elevation than the present floodplain and contain mainly well drained soils. This landform may be broad, extensive areas in some places of narrow and oblong in others. Regardless of size of shape they have existed for a fairly long geologic period to have permitted deep soil development. This includes homogenization and soil structure formation. River terraces are usually not subject to common flooding.

c. Sub-recent floodplains are common to the Indus River and its tributaries. They usually range from a half meter to two meters above the present or recent floodplain. Floods are a hazard to these areas. A large part of the Sind Province is sub-recent floodplains. These lands have been existence over a relatively short period, but some soil formation has occurred. The surface layer and a thin subsoil indicate soil formation through the increase in organic matter and the modification of stratified sediments by homogenization. Generally, the soil structure (natural binding of soil particles in to blocks and granules) is weak and a high watertable may restrict normal soil formation and the growing of common crops. Saline and sodic conditions are prevalent on this landform due to capillary vise of salty water up through the soil profile.

d. Sub-recent floodplain areas often contain flood or overflow level. These channels may create new depositions or cause soil removal.

e. Recent floodplains are the lowest areas in steam valley. They are, of course, most susceptible to flooding and scouring one or more periods per year. The alluvial material on these generally level areas can vary from sands to silty clays, but exhibit little or no evidence of soil formation.

The soil profile contains thin layers of veriable sediments. These layers (3 mm to several centimeters thick) are dif- ferentiated from each other by changes in texture, color, and thickness. This stratification represents annual deposition by variable velocities of the stream currents, during periods of floodplain overflow, poor drainage, high watertables, and salinity are common problems that restrict the crop production of soils in the land form.

f. In the preceding paragraphs, the land forms common to the Indus valley and its tributaries have been described. Even though these land forms are most prevalent in irrigated areas of Pakistan, some mention should be made of the hilly and mountainous uplands. These areas contain a variety of hills often called interfluves and the associated and dissecting waterway or stream channel. Steeper areas with greater relief will have a fast moving stream at the lowest level, than a foot slope that ascends to a steep escarpment. All of these upland or hilly land forms are subject to geo- logic and man-made erosion that produces sediment for the lower elevations of floodplains and estuaries.

II. Physical Nature of Soils

A. The flow and storage of soil moisture, the air movement, and the ability of the soil to supply plant nutrients are examples of properties that are dependent on the size and arrangement of soil particles.

B. The four major components of soils are inorganic particles (sand, silt, clay), organic matter, water, and air. Each of these varies greatly from place to place and has a bearing on the management and productivity.

1. Inorganic particles occupy about fifty percent of the total volume of most surface soils. These particles are divided into the following sizes according to USDA:

   Sand - 0.5 to 2.0 mm = 2000 n

   Silt - 0.002 to .05 mm = 50 n

   Clay - less than .002 m = 2 n

   Percentages of these particles sizes contained in specific soils determine its texture (refer to soil texture triangle).

   a. Sand - This particle-size often acts as an individual grain and consists mainly of rock fragments or primary minerals such as quartz.

   b. Silt - A primary mineral similar to sand but has an increased surface area per unit of volume or weight. The increased surface area promotes greater chemical activity. More plasticity and cohesion is found in the silt size fraction.

   c. The clay particle control most of the important properties of soils. They are secondary minerals composed of alternate layers of aluminum and silica. The space between and around these platy layers of aluminum and silica have many negative (-) electrical charges that attract (ions) of elements that have a positive (+) charge. Examples of positive ions are H^+, Ca^{++} and K^+.

d. The layers within the clay particle react with water and results in changes in plasticity, cohesion, and shrinkage. This volume change in clays is often visible in fields that crack upon drying and expand upon wetting.

2. Earlier it was stated that the volume of soils consist of 50 percent inorganic particles on the average. The remaining 50 percent consists of pore spaces and organic materials. The pore spaces are occupied by air and soil water. Diameters of soil pores range greatly in size and to large extent, control the height of capillary rise (upward water movement) in the soil profile. Soil pore sizes and continuity effect the rate of irrigation water intake.

C. Soil Aggregates (Structure).

In most soils, the sand, silt, and clay particles combine together with the aid of organic colloids which act as a binding agent to form soil structure. These individual particles (sand, silt, clay) come together and form granules, blocks, and prisms. These structural forms range in size from 2 to 5 mm. to several centimeters in width and length. The strength and stability of granular or blocky structural forms is determined by the amount of organic matter, clay, and age of the soil.

The stable soil structure promotes greatest air and water stability within the soil because each individual structure element (i.e.

block or granule) has a surface that is an avenue for air and liquid movement. Consequently, stable structure development is a process that improves the productivity potential of a soil. Unstable soil structure usually refers to some hemicol that destroys natural aggregation and promotes dispersion of individual soil particles. An example of this deterioration occurs when sodium (Na^{++}) is added to soil by irrigation water. Dense, impervious and structureless soil layers result.

III. Chemical Properties of Soils

A. The successful and economical growth of agronomic crops is dependent on soil nutrients. These nutrients are either supplied from the soil through mineral and organic decomposition or by the application of fertilizers. Nutrients used by plants are stored in the soil by attaching themselves by electrical charge to the clay particles or are trapped in the soil water within soil pores. Regardless of how soil nutrients exist in soils, they must eventually become soluble (dissolved in water) before plants can utilize them. For example, a dissolved ion (K^{+}) of potassium may have entered the soil solution from potash fertilizer or from weathered minerals. In either case, the ion is in solution and will enter the plant through osmotic forces along the sides of root hairs.

B. Plant growth is affected by soil reaction. Reaction refers to the acidity of alkalinity of a soil. The actual reaction or the relative acidity or alkalinity is expressed by a pH scale which ranges from 0 to 14. A soil with a pH of 7 is considered neutral. Acid solutions have a pH of less than 7. This scale is actually a measurement of the hydrogen ion (H^+) concentration expressed as a negative logarithm. Thus, a soil with a pH of 5 is 10 times more acid than one with a pH of 6, changing a strongly acid soil to one that is less acid requires that addition of calcium which replaces the hydrogen ion on the clay particle. Both strongly acid or alkaline soils affect the growth of many crops by reducing the solubility of nutrients such as phosphorus, boron, and nitrogen.

C. The cation-exchange capacity of a soil is dependent upon the kinds and amounts of clay size particles present. Therefore, a sandy soil has less cation-exchange capacity than a silt loam. The latter soil would have the greatest potential for stored fertility. The exchangeable cations are held on the surface of the clay particle by negative charges. Some of these cations are detached from the clay as moisture in the soil increases or as other cations move in and replace those on the particle. In fact, there is a continuous movement of soil water which carry cations from one part of the soil to another.

APPLICATION

Soil should be used according to their capability. Management practices can be adopted according to the type of soil. On the field trip, the different soils will be pointed out and their capabilities discussed.

QUESTIONS

1. Differentiate between physical and chemical properties of soil.
2. What do you mean by granules and dispersed soils?
3. What is the exchange complex?
4. Name the active ingredients of the soil.

FIELD EXERCISE

TECHNIQUE OF DETERMINING THE TEXTURE OF SOIL IN THE FIELD

From the surface of the ground, take up a handful of the soil in a moist (not wet) condition, mould it with the whole hand and ask yourself three questions or as many as are necessary for the purpose.

1. Is the soil gritty? By gritty is meant that sensation which is experienced when a handful of sand is kneaded between palm and fingers.

2. Is the soil silky? The feeling that is imparted by handling silk fabric.

3. Is the soil sticky?

Let us suppose that answer to the above questions is No, i.e., soil is devoid of grittiness, silkiness and stickiness. Soil is Loam.

If the answer to first question is Yes, i.e. if the soils are gritty than see - -

If it soils or slightly sticks to fingers;

If it can be moulded into a cohesive ball;

If the soils are gritty, soils the fingers and can be moulded into a cohesive ball then they are Sandy Loam (C) (20 to 50% silty and clay).

If the soils are gritty and soils the fingers but cannot form the cohesive ball, the soils are Loamy Sands (B) (15 to 20% silt and clay).

If the soils are gritty but do not soil the fingers and do not form the cohesive ball, the soils are Sands (A) (less than 15% silt and clay).

If the soils are neither gritty nor silky nor sticky, the soils are Loams (50% or more silt).

Return to the second question:

Is the soil silky? If the answer is yes, then see if it can be polished by pressing a sample of the soil in a moist (but not wet condition) state between the thumb and the forefinger. If it is not polished, then the soils are:

Silty Loam: When the silky feeling is just recognizable, but there is very little resistance to the deformation of half a handful of the soil moulded into little ball.

Silt Loam: Silky feeling is quite obvious and there is considerable resistance to deformation.

If the soil is polished, then:

Silty clay loam: If resistance to moulding is considerable but can be overcome without difficulty.

Clay Loam: Resistance to deformation begins to be difficult.

Clay: Resistance to deformation between the finger and thumb is exceedingly difficult.

Subject: ESSENTIAL NUTRIENTS, FUNCTIONS AND SYMPTOMS

Trainer Soil Scientist
Class Room 2 hours
Field 0 Days

OBJECTIVES

1 - To learn the major and minor elements required by plants.

2 - To diagnose the deficiency symptoms of different elements in the field and apply the required element to eliminate the deficiency.

MATERIALS NEEDED

None

TRAINING AIDS

1 - plants, photographs showing deficiency symptoms of different elements

2 - slide set "Nutrient deficiency symptoms of crops" by the Potash Institute

INTRODUCTION

Elements essential for plant nutrition and their functions.

Carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur are the elements of which proteins, hence protoplasm, are composed. In addition to these six, there are fourteen other elements which are essential to the growth of some plant or plant(s). These are calcium, magnesium, potassium, iron manganese, molybdenum, copper, boron, zinc, chloride, sodium, cobalt, vanadium, and silicon. Not all are required for all plants but all have been found to be essential to some. Each of the twenty elements play a role in the growth and development of plants and when present in insufficient quantities, can reduce growth and yields.

The first nine are major elements and the rest are minor elements. Out of the major nutrients, N, P and K are called the fertilizer elements because they are generally applied in fertilizers. C, H and C are obtained principally from water and carbon dioxide. The major nutrients are used in large quantities by plants and out of these, N, P and K are very commonly deficient in soils. S is often added with these elements, because it is a part of most of the fertilizers supplying N, P and K to soil, e.g., ammonium sulphate, superphosphate, and potassium sulphate, Ca and Mg are usually present in ample quantities in arid region irrigated soils except in sodic soils. Elements such as Fe, Mn, B, Cu, Zn, Mo, Cl, Na, Co, V and Si are known as micro-nutrients because they are required by plants in very small quantities. They are also called trace, minor, or rare elements.

PRESENTATION

Nitrogen:

Most of the plants (except legumes) absorb N in a form other than elemental. The forms most commonly assimilated by plants are the nitrate (NO_3^-) and the ammonium (NH_4^+) ions. The absorbed nitrogen (NO_3 or NH_4) is reduced to NH_2 and then converted into more complex compounds and ultimately into protein. It is also an integral part of chlorophyll molecules. An adequate supply of nitrogen is associated with vigorous vegetative growth and a deep green color. Excessive quantities of nitrogen, under some conditions, prolong the growing period and delay crop maturity, especially when other plant nutrients are not sufficiency present. The supply of nitrogen is related to carbohydrate utilization. Less carbohydrate is thus deposited in the vegetative portion, more protoplasm is formed. Because protoplasm is highly hydrated, a more succulent plant results.

Excessive succulence in some crops may have a harmful effect. With grain crops, loding may occur when varieties are not adopted to high levels of nitrogen fertilization. A weakening of the fibre may result in cotton. Excessive nitrogen fertilization will also reduce the sugar contents of sugar beets and sugar cane. In some cases, excessive succulence may make a plant more susceptiable to disease or insect attack.

When plants are deficient in nitrogen, they become stunted and yellow in appearance. This yellowing or chlorosis usually appears first on the lower leaves; the upper leaves remain green. In a severe nitrogen shortage, the leaves will turn brown and die. In grasses, the lower leaves usually 'fibre', or turn brown, beginning at the leaf tip and progressing along the midrib until the entire leaf is dead. The tendency of the young upper leaves to remain green as the lower leaves become yellow or die is an indication of the mobility of nitrogen in the plant.

<u>Phosphorus</u>:

It is generally considered that plants absorb most of the phosphorus as the primary orthophosphate ion, $H_2PO_4^-$. Smaller amounts of the secondary orthophosphates ion, HPO_4, are also absorbed. Lower pH values will increase the absorption of the $H_2PO_4^-$ ion, whereas higher pH values will increase absorption of the $HPO_4^=$ form.

Phosphorus is associated with early maturity of crops, especially the cereals, and a shortage is accompanied by a marked reduction in plant growth. It is considered essential to seed formation and it is found in large quantities in seed and fruit. A good supply of phosphorus has been associated with increased root growth. The quality of certain fruit, forage, vegetable, and grain crops can be improved. Phosphorus is readily mobile in plants, and when a deficiency occurs, it moves from the older tissues to the active meristematic regions. Deficiency of this element retards the overall growth but the striking foliar symptoms (as in nitrogen or potassium) are seldom observed. As with other nutrients, some of the symptoms associated with phosphorus deficiency are not specific. The growth of both shoots and roots is greatly reduced and the growth habit is often upright and spindly; premature defoliation beginning with the older leaves is common; lateral shoots are fewer in number and lateral buds may die or remain dormant; blossoming is greatly reduced with consequent poor yields of grain and fruits; the opening of buds, leaves and blossoms in spring are delayed. One of the most common diagnostic aids in identifying phosphorus deficiency is the color of the foliage. In many plants, phosphorus deficinecy is recognized by bronzing of the leaves; which are generally characterized by a dull, bluish green with purple or brown spots. Although the purple tinge of the foliage is characteristic, it is not an infallible guide to the identification of phosphorus deficiency. A modification of the anthocyanin pigment metabolism by other causes sometimes produces similar effects.

Potassium:

It is absorbed as the potassium ion (K^+). Plant requirements for this element are high. When it is present in short supply, characteristic deficiency symptoms appear in the plant. Potassium is a mobile element which is translocated to the younger, meristematic tissues if a shortage occurs. Its function appears to be catalytic in nature and is essential to the following physiological functions:

1. Carbohydrate metabolism or formation and breakdown and translocation of starch.
2. Nitrogen metabolism and synthesis of proteins.
3. Control and regulation of activities of various essential mineral elements.
4. Neutralization of physiologically important organic acids.
5. Activation of various enzymes.

6. Promotion of the growth of meristematic tissue.

7. Adjustment of stomatal movement and water relations.

Potassium deficiencies greatly reduce crop yields without an exhibition of deficiency symptoms (phenomenon termed 'hidden hunger' by some groups). Potassium deficiency is associated with a decrease in resistance to certain plant diseases. The quality of some crops, particularly fruits and vegetables is deteriorated with low supplies of potassium. Photosynthesis is decreased with insufficient potassium, whereas at the sam time respiration may be increased. This seriously reduces the growth of the plant.

Calcium:

It is absorbed as the ion Ca^{2+}, it is found in large quantities in the leaves of plants. It may occur in the ionic form in cell sap. A deficiency of calcium manifests itself in the failure of the termical buds of plants to develop. The same applies to the special tips of roots. As a result of these two phenomena, plant growth ceases in the absence of an adequate supply. Calcium is related to protein synthesis by its enhancement of the uptake of nitrate nitrogen and is associated with the activity of certain enzyme systems. It is considered to be an immobile element.

Magnesium:

Magnesium is absorbed in the form of ion, Mg^{2+}. It is the only mineral constituent of the chlorophyll molecule and is located at its center. Appreciable quantities of Mg^{2+} are frequently found in seeds. It appears to be related to phosphorus metabolism and is considered to be specific in the activation of a number of plant enzyme systems.

Magnesium is a mobile element, so the symptoms often appear first on the lower leaves. In many species, the deficiency results in an intervenina1 chlorosis in the leaf, in which only the veins remain green. Magnesium is required for the activation of enzymes related with carbohydrate metabolism with nitrogen metabolism. With sulphur, it brings significant increases in the oil contents of several crops due to its role in oil synthesis.

Sulfur:

Sulfur is absorbed by plant roots mostly as sulphate ion, SO_4^{2-}, small smounts are absorbed as sulphur dioxide (SO_2) through plant leaves. A deficiency of sulphur is characterized by uniformly chlorotic plants, stunted, thin stemmed, and spindly (resembles those of nitrogen). Unlike nitrogen, sulfur is not easily translocated from older to younger plant parts in case of deficiency. The specific functions of sulfur in plant growth and metabolism are:

1. It is required for the synthesis of the sulfur containing amino acids, and for protein synthesis.
2. It activates certain proteolytic enzymes.
3. It is a constituent of certain vitamins of coenzyme A, and of glutathione.

MICRONUTRIENTS

Boron:

Boron is generally considered to be absorbed in one of its ionic forms, such as $B_4O_7^{=}$, $H_2BO_3^-$, HBO_3^{--} or BO_3^{---}. Boron plays a role in protein synthesis and seems to function in the plant directly at the growing points so that where boron is deficient, terminal buds are disintegrated and growth ceases. The boron needs of plants are related also to the supply of both Ca and K. It is necessary for nodule formation in certain leguminous plants.

Boron is immobile in most crop plants. The first deficiency symptom noted is a cessation of growth of the leaves of the terminal bud. These leaves may die, commencing at the base of the leaf, giving a curled and drawn-down appearance. This is shortly followed by complete death of the buds. Plants so affected frequently have a roosted appearance.

Iron:

Iron may be absorbed by plant roots in the inorganic forms or in the form of complex organic compounds. This element is also absorbed through the leaves when iron sulphate is supplied as foliar spray. The driving of iron nails into woody trees has been employed as a means of supplying this element to certain species.

Iron functions in the plant in conjunction with certain respiratory enzymes, e.g., cytochrome. It also catalyzes the formation of chlorophyll in plant leaves. Iron is an immobile element and is not translocated from older to younger plant parts when a deficiency occurs. Hence, the leaves at the growth point exhibit an intervenial chlorosis. As the deficiency increases, these leaves may become almost completely white and growth ceases. This disease is commonly called chlorosis.

Manganese:

Where iron deficiency gives a bright yellow color, manganese deficiency results in a yellowish-brown color of the leaves. The function of manganese appears to be similar to that of iron in being involved in oxidation and reduction reactions. It also increases the efficiency of light utilization, aids in protein synthesis and acts as a general catalyst of reactions within plants. Manganese is absorbed by plants as the divalent ion, MN^{2+}.

Like iron, manganese is not mobile and as a result, the deficiency symptoms usually appear in the young leaves first. With broad-leaved plants, the symptom is one of interveinal chlorosis, the veins remaining green. In severe cases, the leaves will become entirely yellow with brown necrotic spots appearing, followed by death of the plant.

Copper:

Copper is absorbed by the plants as the cupric ion Cu^{2+} or Cuprous Cu^{3+}. Copper deficiency commonly reduces plant growth appreciably. It aids in chlorophyll formation and is an important constituent of at least three oxidizing enyzmes. In case of copper deficiency, the upper or terminal parts of most plants wilt. In other cases, a bluish green color of the leaf tips has been reported.

Zinc:

Zinc is absorbed by plants in the form of zinc ion, Zn^{2+}. It effects the activity of auxin, the plant growth hormone. Seed formation is often inhibited by zinc deficiencies. Leaves of plants deficient in zinc are mottled and thickened, the internodal length may be shortened.

Molybdenum:

This element is absorbed as $MoO_4^{=}$ (molybdate) ion. Its role is generally thought to be related to nitrate reducing enzymes inside the cell. Molybdenum is very much important in the atmospheric nitrogen fixation by leguminous plant. Deficiency of Mo has been shown to cause mottling of leaves and also curling and breakdown of leaf edges.

Chlorine:

Chlorine is absorbed as the chloride ion, Cl^-. Plants responding to this element include tobacco, tomatoes, sugar beets, buckwheat, peas, lettuce, cabbage, carrots, barley, corn, potatoes and cotton. In nutrient cultures, it has been shown that chlorine deficiency is associated with reduced root growth. Its deficiency under field conditions has not been reported.

Cobalt:

Cobalt is required by Phizobia for the fixation of elemental nitrogen. It helps in synthesis of vitamin B_{12}.

Representation

Different plants showing deficiency and excess of any element will be shown to the trainees. The slide set "Nutrient deficiency symptoms of crops" will be shown.

APPLICATION

Each trainee will examine 2-3 crops in the field according to the season and judge the deficiency of certain elements, if any.

QUESTIONS

1 - What is an essential element?

2 - What is a fertilizer element?

3 - What do you mean by macro and micro elements?

4 - What are the functions of N, P and K in the plant?

5 - Describe the deficiency symptoms of Zn and P on rice and maize, respectively.

Subject: FERTILIZER NUTRIENTS IN THE SOIL

Trainer Soil Scientist
Class Room 2 hours
Field 0 Days

OBJECTIVES

To gain an understanding of how fertilizers react in the soil and factors that affect their uptake by plants.

MATERIALS NEEDED

16mm sound projector and screen.

TRAINING AIDS

16mm movie film with sound track "Water Movement in Soil" by W.R. Gardner, Washington State University.

INTRODUCTION

It is a well established fact that we cannot achieve maximum production without applying commercial fertilizers to most crops. With the application of fertilizers on accompanying improvement in other cultural practices such as using recommended varieties, proper irrigation practices and pest management must be integrated into the cultural system or the benefit of the commerical fertilizer will not be realized. This relationhip should not be forgotten.

PRESENTATION

Fertilizer-Soil Reactions

The basic assumption for applying fertilizers is that they will add nutrients needed for crop growth and increase fields. Once fertilizers are applied, a host of reactions occur between compounds in the fertilizer and the soil. The more important ones affecting fertilizer use-efficiency are discussed below.

Nitrogen

Ammonification is the biological conversion of organic nitrogen, such as in proteins, to ammonium (NH_4^+) nitrogen. The process occurs stepwise:

$$\text{Protein} + H_2O \xrightarrow{\text{Bacteria}} \text{Amino acids} +$$

$$H_2O \xrightarrow{\text{Bacteria}} NH_4^+$$

It also is the enzymatic process that converts urea to ammonium nitrogen.

$$CO(NH_2)_2 + H_2O \underset{\text{(enzyme)}}{\xrightarrow{\text{urease}}} NH_4^+$$

Other steps are involved in urea hydrolysis but the basic process is that of urease (an enzyme universally present in soil) acting on urea. Under moist, warm conditions, conversion of urea to ammonium nitrogen can be complete in one or two days following application.

Ammonia adsorption occurs immediately when anhydrous ammonia is applied or when urea is hydrolyzed. Once gaseous ammonia is converted to NH_4^+,

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

it is adsorbed by the soil like other cations. This adsorption largely accounts for the fact that ammonium nitrogen is resistant to leaching.

The process of ammonium ion formation produces hydroxyl ions (OH^-). These are basic ions and account for the sharp increase in soil pH in the ammonia band immediately following application. However, the pH in this zone quickly drops as nitrification occurs.

Nitrification is the bacterial conversion of ammonium nitrogen to nitrate nitrogen (NO_3).

$$NH_3 \xrightarrow{\text{Nitrosomonas}} NO_2^- \text{ (nitrite)} + 3H^-$$

$$NO_2 \xrightarrow{\text{Nitrobacter}} NO_3^- \text{ (nitrate)}$$

The two-step oxidation process (one that provides energy for bacteria) goes on simultaneously in warm, well-drained soils. Consequently, nitrite nitrogen--which can be toxic to some plants--exists for only a short time.

The by-product of nitrification, hydrogen ions, contributes to soil acidity. This condition accounts for the reason that all forms of ammonium nitrogen when nitrified have an acidifying effect--an effect which requires approximately 1.8 pounds of pure calcium carbonate to neutralize the acidity produced by one pound of ammonium nitrogen.

Several conditions favor nitrification--presence of oxygen (well-aerated soils), warm temperatures (70-95°F) and a soil pH of about 6.5 or slightly above.

The characteristic of nitrification being "temperature dependent" explains why fall application of ammonium nitrogen to soils subject to leaching (low CEC) is not recommended. As long as nitrogen stays in the ammonium form, it is adsorbed to the soil colloids and not lost by leaching.

Denitrification, as the name implies, is essentially the reverse of nitrification and occurs under opposite conditions.

When soil pore spaces are full of water, oxygen and other gases are excluded. Under such waterlogged or anaerobic conditions, certain bacteria utilize nitrate nitrogen for the same purposes as oxygen. They do not utilize the oxygen in the nitrate ion because it is in the wrong chemical form. Instead, they use the nitrogen in place of oxygen with resulting conversion of nitrogen into gaseous forms. Essentials of the process are:

Bacteria

$$\underset{\text{(Nitrate)}}{NO_3^-} \rightarrow \underset{\text{(Nitrite)}}{NO_2^-} \rightarrow \underset{\text{(nitrous oxide-gas)}}{N_2O} \rightarrow \underset{\text{(elemental N-gas)}}{N_2}$$

$$NO_2^- \downarrow \underset{\text{(Nitric oxide-gas)}}{NO}$$

Warm temperatures, a large supply of oxidizable carbon compounds, a high pH, and a large bacterial population favor denitrification when oxygen is in short supply.

There is an important point regarding denitrification. Only nitrate nitrogen can be denitrified. Ammonium nitrogen cannot be denitrified.

Ammonia Volatilization

Volatilization losses of ammonia from urea and ammonium nitrate may also occur under exceptional conditions. These conditions usually evolve surface applications to low cation exchange capacity soils that are dry and hot. The magnitude of this loss is very difficult to assess and is probably more of a worry than a reality under most conditions. It is alleviated by shallow incorporation of the applied N.

Phosphorus

Commerical fertilizers contain highly soluble phosphorus compounds, some approaching 100 percent water solubility. Such phosphorus quickly combines with a variety of constituents of a moist soil.

Largely because of the high "reactivity" of soluble phosphorus, it moves only a short distance (usually less than an inch) from the point of application. Hence, the volume of soil enriched from applied phosphorus is small, and tends to be less with row applications than with broadcast materials.

Reversion in high-calcium soils, particularly those containing free calcium carbonate, is a process which converts fertilizer phosphorus into tricalcium phosphate, a form similar to phosphate rock. This phosphate form has a low level of availability to plants.

Reverted phosphorus is not lost forever to plants, but may be available slowly. Such phosphorus will show up in soil tests with acid extractants. For this reason, special soil tests (usually bicarbonate methods) are necessary for calcareous soils.

Potassium

Potassium does not react in soils to form compounds such as is the case with phosphorus. Potassium available to plants is present in the soil solution or adsorbed on the surface of soil colloids. When displaced from exchange sites on soil colloids it is released into the soil solution and ready for plant absorption.

Some clay minerals have the ability to fix potassium by physically trapping it within or between clay particles. This "fixed" potassium may be replaced by other cations--such as the ammonium ion, similar in charge and size--and released back to the soil solution.

When present in the soil solution, potassium is mobile and subject to leaching. However, potassium concentrations in the soil solution at any one time are usually quite low, and thus, leaching losses are slight except on sandy, low-exchange-capacity soils.

Sulfur

Sulfur resembles nitrogen in many respects. It is a part of organic matter, it undergoes transformations by bacteria and as an anion (SO_4^{2-}) is highly subject to leaching.

Mineralization is the bacterial process of converting organic sulfur into inorganic forms of sulfur. Most soil sulfur is in the organic form and mineralization is important to convert it to an inorganic form which plants can absorb (sulfate).

Sulfofication is the bacterial oxidation of reduced sulfur (elemental S, sulfides) to sulfate. Like nitrification, it is an acid-forming process. It, likewise, is favored by plenty of oxygen, high temperatures, adequate moisture, and a high bacterial population.

The acid-producing effect of sulfofication is the reason why elemental sulfur is used on alkali soils and others to lower pH, or increase acidity. The process is illustrated below.

$$S + H_2O + O_2 \xrightarrow{\text{Bacteria}} H_2SO_4$$

Desulfofication, like denitrification, occurs in waterlogged soils with a shortage of oxygen. Warm temperatures, plenty of oxidizable carbon such as in crop residues, and a large number of appropriate organisms favor the process. The process generates hydrogen sulfide, H_2S , a gas which can escape from the soil.

Sulfate adsorption is similar to phosphate adsorption by clay minerals and iron compounds, but occurs to a lesser extent. Normally, sulfate is fairly mobile, tending to leach with percolating water. Thus, sulfate adsorption is of practical importance because of reduced susceptibility to leaching.

Calcium and Magnesium

These elements, like potassium, exist as cations or as insoluble portions of soil minerals. The available forms, Ca^{--} and Mg^{--}, are adsorbed on soil colloids. By cation exchange, they pass through the soil solution before being absorbed by plants.

APPLICATION

Discuss the best method of applying fertilizer to the soils of your area and the best forms with the trainer and other trainees.

QUESTIONS

1 - What will happen if you apply all N at sowing to wheat in a sandy soil?

2 - What forms of N are subject to leaching?

3 - What happens to P availability in a calcareous soil?

Subject: MAKING FERTILIZER RECOMMENDATIONS

Trainer Soil Scientist
Class Room 2 hours
Field 0 Days

OBJECTIVES

To understand the proper fertilizer recommendations for most of the crops grown in the country and develop a knowledge of soil testing.

MATERIALS NEEDED

Samples of different fertilizers and soil sample collection equipment.

TRAINING AIDS

1 - Slides and photographs of fertilizer application operations.

2 - "Handbook of Fertilizers" hand out one to each student.

3 - Slide set "Taking soil samples for Fertilizer Recommendations" by the Potash Institute.

INTRODUCTION

Fertilizers and manures enable the farmers to increase production and get higher returns. Perhaps more important on many soils, they make possible good yields of many valuable crops which would not grow without fertilizers. Fertilizers are often regarded as substitutes for animal manures. From the plant nutrient standpoint, this is true, but animal manures also improve the soil condition. Commercial fertilizers supply extra nutrients and improve fertility.

PRESENTATION

The factors for successful farming and the efficiency use of fertilizers are:

1. There should be a satisfactory balance among the major land uses.

2. There should be a well planned cropping system, i.e., rotation system than monoculture. Improved and disease resistant varieties should be used.

3. Cultural operations should be proper and timely.

4. There should be an organized and planned system of water use and drainage.

5. A system for the conservation and use of organic matter is necessary.

6. Soil amendments should be used if necessary.

7. A system of fertilizer use should be developed with the other practices to make possible the best combination of crops and to assure higher yields.

Potential Use of Soil Testing

Although soil testing is not used much in Pakistan, you should have some knowledge of its use and potential. Government laboratories are presently analyzing soil samples and after you can initiate a demonstration in cooperation with these government workers in order to educate the farmer as to the potential for soil testing. Once he has been convinced he may start to use the government laboratory to test his soil and make fertilizer recommendations.

1. Considerations in Soil Testing

If soil tests are to answer questions of how much fertilizer to apply, then all aspects of such programs must be continually updated. In many cases, field correlations between lab data and crop responses have not kept pace with other advancements.

Analyzing soils for nutrient availability generally involves two approaches. First, there are measurements of the total amount of the nutrient, or a particular form, at the time of sampling, as in nitrate nitrogen where sampling is usually deep enough to represent the crop rooting depth.

Secondly, most soil test procedures measure only a portion of the total available supply of nutrients. Extracting solutions remove certain fractions of the nutrient(s) of concern. The chemistry of reactions of these soil test solutions, ratios of extracting solutions to soil, length of shaking time and other factors influence the quantity of each nutrient removed. The amount of extracted nutrients is then correlated with crop yield increases from fertilizer treatments in field experiments.

Soil samples usually are taken from the cultivated plow depth. Thus, only a part of the total available supply of nutrients is represented by the sample. Success, then, of soil test correlations depends upon carefully conducted field experiments.

As crop genetics change, greater yielding capability is added and soil test correlations need updating. All these factors affect soil test correlations.

Within certain limits, correlation information can be extended to similar soils and climatic conditions. However, great care is needed in making extrapolations prepared from these correlations for there is no substitute for field experiemnts. The simplest approach to correlation is single-nutrient experiments as shown in Figure 1. This simply says that it takes more fertilizer to produce a high yield on a "low" testing soil than on one testing "medium".

Experiments which have yield limitations caused by disease, poor stand, low-yielding varieties, etc., should be eliminated from soil test correlations. Or, data should be grouped by such conditions to reflect different production or management problems.

Fertilizer Guide sheets are the main instruments for interpretation of soil tests and should:

1. Refer to a specific crop under specific management such as "Irrigated Winter Wheat".

2. Restrict interpretations to regions and soils with similar soil test correlations.

3. Contain tables of soil test values and ranges of nutrient rates, also modifying statements to assist with interpretations.

4. Show sources of information, soil test methods, and authorship.

5. Consist of a single, up-to-date sheet.

More complicated approaches must be used when interactions occur among different nutrients, stored soil water and expected precipitation.

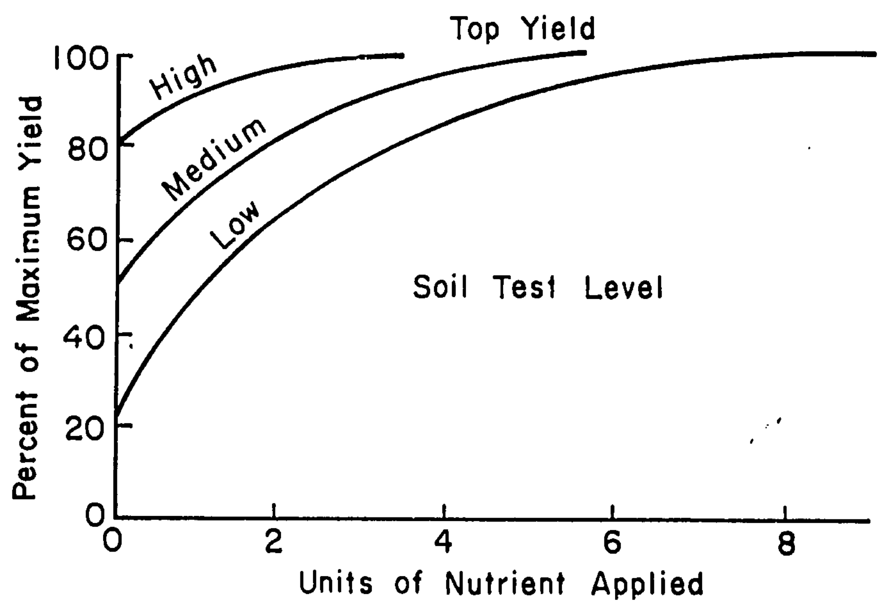


Figure 1. Yield Responses From Fertilizer Nutrient Additions at Low, Medium, and High Soil Test Levels.

2. Basic Soil Sampling Rules

(a) Keep accurate records. Always be sure to keep the records accurately so the field or area can be identified.

(b) Use the right tools. Soil tubes, augers, and spades are the most frequently used tools for sampling soil. These tools work well for plot depth and with extensions can be used for subsoil samples.

(c) Each sample must represent a UNIFORM soil area. That means a narrow slope range, similar soil color, texture, and depth. Look for other indicators of uniformity or variability such as crop height and yield, tough plowing, stones, dead furrows, fence rows, wet or salty spots, eroded knobs, ditches, etc. You may need more than one sample to represent the field.

Variability in fields and poor sampling probably are the cause of more errors in fertilizer use decisions than any other. These variations include:

1. Horizontal - natural or inherent soil fertility differences from place to place across a field.
2. Vertical - change in fertility with depth.
3. Variation in sampling technique (human factor of judgement as to exact details of sampling). This is one of the big sources of differences between samples taken by different people.
4. Sloppy sampling techniques - failure to clean sampling tool between samples - allowing surface soil to slough down into sample hole before taking next sample when sampling subsoils.
5. Contamination.
6. Sample splitting - inadequate mixing and subsampling.
7. Changes during sample shipment and storage alter nitrate and sulfate content due to biological breakdown of organic matter.

8. Physical changes during drying process (movement of mobile nutrients or salts to sample surface during drying).

9. Mineralogical changes during drying. Drying, especially at above room temperatures, can cause potassium fixation or release.

(d) Sample to right depth. This depends upon the problem you are trying to diagnose. Samples are usually taken from plow depth or to six inches in noncultivated fields. In addition, subsoil samples from six to 12 or 18 inches deep will help to better characterize the soil.

Salts move up and down according to drying and wetting cycles, and plow depth samples will provide only part of the needed information. If there are excess salts, draining and leaching are usually needed. However, for sodium it is necessary to run enough analyses to determine the amount of gypsum or other suitable amendments required to correct the problems.

(e) Mix 20 to 25 cores thoroughly in a clean plastic pail for each sample to send the lab. A greater number of cores will minimize the effect of accidentally sampling a spot where fertilizer was spilled or a salty area not visible at time of sampling.

(f) Package samples as instructed. Usually a one-pound sample is enough to send the lab. But, be sure to crumble the soil and mix well to insure a good sample. If the soil does not crumble easily, dry and then mix.

Air drying should be done before mailing to eliminate biological changes in nitrate nitrogen and sulfate sulfur. The kinds of tests to be run dictate how to handle samples. Again--follow laboratory instructions.

The slide set entitled, "

3. Basic Fertilizer Recommendations

Since soil testing is not always, or is rarely, available for use in making fertilizer recommendations, the basic fertilizer recommendations for most crops grown in any sizable acreage is shown in Table 1. The most impor-tnat consideration in using this table is "Soil Fertility Level" of the field. Lower than average yielding fields should be considered as "low" fertility level and fields that historically yield much higher than the acreage for the area are classified "high" in fertility level. A fertile soil would be on that has produced better than average yields over the years but not out-standing yields as a high fertility field would.

APPLICATION

Guidance of the farmers on the use of fertilizers to increase their efficiency by applying fertilizers at the proper time should be discussed with the other trainees. Make a fertilizer recommendation outline for an entire year for an average farm from your area. Discuss it with the trainer.

QUESTIONS

1. Give the optimum does of N, P and K for the following crops on low fertile soils: wheat, cotton, sugar cane, berseem.
2. What are the advantages of soil testing?
3. Do you feel soil testing is practicable for the average farmer? Why?

Table 1. Basic Fertilizer Recommendations for Various Crops.

No.	Name of Crop	Soil Fertility Level	Time of Applications	Nutrients in lb/acre N	P_2O_5	K_2O	Method of Application	Remarks
1.	Wheat (medium saturated varieties)	a. High		Nil	Nil	Nil		When the expected yield is 50-55 mds/acre, without fertilizers.
		b. Fertile	(i) At sowing	50	60	Nil	To be broadcast and mixed in the soil, planked and sowing is completed.	When the expected yield is 35-40 mds/acre, without fertilizers.
		c. Medium	(ii) With 1st or 2nd irrigation	50	Nil	Nil	To be broadcast at 1st or 2nd irrigation.	
		c. Medium	(i) At sowing	60	75	Nil	As in (b)	When the expected yield is 25-30 mds/acre, without fertilizers.
			(ii) With 1st or 2nd irrigation	60	Nil	Nil	As in (b)	When the expected yield is less than 15 mds/acre, without fertilizers.
		d. Low	(i) At sowing	75	75	Nil	As in (b)	General Comment for all Recommendations For local wheat varieties, the quantity of fertilizer is 1/2 of what given in the chart. For sandy soil and in the areas of rice, sugarcane and berseem application of 40-50 lbs/acre of K_2O is also recommended. For light (sandy) soil the application of N may split into more than two doses
			(ii) With 1st or 2nd irrigation	75	75	Nil	As in (b)	
	(Late sowing)	Any	At sowing	125	75	Nil	To be broadcasted and mixed with soil.	
	(Barani)	a. Medium	At sowing	50	40	Nil	To be broadcasted and mixed with soil.	
		b. Low	At sowing	75	40	Nil	To be broadcasted and mixed with soil.	
2.	Sugarcane (Fresh crop)	a. Fertile	(i) At sowing	50-60	50-60	40-50	To be drilled three inches away from the seed furrow.	Application of 10 cart loads of farm yard manure should be done during bed preparation.
			(ii) Middle of May	50-60	Nil	Nil	To be broadcasted after being followed by irrigation.	Application of 10 cart loads of farm yard manure should be done during bed preparation.

Table 1. (continued)

No.	Name of Crop	Soil Fertility Level	Time of Applications	Nutrients in lb/acre N	P_2O_5	K_2O	Method of Application	Remarks
		b. Medium	(i) At sowing	40-50	60-75	50-60	As in (a)	Application of 10 cart loads of farm yard manure should be done during bed preparation
			(ii) Middle of May	40-50	Nil	Nil	As in (a)	
			(iii) End of June	40-50	Nil	Nil	To be broadcast and followed by irrigation.	
	(Ratoon crop)	All	(i) March	50-60	75-90	50-60	To be drilled three inches away from the seed furrow.	
			(ii) Middle of May	50-60	Nil	Nil	To be broadcast after hoeing and followed by irrigation.	
			(iii) End of June	50-60	Nil	Nil	To be broadcast after hoeing and followed by irrigation.	
3.	Rice (Local varieties, Bas-mati-370 and Jhona-349, etc)	a. Fertile	(i) At puddling	30	30	30	Broadcast.	
			(ii) After 40-50 days of trans-planting	30	Nil	Nil	Broadcast.	
		b. Medium	(i) At puddling	30-45	Nil	Nil	Broadcast.	
			(ii) After 40-50 days of trans-planting				Broadcast.	
	(IRRI-PAK)	a. Fertile	(i) At puddling	50	50	50	Broadcast.	
			(ii) After 40-50 days of trans-planting	50	Nil	Nil	Broadcast.	
		b. Medium	(i) At puddling	75	75	50	Broadcast.	
			(ii) 40-50 days after trans-planting	75	Nil	Nil	Broadcast.	
4.	Maize (local varieties)	a. Fertile	(i) At sowing	40	40	Nil	To be drilled 2-3 inches away from the seed furrow and 1/2 inch deeper than the seed.	During seed bed preparation addition of ten cart loads of FYM is highly effective.

Table 1. (continued)

No.	Name of Crop	Soil Fertility Level	Time of Applications	Nutrients in lb/acre N	P_2O_5	K_2O	Method of Application	Remarks
4.	(Hybrid/synthetic varieties)	b. Medium	i) At sowing	60	50	Nil	To be drilled 2-3 inches away from the seed furrow and 1/2 inch deeper than the seed.	
		a. Fertile	i) At sowing	40-50	60	Nil	To be drilled 2-3 inches away from the seed furrow and 1/2 inch deeper than the seed.	
			ii) When crop is 2½-3½ ft. high	40-50	Nil	Nil	To be broadcast near the crop furrows followed by irrigation.	
		b. Medium	i) At sowing	60-75	60-75	Nil	To be drilled 2-3 inches away from the seed furrow and 1/2 inch deeper than the seed.	
			ii) When crop is 2½-3½ ft. high	60-75	60-75	Nil	To be broadcast near the crop furrows followed by irrigation.	
5.	**Cotton**	a. Fertile	i) At sowing	Nil	30	Nil	To be drilled 2½-3 inches away from the seed furrow and ½ inch deeper than the seed.	
			ii) At preflowering stage	50	Nil	Nil	To be broadcast near the crop line after hoeing followed by irrigation.	
6.	Oilseeds, (Torya, Rays, Sarson)	a. Medium	i) At sowing	50	40	Nil	To be drilled 2½-3 inches away from the seed furrow and ½ inch deeper than the seed.	
			ii) At 1st irrigation	30	Nil	Nil	To be broadcast followed by irrigation.	
7.	Sunflower	a. Fertile	i) At sowing	30-45	Nil	Nil	To be drilled 2½-3 inches away and ½ inch deeper than the seed.	
			ii) When the crop is 2½ ft. high	30-40	Nil	Nil	To be broadcast followed by irrigation.	
8.	Berseem and Lucern	a. Fertile	i) At sowing	20	50-60	Nil	To be broadcast and mixed in the soil.	
		b. Medium	At sowing	30	75-90	Nil	To be broadcast and mixed in the soil.	
9.	Groundnut	All	At sowing	25-30	54-50	Nil	To be broadcast and mixed in the soil.	Nitrogen for groundnut, gram, mung and mash is recommended to increase initial growth.
10.	Gram	All	At sowing	25-30	25-30	Nil	To be broadcast and mixed in the soil.	

Table 1. (continued)

No.	Name of Crop	Soil Fertility Level	Time of Applications	Nutrients in lb/acre N	P_2O_5	K_2O	Method of Application	Remarks
11.	Mung and Mash	All	At sowing	25-30	30-40	Nil	To be broadcast and mixed in the soil.	
12.	Jute	Medium	At sowing	50	30	Nil	To be broadcast and mixed in the soil.	
13.	Cats	Medium	i) At sowing	35	40	Nil	To be broadcast and mixed in the soil.	
			ii) At 1st irrigation	40	Nil	Nil	To be broadcast followed by irrigation.	
14.	Bajra	Medium	At sowing	60	30	Nil	To be broadcast and mixed in the soil.	
15.	Barley (short statured 568!) Medium height, C-141		At sowing	75	50	Nil	To be broadcast and mixed in the soil.	
16.	Potato	Medium	i) At sowing	100	100	100	To be broadcast and mixed with soil ridges be made seed be sown.	10 cart loads of farm yard manures to be applied seed bed preparation.
			ii) At 1st earthing up	100	0	0	To be broadcast and mixed with soil by sowing and earthed up, followed by irrigation.	
17.	Carrots	Medium	At sowing	50	25	50	To be broadcast and mixed in the soil, planked and sowing be done	15-20 cart loads of farm yard manures per acre should be applied at seed bed preparation
18.	Radish	Medium	At sowing	50	50	0	To be broadcast and mixed in the soil, planked and sowing be done.	15 cart loads of farm yard manure should be applied at seed bed preparation
19.	Turnips	Medium	At sowing	50	50	0	To be broadcast and mixed in the soil, planked and sowing be done.	15 cart loads of farm yard manure should be applied at seed bed preparation
20.	Spinach	Medium	At sowing	60	30	0	To be broadcast and mixed in the soil, planked and sowing be done.	15 cart loads of farm yard manure should be applied at seed bed preparation

Table 1. (continued)

No.	Name of Crop	Soil Fertility Level	Time of Applications	Nutrients in lb/acre N	P_2O_5	K_2O	Method of Application	Remarks
21.	Methi	Medium	At sowirg	60	30	0	To be broadcast and mixed in the soil, planked and sowing be done.	15 cart loads of farm yard manure should be applied at seed bed preparation.
22.	Lettuce	Medium	At sowing	30	30	30	To be broadcast and mixed in the soil, planked and sowing to be done.	15 cart loads of farm yard manure should be applied at seed bed preparation.
23.	Cauliflower	Medium	i) At transplanting	30	60	0	To be broadcast and mixed in the soil, planked and sowing be done.	25 cart loads of farm yard manure should be applied at seed bed preparation.
			ii) 1½-2 months after transplanting	30	0	0	Should be mixed with soil, followed by earthing and irrigation	15 car loads of farm yard manure should be applied at seed bed preparation
24.	Cabbage	Medium	i) At transplanting	50	20	0	To be broadcast and mixed with soil and ridges should be made and seedling be transplanted.	
25.	Peas	Medium	i) At sowing	25	50	0	To be broadcast and mixed with soil and ridges should be made and sowing be completed.	15 cart loads of farm yard manure should be applied at seed bed preparation.
			ii) 2 months after sowing	25	0	0	To be broadcast, mixed by hoeing and earthed up on ridges, followed by irrigation.	15 car loads of farm yard manure should be applied at seed bed preparation.
26.	Tomatoes	Middle	i) At transplanting	30	60	0	As for peas at No. (i)	15 cart loads of farm yard manure should be applied at seed bed preparation.
			ii) 1½ months after transplanting	30	0	0	As for peas at No. (ii)	15 cart loads of farm yard manure should be applied at seed bed preparation.
27.	Brinjals	Medium	At transplanting	30	30	0	To oe broadcast, mixed in the soil, ridges be made and sowing be done.	15 cart loads of farm yard manure should be applied at seed bed preparation.
28.	Chillies	Medium	At transplanting	30	30	0	To be broadcast, mixed in the soil, ridges be made and sowing be done.	15 cart loads of farm yard manure should be applied at seed bed preparation.

Subject: SALT AFFECTED SOILS

Trainer Soil Scientist
Class Room 2 hours
Field 0 Days

OBJECTIVES

1 - To be able to diagnose a salt affected soil.

2 - To determine the methods of improvement and management of salt affected soils.

MATERIALS NEEDED

Samples from salt affected soils, distilled water, Universal indicator, conical flask test tube, filter paper, conductivity meter.

TRAINING AIDS

Slides showing steps involved in diagnosis and improvement of salty soils. Photographs of salt affected soils and plants growing on these soils.

PRESENTATION

The Classification of Salt Affected Soils

Saline Soils:

These include soils containing sufficient amounts of soluble salts to interfere with the germination, growth and yield of most crop plants, but not containing enough exchangeable sodium to alter soil characteristics appreciably. Technically, a saline soil is defined as a soil having electrical conductivity of the saturation extract equal to or greater than 4 mmhos per centimeter and an exchangeable sodium percentage less than 15, pH is usually less than 8.5. Because of the presence of white salt incrustation on the surface, such soils are also called solonchaks or white alkali soils. When adequate drainage is established, the excessive soluble salts may be removed by leaching and they again become normal soils. These soils are flocculated and their permeability is either equal or greater than those of similar normal soils.

Saline-Sodic Soils

These soils contain soluble sodium salts in sufficient quantity to interfere with the growth of most crop plants. Technically, a saline-sodic soil is defined as a soil having exchangeable sodium percentage greater than 15 and the electrical conductivity of the saturation extract exceeds 4 millimhos per centimeter. The pH is seldom higher than 8.5. In the presence of excess soluble salts their appearance is similar to saline soils and remains flocculated. If the excess soluble salts are leached out, in the absence of gypsum, the soil becomes a sodic soil.

Sodic Soils

These soils contain sufficient exchangeable sodium to interfere with growth of most crop plants but do not contain appreciable quantities of soluble salts. Technically, the exchangeable sodium percentage is greater than 15 and the electrical conductivity of the saturation extract is less than 4 millimhos per centimeter. The soil colloids are generally deflocculated, drainage and aeration are poor. The pH ranges between 8.5 and 10. These soils are also called black alkali or solonetz soils.

Reclamation of Salt Affected Soils

The chemical and physical analysis of soils provides a basis for the diagnosis, treatment and management of salt affected soils. After diagnosing the problem and before actual reclamation, two steps must be observed.

1. Establishing adequate drainage in the area. Water table must be lowered if it is presently high. The water should be at least 3-4 meters below the surface.

2. Level the lands so that surface of soil may be covered uniformly with water.

Saline Soil

If soil is only saline, it can be reclaimed simply by leaching the exc salts below the root zone. The quantity of water depends upon the texture of soil, concentration of salts and amount of salts to be leached. On an average, 0.75 to 1.25 meters of water is required for good results.

Correcting Problem Soils With Amendments

The presence of lime (free calcium carbonate) in the soil allows the widest selection of amendments. To test for this, a simple procedure can be followed by taking a spoonful or clod of soil and dropping a few drops of muriatic or sulfuric acid on it. If bubbling or fizzing occurs, this indica the presence of lime.

If the soil contains lime, any of the amendments listed in Table 1 may be used. If lime is absent, select only those amendments containing soluble calcium.

TABLE 1. Commonly Used Materials and Their Equivalent Amendment Values.

Material (100% Basis)	Chemical Formula	Tons of Amendment Equivalent to 1 Ton of Pure Gypsum	Tons of Amendment Equivalent to 1 Ton of Soil Sulfur
Gypsum	$CaSO_4 \cdot 2H_2O$	1.00	5.38
Soil sulfur	S	0.19	1.00
Sulfuric acid	H_2SO_4	0.61	3.20
Ferric sulfate	$Fe_2(SO_4)_3 \cdot 9H_2O$	1.09	5.85
Lime sulfur	CaSx	0.78	4.17
Calcium chloride	$CaCl_2 \cdot H_2O$	0.86	--
Calcium nitrate	$Ca(NO_3)_2 \cdot H_2O$	1.06	--
Aluminum sulfate	$Al_2(SO_4)_3$	--	6.34

The percent purity is generally given on the bag or identification tag.

Types of Amendments

Calcium-containing amendments, such as gypsum, react in the soil as follows:

gypsum + sodic soil → calcium soil + sodium sulfate

Leaching is essential in removing the sodium salt, the amount dependent upon the severity of the alkali problem.

Acids such as sulfuric acid require two steps:

1. sulfuric acid + lime → gypsum + carbon dioxide + water
2. gypsum + sodic soil → calcium soil + sodium sulfate

The acid-forming materials such as sulfur go through these steps. First, oxidation:

1. sulfur + oxygen + water → sulfuric acid
2. sulfuric acid + lime → gypsum + carbon dioxide + water
3. gypsum + sodic soil → calcium soil + sodium sulfate

Effectiveness of Amendments

The values given in Table 1 are for 100 percent pure amendments. If an amendment is not pure, a simple calculation will indicate the amount needed to be equivalent to 1 ton of pure material:

$$\frac{100}{\%\ \text{purity}} = \text{tons}$$

Example: If gypsum is 60 percent pure, the calculation would be $\frac{100}{60}$ = 1.67 tons, or 1.67 tons of 60 percent gypsum would be equivalent to 1.00 tons of 100 percent pure gypsum.

When considering sulfur, the purity and degree of fineness must be taken into account. Most sulfur is over 99 percent pure. Sulfur must be oxidized before it is effective as an amendment. The finer the material, the faster it will be oxidized in the soil.

MANAGEMENT OF SALINE AND ALKALI SOILS

Often it is not practical to completely reclaim saline or alkali soils or even to maintain these soils at a low saline or alkali condition. The reasons may be cost of reclamation, inability to adequately drain, high cost of amendments, low quality irrigation water, etc.

Management practices that aid in the control of salinity and alkalinity include:

1. Selection of crops or crop varieties that have tolerance to salt or alkali.
2. Use of special planting procedures that minimize salt accumulation around the seed.
3. Use of sloping beds or special land preparation procedures and tillage methods that provide a low alt environment for the germinating seed.
4. Use of irrigation water to maintain a high water content to dilute the salts or to leach the salts out of the germination and root growing zone.
5. Use of physical amendments for improving soil structure.
6. Deep ripping the soil to break up hardpan or other impervious layers to provide internal drainage.
7. Use of chemical amendments as described.

It is essential to know the nature of soil, both physical and chemical, the quality and quantity of irrigation water available, the climate of the area including the growing season, the economics of the situation, etc., before a satisfactory management program can be developed. Consulting with the appropriate authorities and having suitable tests made are essential steps in management.

Factors that Modify the Effect of Exchangeable Sodium on Soils

It is expected that sodic soils having similar exchangeable Na percentage may vary considerably with respect to their physical properties, their ability to produce crops and their response to management practices. Although the reason for variable behavior of sodic soils are not well understood, experience and limited data indicate that the adverse effect of exchangeable Na may be modified by several soil characteristics.

Texture of the Soil

It is well known that distribution of particle sizes influence the moisture retention and transmission properties of water in the soil. As a rule, coarse textured soil have low moisture retention and high-permeability where as fine textured have high moisture retention and generally have lower permeability.

In general, the physical properties of fine textured soils are affected more adversely at a given exchangeable Na^+ percentage than coarse textured soils.

Surface Area and Type of Clay Mineral

It is generally recognized that soils containing clay of expanding lattice type exhibit such properties as swelling, plasticity and dispersion to a greater extent than soils containing equivalent amounts of nonexpanding lattice clay, especially when appreciable amounts of exchangeable Na^+ are present.

Organic Matter

Organic matter has a favorable effect upon the physical properties of soils. There is considerable evidence that organic matter tends to reduce the unfavorable effect of exchangeable sodium on soils.

APPLICATION

Most of the area of Pakistan lies in arid and semiarid zones; high ground water has caused many acres or soils to become salty and unproductive. Diagnosing the problem and helping the farmers in improving and managing soils a major problem and can yield great results if undertaken properly. A laboratory exercise will be undertaken to determine soil salinity on some soil samples and methods of reclamation outlined for each soil.

QUESTIONS

1 - What is a salt tolerant crop? Which crops will you recommend for waterlogged areas?

2 - How will you reclaim sodic soils?

3 - What should be the optimum depth of water table?

4 - If you cannot apply an amendment, how can you reduce the toxic effects of sodium?

Subject: QUALITY OF IRRIGATION WATER

Trainer Soil Scientist
Class Room 2
Field 0 Days

OBJECTIVES

1 - To learn the factors that influence irrigation water quality and the effect of water quality on crop production.

2 - To learn how to classify irrigation water for their salinity hazard and effects on crops.

MATERIALS NEEDED

1 - Plants from greenhouse or field that have been damaged by poor quality irrigation water.

2 - Soils that have been irrigated with good and poor quality irrigation water.

TRAINING AIDS

Slides of salt affected plants and soils.

INTRODUCTION

There are four basic criteria for evaluating water quality for irrigation purposes:

1. Total soluble salt content (salinity hazard).
2. Relative proportion of sodium cations (Na^+) to other cations (sodium hazard).
3. Concentration of elements that may be toxic.
4. Bicarbonate anion (HCO_3^-) concentration as related to calcium (Ca^{++}) plus magnesium (Mg^{++}) cations.

There also are many nonwater factors that must be considered in deciding the usefulness of water for a specific situation. These include soil texture and structure, drainage conditions, gypsum and lime content of the soil, salt and sodium tolerance of the crop and irrigation method and management.

PRESENTATION

Salinity Hazard. One of the hazards of irrigated agriculture is the possible accumulation of soluble salts in the root zone. Some plants can tolerate more salts than others, but all plants have a maximum tolerance. With reasonably good irrigation practices, the salt content of the saturation extract of soil is 1.5 to 3 times the salt content of the irrigation water. Where ample water is used to remove excess salt from the root zone, the salt level in the saturation extract is about 1.5 times that of the irrigation water. Where water is used more sparingly, there may be 3 times as much salt.

An acre-foot of water (the amount of water covering one acre, one foot deep) weighs approximately 2,720,000 pounds; therefore, 1 ppm of a salt in an acre-foot of water weighs 2.72 pounds. This means that one acre-foot of water containing only 735 ppm (EC = 1.15 mmhos/l) carries one ton of salt!

With ordinary irrigation methods, there is some leaching, hence, the accumulation of salts in the soil water is reduced but not eliminated. Before a critical assessment of the salinity hazard of any irrigation water is made, it is necessary to know how much salt the crop can tolerate and how much leaching is needed to maintain the desired salt level in the soil water.

Plants can tolerate a higher salt content in the lower root zone than was previously believed possible, hence the leaching requirement (percent of water needed for leaching) may be reduced. Figures 1, 2 and 3 show the crop tolerance for several crops.

Growers rotating crops must provide enough leaching, so that damage to the most salt-sensitive crop in the rotation will be at a minimum.

With reasonable irrigation practices, there should be no salinity problems with irrigation water with an EC of less than 0.75 mmhos/cm. Increasing problems can be expected between EC 0.75 and 3.0 mmhos/cm. An EC greater than 3.0 will cause severe problems except for areas restricted to only a few salt-tolerant crops. If salinity problems are inevitable cultural practices such as bed and furrow modification may be helpful as demonstrated in Figure 4.

It has generally been assumed that the effects of a saline water could be offset by increasing the amount of leaching so that the average salt content of the root zone would not be increased. The U.S. Salinity Laboratory has demonstrated that yields of alfalfa (and probably other crops) is governed not by average soil salinity but primarily by the salinity of the irrigation water. Yields were reduced as the salinity of the water increased no matter how much leaching was done. With this in mind, the practice of blending saline drain waters with low-salt irrigation waters needs to be used.

Table 1 presents the basic guidelines for water use relative to its salt content.

Sodium Hazard. The sodium hazard of irrigation water usually is expressed as the sodium adsorption ratio (SAR). This is the proportion of Na^+ to Ca^{++} plus Mg^{++} in the water. The following formula is used to calculate SAR:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Figure 1. Salt Tolerance of Vegetable Crops*

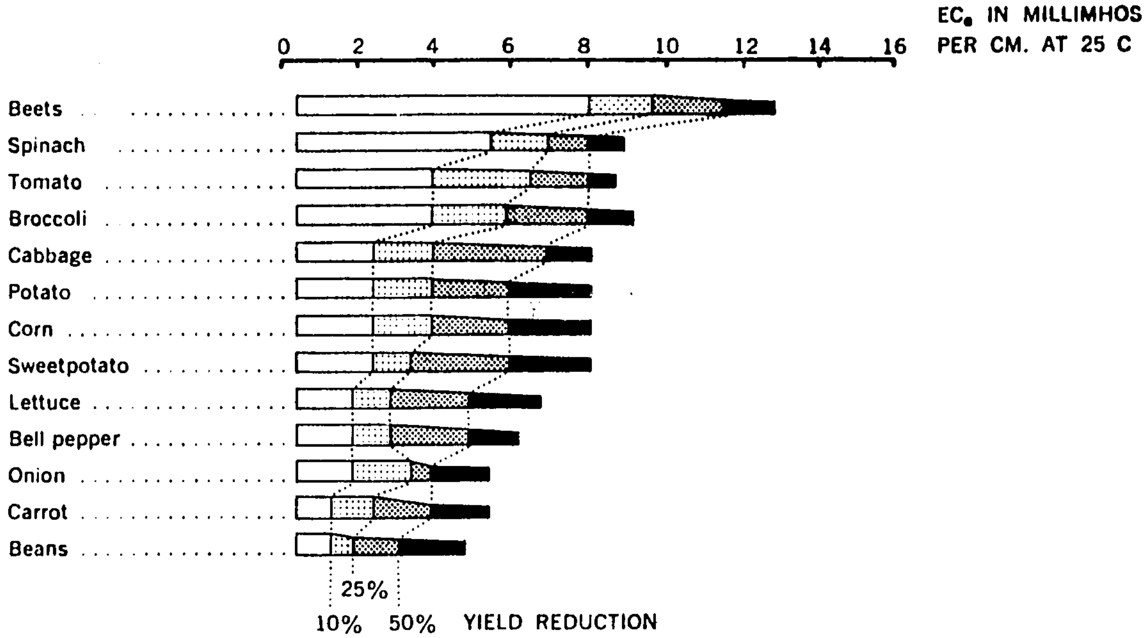
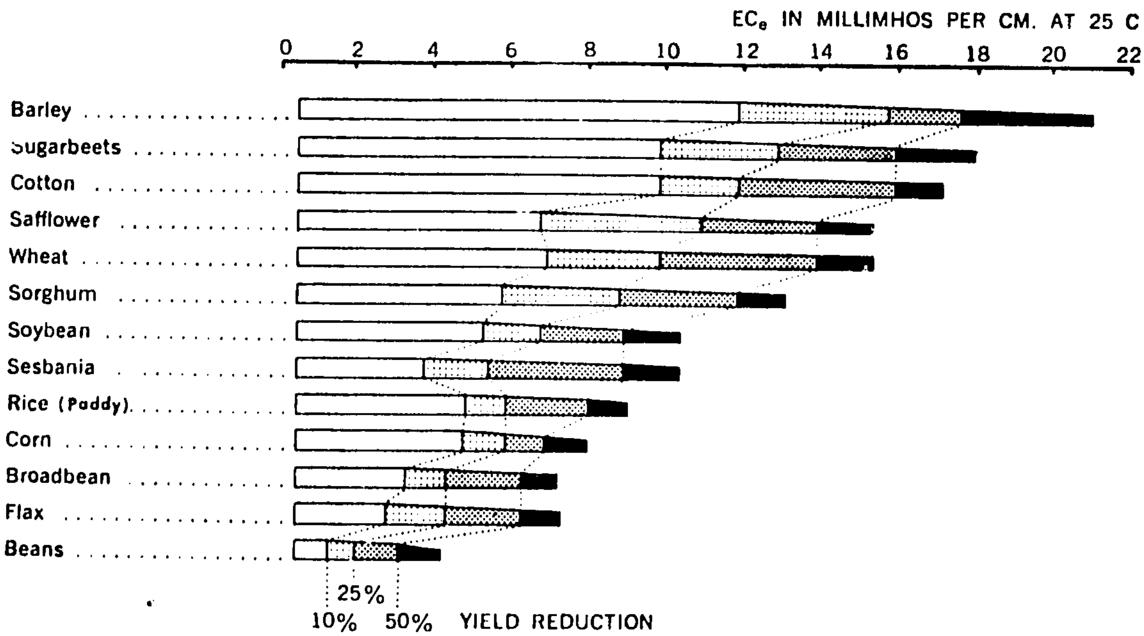
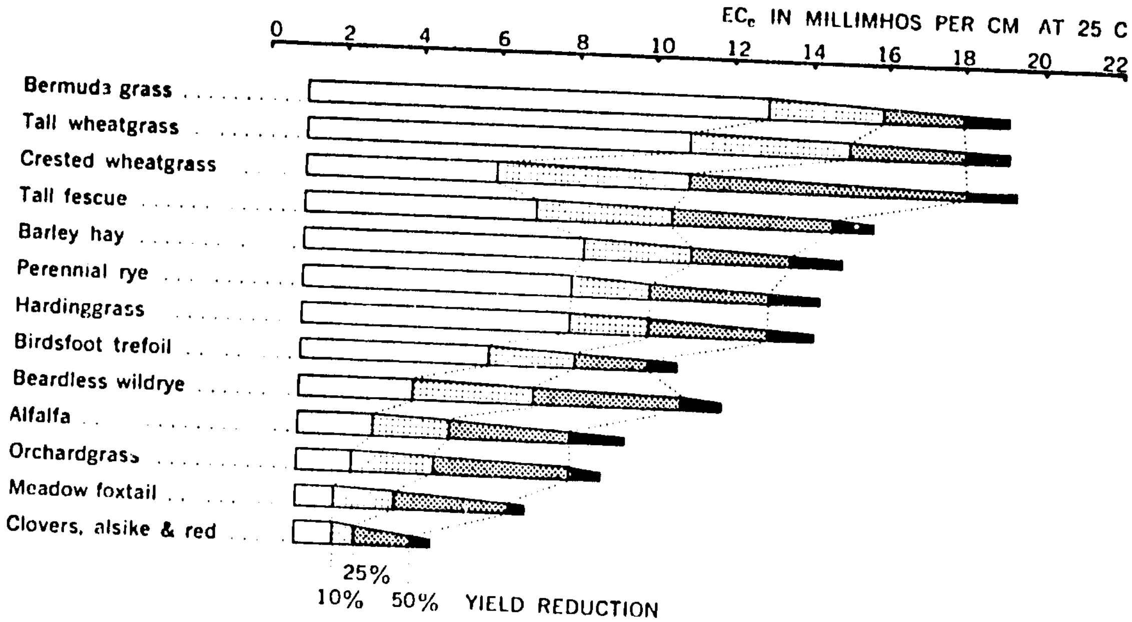


Figure 2. Salt Tolerance of Field Crops*



*The indicated salt tolerances apply to the period of rapid plant growth and maturation, from the late seedling stage onward. Crops in each category are ranked in order of decreasing salt tolerance. Width of the bar next to each crop indicates the effect of increasing salinity on yield. Crosslines are placed at 10, 25, and 50-percent yield reductions.

Figure 3. Salt Tolerance of Forage Crops*



*The indicated salt tolerances apply to the period of rapid plant growth and maturation, from the late seedling stage onward. Crops in each category are ranked in order of decreasing salt tolerance. Width of the car next to each crop indicates the effect of increasing salinity on yield. Crosslines are placed at 10, 25, and 50-percent yield reductions.

Figure 4. Modification of Seedbeds Permits Germination of Seeds for Good Stand Establishment.

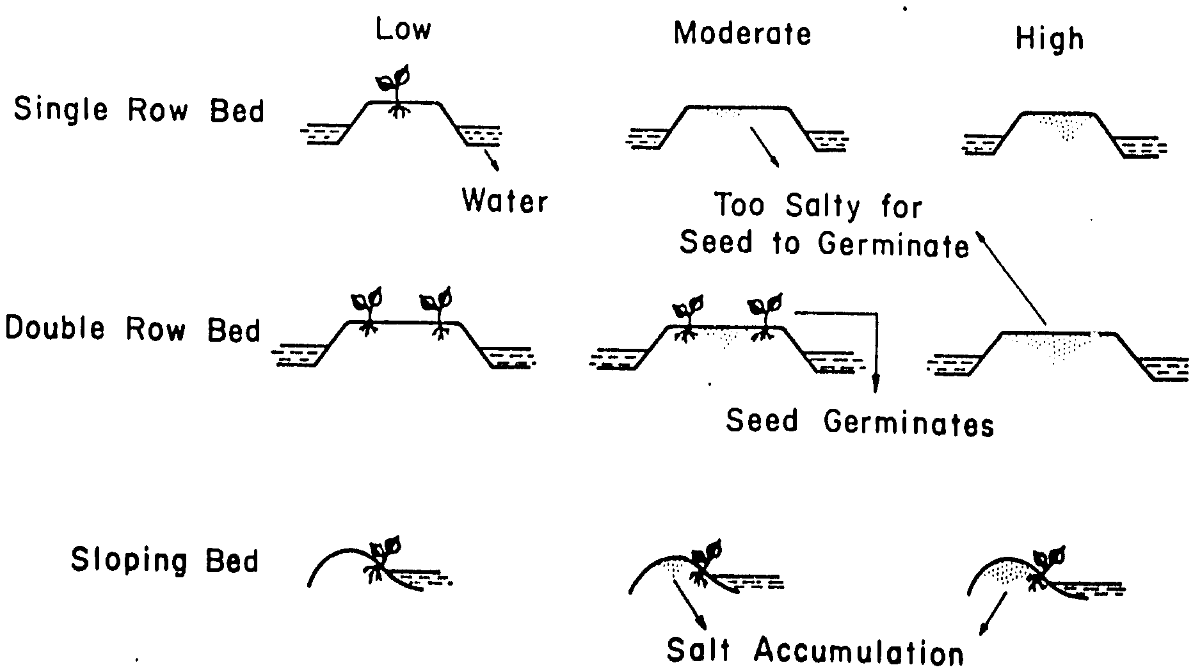


TABLE 1. Salinity Hazard of Irrigation Water.

Hazard	Dissolved salt content	
	ppm	EC-micromhos/cm
Water for which no detrimental effects will usually be noticed.	500	750
Water which may have detrimental effects on sensitive crops.	500-1000	750-1500
Water that may have adverse effects on many crops and requiring careful management practices.	1000-2000	1500-3000
Water that can be used for salt tolerant plants on permeable soils with careful management practices and only occasionally for more sensitive crops.	2000-5000	3000-7500

Ions in the equation are expressed in milliequivalents per liter.

Although sodium contributes directly to the total salinity and may be toxic to sensitive crops, such as fruit trees, the main problem with high sodium concentrations is its effect on soil physical properties.

The use of water with an SAR value greater than 10 should be avoided if it must be used as the only source of irrigation water for long periods. This is true even if the total salt content is relatively low.

If the soil contains an appreciable amount of gypsum, an SAR value of 10 may be exceeded somewhat. The gypsum content of the soil can be determined by the CSU Soil Testing Laboratory.

Continued use of water having a high SAR value leads to a breakdown in the physical structure of the soil caused by excessive amounts of colloidally adsorbed sodium. This breakdown results in the dispersion of soil clay which the soil to become hard and compact when dry and increasingly impervious to water penetration due to dispersion and swelling when wet. Fine textured soils, those high in clay, are especially subject to this action.

Toxic Elements. Direct toxicity to crops may result from some specific chemical element in irrigation water. The actual concentration of an element in water that will cause toxic symptoms varies depending on the crop.

When an element is added to the soil through irrigation, it may be inactivated by chemical reactions, or it may build up in the soil until it reaches a toxic level. An element at a given concentration in water may be immediately toxic to a crop or it may require a number of years to accumulate in the soil before it becomes toxic.

There is a long list of elements that can cause a toxic effect on crops, including such heavy metals as arsenic, cobalt, copper, lead, nickel and zinc.

Little is known about most of these elements relative to toxicity levels for the various crops and soil conditions. They are not known to be a problem in Pakistan irrigation waters; therefore, no attempt is being made to suggest toxicity limits.

Bicarbonate Concentration. Waters high in bicarbonate (HCO_3^-) will tend to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) when the soil solution concentrates through evapotranspiration. This means that the SAR value will increase--the relative proportion of sodium ions becoming greater. This, in turn, will increase the sodium hazard of the water to a level greater than indicated by the SAR value.

SUMMARY

In general, the so-called highly saline waters containing moderate amounts of Na may be used for irrigation provided the following factors are satisfied: (1) the root-zone is fairly permeable; (2) ample water is made to pass through the root-zone to remove as much salts from the soil profile as is added to it by the irrigation water; (3) the leachate is effectively drained away from the irrigated soil, and (4) the rise of salts by evaporation through capillaries is prevented by increased intensity of cropping. As long as the salinity and ESP of the root-zone is not allowed to exceed certain limits, dictated by the salt tolerance of the crops and tilth of the soil, profitable agriculture may be practiced.

APPLICATION

Our soils lie in the arid and semi-arid zones and there is shortage of irrigation water. The groundwater is generally hazardous. The agricultural worker will suggest, keeping in view the above mentioned factors, what type of water is to be applied to a certain area.

QUESTIONS

1 - Explain the water quality criteria to grow salt sensitive crops.

2 - What factors should you keep in mind while recommending a water for a soil?

3 - What is meant by SAR and how is it used in irrigation water evaluation?

Subject: INTRODUCTION TO FARM MANAGEMENT

Trainer Agricultural Economist
Class Room 1 hour
Field 0 Days

OBJECTIVE

To understand the role of farm planning and management in scientific agriculture.

MATERIALS NEEDED

None

TRAINING AIDS

None

PRESENTATION

Business survival, to say nothing of growth and expansion, is an important objective of every commercial farm. In this age of science and technology, the survival of a farm requires many long-run and day-to-day decisions. The person responsible for making these decisions should be well trained in the methods and procedures of management, as well as in science and technology.

It is assumed that a farmer wants to maximize satisfactions for himself and his family. Satisfactions include profits as well as leisure, prestige and security. Since profits can be measured objectively and are usually of considerable importance to farmers, the method presented here will emphasize maximization of profit. This, however, does not preclude the consideration of intangible satisfactions associated with the business of farming.

Advances in science and technology have opened new opportunities for the farmer. In many cases traditional methods have become obsolete. Farmers who want to establish profitable farms or who want to increase profits on their present farms need to decide which new systems and techniques to adopt.

The development of a profitable farm involves making decisions about the kinds and amounts of inputs to use in the production processes, and the kinds and amounts of products to produce. The optimum kinds and amounts of inputs and products depend on price relationships and technology which change more or less continually. Thus, it is important for the decision maker to have a logically consistent, systematic method, for evaluating alternatives and selecting optimum input-output relationships continually through time.

Specifically, farm planning and management is helpful and advantageous to the farmer in the following ways:

(i) Higher incomes to the farmer.

Farm planning is a pre-planned scheme of action to bring about improvements in the income levels of the farmers. Such changes in incomes are possible from a given bundle of resources by re-organizing the present type of production, as well as through technological adoption and development.

(ii) Desirable organizational changes.

There are rapid technological developments in the field of agriculture today. There are also serious maladjustments with respect to resource use on a majority of the farms. Farm planning helps the farmers to determine the kind of changes which are needed regarding resource use at the farm level to improve farm productivity and profitability.

(iii) Measurement of credit needs.

The agricultural credit program at present does not work to the particular needs of most farmers. Loans are often granted to farmer's on the basis of wealth and not according to their productive capacity. It is also very common to advance loans to those who need it least and not to those who need it most. Farm planning helps to find out the best alternative for the reorganization of the farming units. As a result of it, the type of production at the farm level is determined. This helps the farmer to assess his resource requirements that are needed to execute the proposed improved farm plans. In the process of reorganizing the farm, additional funds, in all likelihood, will be needed. Some of these funds may be met by the farmers out of thier own resources, or by relatives. However, much of the financial help will have to be secured from private and governmental lending agencies. Without a properly prepared farm plan it would be most difficult to secure outside credit.

Subject: FARM BUSINESS ANALYSIS

Trainer Agricultural Economist
Class Room 3 hours
Field 0 Days

OBJECTIVE

To introduce the students to the purpose and importance of farm business analysis and farm record keeping. The major uses and components of farm records will be discussed along with a review of data sources and the possible introduction of electronic data processing in certain cases.

MATERIALS NEEDED

None

TRAINING AIDS

Chalk and board.

PRESENTATION

The foundation of any successful business is a well organized set of records and accounts. Records and accounts provide a major tool for sound business management. They record the heartbeat of the business. The pulse must be recorded in all parts of the business, as in the body, for it to remain alive and functioning productively. This is just as true for today's modern commerical farm as for any large business in industry. Farming today is big business and as such requires detailed records of resource use and production as well as financial accounts of the flow of money into and out of the business.

It should not be inferred that records and accounts can solve all of the farmer's management problems. They are only a tool to be used in connection with others such as economic principles and budgeting. Records and accounts are historical by definition; they predict the future only in terms of the past. If the farmer is trying to predict next fall's cotton prices, he needs to check outlook reports. If he is adding a new enterprise or new machine, he must go to a source where information is available. However, accounts can be useful in illuminating the ailing as well as the healthy segments of the business and, in some cases, prescribing the appropriate medication. Even though they do not predict the future, they may serve as useful guides. For example, the soil characteristics, past cropping systems, fertilization programs and past production of a field may be the best available guides to crop yield expectations.

Major uses of farm records and accounts may be summarized as follows:

1. Management Tool. Farm records allow the farmer to measure his efficiency in using the factors of production--land, buildings, machinery, labor, etc.--and in producing agricultural products for sale at a profit. The farmer must be an engineer, biologist and economist. As an engineer, he must measure the use of inputs relative to outputs or yield quantities on his farm and design and use the various structures, machinery, watercourses etc. in the proper manner. As a biologist, he should know what yields he is obtaining under different crop treatments as the inputs such as water, fertilizer, seed, tillage, etc. are varied. Likewise, he must know how his animals respond to various feeds, feed rates and other input factors important in animal production. Finally, he must put all of his operations into an economic framework so that he can measure his success to producing income for family living, profit, and business growth.

2. Records properly and accurately kept, provide the banker, government, or other lender with the financial information needed for determining the future profitability and loan repayment capacity of the farm.

3. Records and accounts also provide the bases for farm lease arrangements and other contracts, farm insurance programs, and participation in government programs.

The listing which follows is not an exhaustive treatment of farm records and accounts, but some of the major components useful in farm accounting are discussed.

1. Asset and Liability Account. This is a physical and financial account of all farm resources (assets) and the claims against those resources (liabilities). The proper ordering of the assets and liabilities account will provide the net worth statement or balance sheet of the business. The net worth statement is an account of the farmer's financial position at any point in time.

2. Receipt and Expense Account. This account of financial flows into (receipts) and out of (expenses) the business over a period of time, usually one year, may include both cash and noncash transactions. Subtracting expenses from receipts gives net farm income, which measures the profitability of operating the business, i.e., the return to the operator for his labor, management and capital.

3. Capital Account. This is a purchase record of capital assets and improvments, which cannot be debited fully as expenses in the year purchased, and a sales record of similar items. Purchases and sales of capital items will generally affect the depreciation schedule of the business. These purchases and sales directly affect the asset account and generally result in additions to the receipt and expense account.

4. Credit Account. This record of farm liabilities includes recording new loans as well as keeping track of principal and interest payments and tabulating unpaid principal balances on existing loans.

5. Production and Statistical Records. These records relate to the production of crop and livestock enterprises on the farm and the resources used. Labor, feed, crop fertilization, and crop yield records are examples.

6. The Farm Business Analysis. The inventory and the receipt and expense accounts are combined with production records to probe for strong and weak areas within the business. These analyses are commonly called "efficiency measures". The information they provide often is useful in identifying problems and directing future farm management decisions. Growth and progress can be measured over time by a comparison between years.

7. Enterprise Records and Accounts. All information that can be recorded for the total farm can be kept for individual enterprises. Often only minor additional records are required, over those necessary for the total business, to make rather detailed enterprise analyses. These are often referred to as cost accounts.

The use of accounts and records as a management tool is the primary purpose for collecting them. Records and accounts provide the best information available for detecting business problems and successes. One of the methods used is to compare the performance with the business plans (budgets--a separate discussion of these will follow later) made prior to the accounting period that has just ended. This phase of the decision making process is called "evaluation and responsibility." At least two elements should be considered in this comparison of plans with performance. First is the test of the decision making ability of the manager as he compares his plans with the results. If he meets or exceeds his expectations, he can feel successful about his management skills. It should not be interpreted that if performance in any one year or for any particular item does not meet expectations the manager is a failure. To be successful, the manager must be right only a majority of times or for major decisions. Also, conclusions based upon the performance for any one year may be dangerous because of the variable nature of agricultural production and prices.

The second means of evaluation is the measurement of the efficiency of the business itself. The comparison of performance with plans (rather than the reverse) may be a usrful exercise in identifying business problems. Identifying the strong points of the business may be just as important as identifying the problem areas. These comparisons may take much the same form as the analysis previously discussed.

Farm record data can be much more useful if they are designed and kept with planning in mind. First, more detailed records will be kept. Records must be available to determine physical input-output coefficients (feed per pound of gain, seed and fertilizer per acre, labor per head and per acre, fuel and repair costs per hour or acre of use, etc.) and price relationships. Not only must they be kept for transactions off the farm with outside agencies but for intrafarm transfers to be recorded and appropriately charged. Second, production techniques and practices will be designed to give meaningful data for planning. Even though farmers cannot afford costly trials, they can carry out limited experimentation. For example, a farmer may plant two different varieties of seed, fertilize at different levels and times, feed different qualities of animals, feed different types of feed to the same quality of animals, sell animals at different weights, harvest crops by different methods, produce at different time periods, etc. Comparison of the results from these types of experiments are helpful to farmers in making decisions. The necessity for complete records of these data should be vary apparent.

Even though each farmer cannot carry out detailed and accurate experiments for any one activity (let alone a large number), farmers as a group have an abundance of information. As information is shared they are able to evaluate (within nontechnical limits) crop varieties, fertilizer rates, pest control practices, sources of seed, seeding practices, new production techniques, etc. Observing what other farmers are doing, specifically rather than generally, can be helpful in adding to the knowledge bank for farm planning purposes. Farmers must be able to attach production requirements to each production level, practice, and variety for their data to be useful for planning. Other important sources of information for farm planning are the research stations (Mona, PARI), the University of Agriculture and colleges throughout Pakistan and the Extension arm in the Agriculture Department. These public agencies are charged with the responsibility of conducting research and providing information of benefit to farmers and persons in farm-related businesses. Thus, much of the new technology comes from these sources. New techniques are developed, and information from these public agencies is useful in two areas of planning. First, farmers can make efficiency comparisons between their records and experiment station results. This is another useful approach to identifying farm problems. Second, the data are useful in supplying information not available to the farmer from other sources (or to test the reliability of information from private sources) for planning purposes, particularly where new techniques are involved.

Another important source of farm planning data are private organizations. Many of the larger supply firms (machinery, fertilizer, chemicals, etc.) have developed their own research and have specialists to educate the farmers and public in general about the products they sell. Sometimes this source is the only one available for new products. Who is better able to furnish technical information about a dealers product than the manufacturer?

Much of the information coming to farmers from their own records and from neighbors and private and public sources is in the form of single point estimates, i.e., each tells the result from one combination of inputs and conditions. This often is enough to indicate whether one practice or input level is more profitable than another, but considering all the possibilities, it may not show which is the most profitable. And what good farmer would be satisfied with less? Most products can be produced in several ways. For example, rice can be produced from any one of many varieties, with or without commerical fertilizer, various water applications and timing, etc. Also, the level of production for most products is determined by the level of inputs supplied. For example, the yield of wheat can be increased or decreased by increasing or decreasing the amount of water applied, the rate of fertilizer applied, changing the plant population, etc. Animals being produced for sale can be marketed at heavier weights by increasing the time and amount of feed. Selecting the best production practice and output level requires a consideration of the costs and benefits associated with each incremental change. The selection of the optimum output level or the combination of inputs to maximize business profits is the subject matter of economics. A consideration of the basic principles of production economics is useful in interpreting business records and accounts and in making future plans.

The basic economic principles involved revolve around the following questions. (1) What to produce? Here one must consider the product mix of crops and livestock enterprises on the farm. It considers questions of specialization, participation in government programs, use of idle resources, etc. (2) How to produce? Here one must consider the combination of inputs to produce a certain amount of product. Many products can be produced in different ways. For example, a cotton crop can be produced under minimum tillage or by conventional cultural practices. Even though more than one method is available, there is only one least cost way. (3) How much to produce? This question is related to the quantity of inputs (water, fertilizer, seed, pesticides, labor, etc.) to apply in producing a product (wheat, cotton, rice, fodder, sugar cane, etc.). There is an economic optimum level of production. (4) When to buy and sell? This question relates to price expectations for the purchase of input factors and the sale of farm products. Again, there is an economic optimum though many of the economic decisions must be based on rather unpredictable data in many cases. Yet, some "educated" guesses can be made which will ultimately lead to increased profits.

The economic principles discussed above revolve around the law of diminishing returns. This law states that if successive units of one input are added to given quantities of other inputs required in the production of some product, output of product per additional unit of input will reach a point where the addition to product will decline. It is well recognized that crop plant populations can be too large, water applications too great and frequent, fertilizer rates too high, and livestock feed efficiency declines as the animals reach heavier weights. These all illustrate the reduction of input efficiency as higher levels of production are attained.

The selection of enterprises, the method of production, and the output level all require a system of analysis that will allow the planner to systematically organize and manipulate his data to arrive at a reliable solution to his problem. Problem identification, data sources and economic logic have all been touched upon. A treatment of analysis techniques and their relationship to records will be discussed in our next lesson plan.

ELECTRONIC DATA PROCESSING

The following is a rather elementary discussion of electronic data processing, commonly known as EDP. It is relatively new in the field of farm record keeping and farm management. However, refinements and improvements in computer hardware and data storage have provided accountants, economists, agronomists, and computer programmers new tools for developing computerized farm accounting programs that are most helpful in farm management and research analysis. It would appear that this would be a most feasible venture for the Mona Station to initiate. First, WAPDA has a very sophisticated IBM computer. Secondly, it has a cadre of excellent programmers. Thirdly, Mona has an on-going research program of its own, as well as a farmer-cooperative relationship, which is ideal for both implementing new research findings and serving as a demonstration activity for all the farmers of Pakistan. Finally, Mona has a highly competent staff that would be capable of introducing an EDP system for its own research activities, as well as bringing it to a number of progressive farmers. This could provide an example of what it might mean to the individual farmer, as well as to the economy of Pakistan. The following is a brief description of EDP.

Electronic data processing can be defined as a system of processing accounting records on an electronic computer. The amount of computer involvement varies with each EDP program. In most research stations it would involve intensive accounting of the many physical input-output relationships related primarily to agronomy, engineering, animal science, soils and ultimately economics. In most farmer programs, the subscriber records the transaction information on prepared forms, or in a record book, and submits these to the servicing organization (Mona) on a monthly, quarterly or annual basis. The subscriber (farmer) identifies each transaction with a predetermined code number or name. The servicing organization then processes the farm data on computers that have been programmed to perform the posting, adding, subtracting, multiplying, dividing and other accounting functions necessary to print out the desired accounting reports. Obviously, the required data and analysis would be much more sophisticated for the Mona research projects than it would be for the farmer related program.

A farmer participating in a EDP program usually sends his business transactions and production records to the servicing organization on a monthly basis. The information is keypunched onto cards or magnetic tape to be read into the computer. The computer can be programmed to perform essentially four functions with the input information:

1. The computer sorts the varied transactions into specific categories. Expenses are sorted from receipts, and each of these may be further sorted by like transactions--i.e., fuel purchases, labor expenses, livestock receipts, crop receipts, etc.

2. The machines subtracts, multiplies, and divides as necessary to tabulate accounting reports and make management or efficiency analysis.

3. Output records are printed according to the exact report format programmed into the computer.

4. Storing information is another function of the computer. The sorted and calculated information can be stored on magnetic tapes or disk packages for use with information received later to calculate and print out reports covering longer periods. For example, if transactions were reported by the farmer once a month, the computer could be programmed to prepare both a monthly and a year-to-year summary of receipts and expenditures.

At this point a word of caution may be in order. Developing and operating an EDP program is not a cure-all for poor records, nor is it a guarantee that you will have good records. The output information is only as good as the record information that goes into the machine, or in IBM parlance, GI = GO (garbage in = garbage out!). EDP subscribers still have the responsibility of recording information accurately and regularly. However, EDP programs can act as a stimulus for keeping farm records up to date. The computer is able to relieve the subscriber of many of the more tedious aspects of farm record keeping such as posting, adding, subtracting, calculating analysis ratios, and preparing accounting reports. The computer is a tremendous timesaver and once the information is in the machine accurately, an unlimited number of reports and summaries can be produced.

With time, EDP systems have grown from a simple cash-flow analysis of income and expense to information packages consisting of enterprise analysis reports, depreciation schedules, net worth statements, family expense summaries, and farm business analysis reports. Together, all these reports can supply a farmer with a relatively complete physical and financial picture of his farm business operation. Without question, a more detailed and comprehensive analysis can be developed for the research activities at Mona.

Operational procedures are the heart of any EDP record-keeping and analysis program. It is extremely important that the code system, recording procedures, output records, and assistance available be carefully evaluated before selecting a program. The code system is used for every recorded transaction. Thus, it should be simple and easy to use. To receive accurate information, the recording procedures must be followed explicitly. The procedures should be as simple as possible and still permit the type of record keeping that is needed. The output reports must be clear and understandable and provide the information wanted. Do not select a more elaborate system than you have time to maintain during peak labor periods or one that provides information you do not need. And finally, the type of assistance available can play an extremely large role in the success or failure of any EDP program. It is felt that WAPDA has that capability.

Subject: ECONOMIC PRINCIPLES OF FARM MANAGEMENT

Trainer Agricultural Economist
Class Room 3 hours
Field 0 Days

OBJECTIVE

To outline the economic principles that are needed to analyze the most efficient combination of resources in farm management.

MATERIAL NEEDED

None

TRAINING AIDS

Chalk and board.

PRESENTATION

Farm Management is defined as making farm business decisions that tend to maximize net income of the farm operator, consistent with the operator and family's objectives. The objectives that might restrict the maximization of income are such things as health, custom, religion, sports, travel, recreation, education and community activities.

The farm manager is responsible for combining the various factors of production. These factors [illegible] land, labor and capital. Economists define the land resources as a[illegible] the natural of 'god' given resources and capital as the manmade resources including all forms of technology. The manager must decide: (1) what to produce, (2) how to produce, and (3) how much to produce. These decisions involve the kinds and amounts of resources to use, the technology to use, when and where to buy and sell, and how to finance the farm operation. Previously, farm record keeping was discussed. In our next lesson plan, farm budgeting will be analyzed. These are both economic tools that provide a systematic way for the farm manager to make the above decisions. Another tool of the manager is that of economic principles. It si important that be understands these if he wishes to maximize his economic returns.

What, then, is an economic principle? Basically, an economic principle is a law, or course of action, concerned with the allocation of scarce resources to obtain optimal alternative ends or uses. The ultimate objective would be to combine the available resources in such a manner that the net returns to the farming operation is maximized.

In order to understand the relationships involved in determining the optimum profit level one must first look at the physical relationships that are important to this decision. The principle is called the "law of diminishing returns." The principle states that when successive increments of a variable input (fertilizer) is added to other productive resources (land) that are held constant (fixed), the total output will increase, first at an increasing rate per unit of input, then, at some point output will continue to increase, but at a diminishing rate per unit of input, until total output reaches a maximum and any additional units of input will actually decrease the total output. Thus, we have the relationship established between the input and resulting output. This relationship is commonly referred to as the "production function."

A hypothetical wheat fertilizer experiment is presented on the following page. Both the schedules and graphic relationships are presented to provide a clearer understanding of the principle. In this case we are adding successive increments of fertilizer to the other resources used in the

HYPOTHETICAL WHEAT-FERTILIZER EXPERIMENT

I. Physical Production Function - Schedules
(Input-Output Relationships - Mds/Ac)

Input[1]	T.P.P.[2]	A.P.P.[3]	M.P.P.[4]
0	0	0	2
1	2	2	3
2	5	2.5	4
3	9	3	5(C)
4	14	3.5	4
5	18	3.6(A)	3(A)
6	21	3.5	2
7	23(B)	3.3	-2(B)
8	21	2.6	

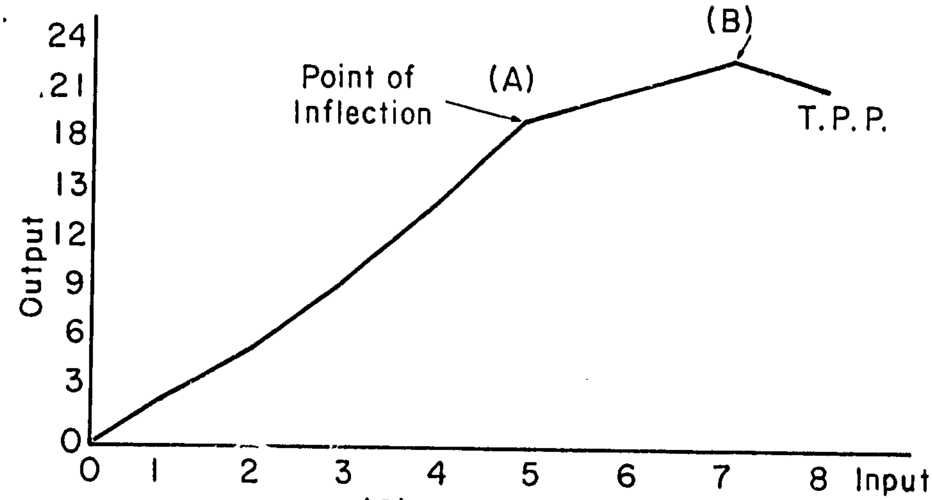
[1] 20# does of N

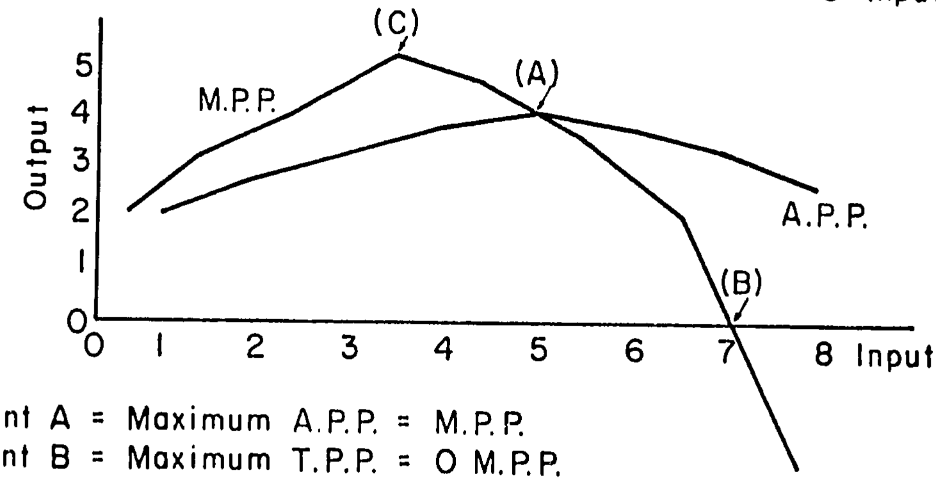
[2] Total Physical Product

[3] Average Physical Product

[4] Marginal Physical Product

II. Graphic Relationships of Production Function





NOTE: Point A = Maximum A.P.P. = M.P.P.
Point B = Maximum T.P.P. = O M.P.P.
Point C = Maximum M.P.P.
Diminishing Returns Point A, Negetive beyond Point B
Point A Represents the Most Efficient Physical Relationship

production process (land, water, etc.). It may be noted that initially the returns per added input unit is increasing. The column labeled M.P.P. (marginal physical product) provides this information. It gives us the change that is taking place in the production process. One may note that at point A, the A.P.P. (average physical product) is at a maximum and that the M.P.P. is equal to the A.P.P. This is known as the point of inflection or the point of diminishing returns on the T.P.P. (total physical product). This is the point that a physical scientist is interested in determining. In other words, at this point one is deriving the maximum product per unit of input. However, this is not necessarily the economic optimum. That is dependent upon the costs of input and the returns obtained from the output. A look at those relationships will be made in a moment, but one further observation should be made in regard to the physical production function. It may be noted that point B is where the T.P.P. is at a maximum and that the M.P.P. is at zero. It, then, becomes obvious that it would be unwise to use input units beyond this level. This means that the level of input use having 'economic relevance' is between points A (maximum A.P.P.) and B (maximum T.P.P.). One might immediately think that point C (maximum M.P.P.) would be the 'best' place to produce. It is the point where that particular input unit added more than all others to total production. Unfortunately, the previous input units must be used to arrive at that point, so that 'on the average' the output per unit is somewhat less. This, of course, is given to use by the A.P.P.

To locate the most profitable use or level of the variable input (fertilizer) within the total range of the physical production function, we must assign prices to both the variable input that we are considering and to the output or product that we are producing. Net returns will be maximized where the cost of the input (marginal input cost-MIC) is equal to the return of the output (marginal value product-MVP). Here we assume that we have unlimited capital and would add successive units of the variable unit as long as the added return is greater than the added cost of the input.

The same hypothetical wheat fertilizer experiment is again presented on the following page. However, we have now assumed that the price of fertilizer is Rs. 150 per unit and wheat is worth Rs. 60 per md. Our basic problem is to determine how many units of fertilizer should be used to maximize the net profits from the production of wheat. It may be noted that the total value product, average value product and marginal value product schedules and curves have the same general relationship as do the product schedules and curves in the previous section. The input cost schedules and curves are constant because we have assumed that the price of fertilizer will not change as increased purchases are made.

In this experiment, the most profitable point of input use is found at point C. Here the difference between T.V.P. and T.I.C. is at a maximum, or in terms of the marginal relationships, M.V.P. is equal tc M.I.C. If the input cost increased to Rs. 200 per unit, the maximum profit point would move to D. Though it is not illustrated, this increase in input costs will shift the T.I.C. upward to a corresponding point at D. Decreasing the cost of inputs will, obviously, allow the use of more input units. Changing the price of wheat will have similar effects on the optimum use of the fertilizer. Increases in the price of wheat will allow increased use of the input and decreases in wheat prices will restrict the use of fertilizer. The opimum physical relationship is found at point A. Here the A.V.P. is at a maximum and the M.V.P. is equal to it. This would correspond to the

DETERMINATION OF OPTIMUM ECONOMIC INPUT-OUTPUT RELATIONSHIP

Assume: Wheat Rs. 60/md; Fertilizer Rs. 150/unit

Input	T.P.P.	A.P.P.	M.P.P.	T.V.P.[1]	A.V.P.[2]	M.V.P.[3]	T.I.C.[4]	A.I.C.[5]	M.I.C.[6]
0	0	0	2	0	0	120	0	0	150
1	2	2	3	120	120	180	150	150	150
2	5	2.5	4	300	150	240	300	150	150
3	9	3	5	540	180	300	450	150	150
4	14	3.5	4	840	210	240	600	150	150
5	18	3.6	3	1080	216(A)	180(A)	750	150	150
6	21	3.5	2	1260(C)	210	120(C)	900(C)	150	150(C)
7	23	3.3	-2	1380(B)	197	-120(B)	1050	150	150
8	21	2.6		1260	158		1200	150	150

[1]Total Value Product

[2]Average Value Product

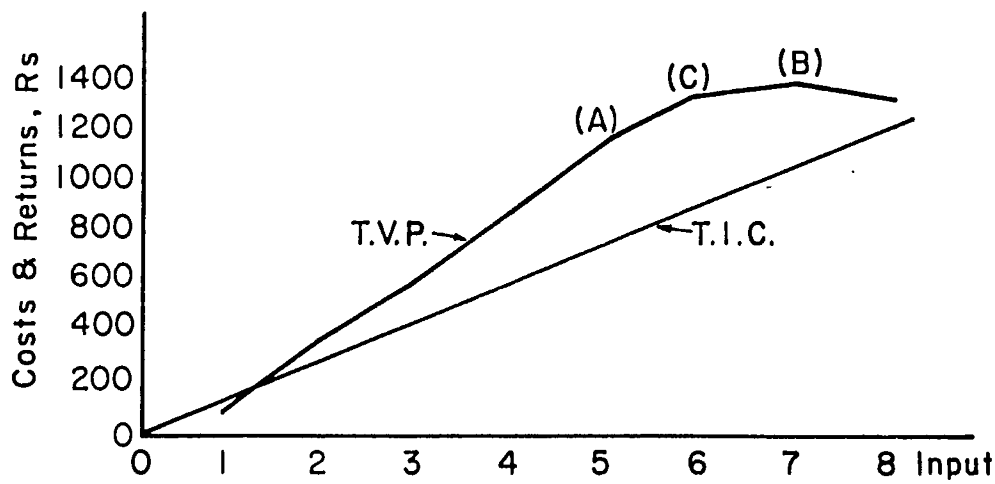
[3]Marginal Value Product

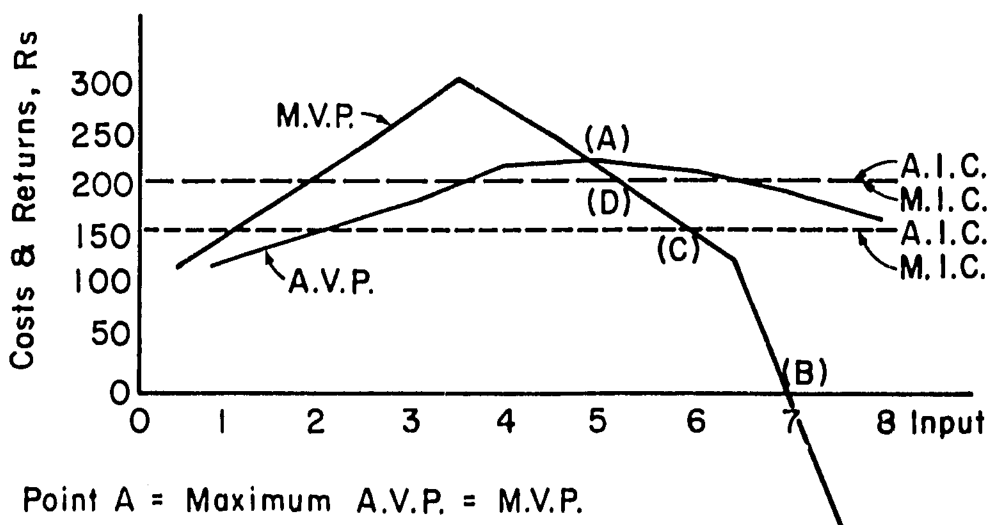
[4]Total Input Cost

[5]Average Input Cost

[6]Marginal Input Cost

GRAPHIC RELATIONSHIPS OF COSTS AND RETURNS:





NOTE Point A = Maximum A.V.P. = M.V.P.
Point B = Maximum T.V.P. = 0 M.P.V.
Point C = Maximum Profit = M.V.P. = M.I.C.
Point D = Maximum Profit with Increased Price of Input (Rs 200) M.V.P. = M.I.C.

point on the previous graph where A.P.P. is at a maximum. If we assumed that the fertilizer were free, the profit maximizing point would be at B where the T.V.P. is at a maximum and the M.V.P. is zero. Perhaps, the most important lesson to be learned from this exercise is to understand that the point of maximum physical efficiency is not necessarily the most efficient economic level of production.

Fixed and Variable Costs

Costs are normally broken down into two categories, fixed and variable. The concept of fixed and variable costs is extremely important in making management decisions.

Fixed costs are those that do not change with changes in production. These costs remain approximately the same whether the farm is operated at maximum capacity or remains idle. They are "sunk costs", meaning that they have been commited. In other words, these expenditures cannot be retracted. Included among these are (1) depreciation, (2) interest on money invested in the farm, (3) taxes, and (4) insurance. Fixed costs do not enter into the analysis of profit maximization during a given production period. However, the farm must be able to cover its fixed costs in the long run. If not, the farm will not be able to make the capital investments, pay the insurance and taxes, and therefore, will be forced to shut down.

Variable costs are those costs incurred once production is undertaken. They vary in proportion to the amount of product produced. For example, the fertilizer costs presented previously represent a variable cost. To a great extent variable cost inputs are used up in the production process. Within a particular decision-making or production period, the variable costs are the decision making costs. They are the costs that are charged in determining the most profitable level of production.

Application of the fixed and variable costs concept is illustrated in the following analysis of a poultry enterprise which is part of a farm business. A similar analysis can be made for all other enterprises that the farm might have. In this example, it is assumed that the land, buildings and labor were fully employed. The year-end analysis of the poultry enterprise showed the following:

Costs:

Grain, layers, and replacements	Rs. 5,500	
Chicks	345	
Repairs to equipment	50	
Interest, depreciation, tax on buildings and equipment	496	
Supplies	300	
Operators labor	1,800	
Total Costs		Rs. 8,491

Returns:

Eggs	Rs. 6,720	
Meat	750	
Total Income		Rs. 7,470
Profit or Loss		- Rs. 1,021

The question to answer in this case is, "Should this enterprise be discontinued in view of the Rs. 1,021 loss?" If one rearranged the cost figures to show only variable costs, the analysis would proceed as follows:

Cash costs: (variable)

Grain	Rs. 5,500	
Chicks	345	
Repairs	50	
Supplies	300	
Total variable costs		Rs. 6,195
Total income		7,470
Profits over cash costs		1,275

In this example, it has been assumed that the labor is a fixed cost in that it cannot be used elsewhere. Thus, by continuing the poultry enterprise Rs. 1,275 can be applied to the fixed costs associated with interest, depreciation, tax on buildings and equipment and labor. Obviously, if this situation persisted for several years the farmer would not be able to replace his equipment and buildings that are "wearing" out and would be forced out of business. However, in the short run he is better off to continue his present operations than to shut down even though he is suffering a loss. In economic parlance, this is known as "minimizing one's losses". This example points up the need to allocate costs properly according to whether they are fixed or variable if one is to determine the economic optimum.

Equa-Marginal Return Principles and Opportunity Costs

These principles are used when resources, especially capital, are limited. Opportunity cost is the value of the resource in its next best use. For example, if a farmer were considering the purchase of a Rs. 10,000 implement, he should consider that the cash interest of 10% is the cost of the capital. It represents the opportunity cost of the capital. If a return of over 10% is not forthcoming from the Rs. 10,000 implement investment, it would be unwise for the farmer to purchase this implement.

The equa-marginal principle is an extension of the opportunity cost concept. The 'ideal' situation is one in which the rupee return from the last increment of investment is the same in each and every resource use. If additional investments in water development brings a greater return than investments in some other input it should be obvious that this is where the investment would be most economic. However, one must keep in mind that as additional investments are made the return per unit of input will decrease until ultimately it will be more profitable to invest in another input. Thus, the equa-marginal principle states that the return "at the margin" should be the same for all resources. We know, of course, that one cannot purchase many of the inputs in rupee units. In other words, one does not buy half a bullock or one-fourth of a tractor. This simply means that the equa-marginal concept is a guiding principle and that it cannot be obtained to the nth degree in the real world.

Any changes in price and technology of one or all production resources will result in a different combination of the resources used to obtain the largest profit. As the prices change or as technology shifts, the mix of production inputs will vary. A good farmer must be aware of these changes if he is to obtain maximum returns from all his enterprises.

If these various alternatives are analyzed with the use of partial budgets, the opportunity costs are automatically accounted for. Consider, for example, the case of the farmer who is contemplating a shift from fodder production to the production of wheat. The returns from fodder associated with the use of certain resources (the opportunity cost of producing wheat), enter the partial budget as "reduced returns" and "reduced costs". Consequently, the concept of opportunity costs does not require special attention if partial budgets are used to evaluate alternatives.

Finally, a word of caution should be given in evaluating yield response information. In the wheat-fertilizer experiment, it was assumed that the economic return was due solely to the grain produced. However, we know that in Pakistan, the busa is considered a very important crop. We also know that the wheat straw is a valuable soil conditioner and fertilizer. If the busa is used for feed the opportunity cost of using it as a soil conditioner should be evaluated and its value as feed should be a part of the economic returns from the production of wheat under the assumption that its value there is greater than as a soil conditioner.

Subject: SUPPORTING INFORMATION FOR FARM MANAGEMENT ANALYSIS

Trainer Agricultural Economist
Class Room 2 hours
Field 0 Days

OBJECTIVE

To describe the need for descriptive information in formulating farm management plans.

MATERIALS NEEDED

None

TRAINING AIDS

Chalk and board.

PRESENTATION

A budget, or more correctly, a combination of complete and partial budgets, is often useful in conveying a farmer's plan for development, organization, and operation of a farm to another person. When used for such purposes, the budget forms previously presented and discussed will usually need accompanying information. The following information should be included in a narrative report along with the budget, to help explain the total farm plan.

Farm Map

A farm map is useful for showing fields, roads, irrigation systems, building locations, fences, natural drainage or rivers, and other special geographical features. It is useful to have fields numbered on the map so that they can be easily identified in the land use plan and narrative report. The map should be drawn approximately to scale to provide proper perspective.

Legal Description

A legal description of the land in the farm is especially important to a prospective lender. It should be included with the narrative report. Also, information about distance from towns, railroads, and markets is helpful.

Soils

The narrative report should give some information about soil types found on the farm. If a detailed soils survey is available mere reference to the survey and location of the survey report may suffice. The narrative should discuss any special soil problems or situations and plans regarding them.

Climate

Information about the climatic conditions in which the farm is located may be of interest and in some cases of extreme importance. Rainfall, temperature, elevation and any climatic features which affect production of crops and livestock are important.

Technology

It is usually necessary to explain the technology employed on the farm, particularly for major crop and livestock enterprises. For example, when is the irrigating done and how it is accomplished, what fertilizers are used, when, how, and on what crops; how is the harvesting done; and what special practices are followed in livestock production? It would be useful to provide a calendar for the planning period showing the usual dates for important cultural operations.

Budget Coefficients

Throughout the budget, price and yield coefficients for crops and livestock are used without explanation or justification. These coefficients are very important factors in determining the amount of net farm income resulting from any proposed plan. Consequently, the justification for using the particular coefficient should be given. The credibility of the whole budget depends on how well these coefficients are justified. For example, yield estimates based on past records of farmers in the area and/or research station data normally lead to greater confidence in the budget results than data based on memory alone.

It is important to keep in mind that a budget is an estimate of the future. The credibility of the estimate depends on reliable sources of information regarding prices and input-output relationships.

Goals, Objectives, Plans

The actual development or operation of a farm is usually done within the framework of goals and objectives peculiar to a specific farm. Such information should be noted in the narrative report as it may help explain the organization of a particular budget. For example, a farm may be currently producing certain crops as part of a soil conditioning process in anticipation of some future production plan. Such information is vital to understanding the logic of a particular farm plan.

Miscellaneous

Any information that makes a particular farm plan unique should be reported in narrative form. The following list, while not exhaustive may suggest items of interest to be included in the narrative report.

- credit facilities
- irrigation facilities
- irrigation water supply
- cost schedule for irrigation water
- local services, e.g., schools, churches, health facilities
- markets
- market contracts
- animal health problems
- taxes
- farmer associations serving the area.

Subject: FARM BUDGETING

Trainer Agricultural Economist
Class Room 4 hours
Field 0 Days

OBJECTIVE

To prepare complete and partial budgets for a farm enterprise. Present a hypothetical example of farm budgeting using fertilizer as an example.

MATERIALS NEEDED

None

TRAINING AIDS

Chalk and board.

PRESENTATION

A budget is a logically consistent device for planning alternative systems of production and for measuring the returns from each system. It provides a method for describing the production relationships between resources (inputs) and products (outputs). A farm budget shows the relationships between resources such as land, labor and capital and products such as wheat, rice and cotton. The data for a farm budget includes facts and relationships drawn from the physical, biological and social sciences including the "applied" sciences. Data for the farm budget also includes observations and experience of the person or persons developing the plan.

A farmer can use a budget to plan a production program in the light of his knowledge of productive resources and their possibilities in the productive processes. After applying his estimates of prices to the input-output relationships, he can compare and analyze alternative systems to determine which one is the most suitable to his objectives.

Budgets may vary in the amount of detail they include. A relatively simple budget for a farm business should consist of (1) a land use plan, (2) a livestock plan, (3) a livestock feed plan, (4) an inventory of depreciable assets, (5) an estimate of expenses, (6) an investment summary, and (7) an income and expense summary. It is not necessary that these plans follow any certain prescribed format as long as the plan is complete and logically consistent. Budgets are also used in negotiating for credit and for purposes of getting counsel and advice from people with special knowledge. Consequently, the budget should be capable of communicating a specific production plan to someone other than the person who wrote the plan. The following hypothetical budget is offered as a suggestion. The forms may be altered to accommodate all farm planning situations.

COMPLETE BUDGETING

THE LAND USE PLAN (SEE TABLE 1)

The land use plan should account for all of the land resources used by the farm. Even waste land should be listed in order that the total acres may agree with the known land area of the whole farm. The land use plan reflects the use of all the land in the farm for a specified period of time, usually one year. If more than one crop is taken in one year from the same land it may be desirable to list the fields by number and show the different crops that are produced in each field during the year.

Table 1. Land Use Plan

CROP	PRODUCTION			DISPOSAL					
	Acres	Yield Per Acre	Total Production	Livestock Feed	Seed	Home Use	For Sale	Expected Price	Sale Receipts
Wheat									
Cotton									
Rice									
Sugar Cane									
Fodder									
Bhusa									
Fallow									
Not available for cultivation, etc.									
Total									

What Yields Should be Used in the Land Use Plan?

Because of the uncertainty associated with farming, crop yields are difficult to project. Normally, they should reflect the technology employed in the farm plan and average conditions of weather, insect pests, and disease. In other words, the yields used in the land use plan should, as a general rule, reflect the "most likely" output if a certain production technology is employed.

Since crop yields are usually quite variable it may be useful to prepare several budgets based on different conditions regarding weather and pests. This depends on the purpose for which the budgeting is being done. In any case, the person preparing the plan should recognize the important influence of yields on the conclusions reached by the budgeting method. He should carefully justify the yields used based on available evidence. Yield differences of a few mounds per acre may greatly influence the feasibility of any farm plan.

What Prices Should be Used in the Land Use Plan?

Much of the discussion pertaining to yields applied to price. However, the future price of crops is more dependent on factors external to the farm business. Pest prices are a guide but there is no guarantee that they correctly reflect future prices. Changes in demand, world production, and marketing conditions greatly influence the prices that farmers receive for crops. Depending on the purposes for which the budgets are being prepared, several levels of prices may be used just as several yields may be used. The farm planner has the responsibility of justifying the prices he uses and pointing out special conditions and uncertainties.

The Completed Land Use Plan

The finished plan shows what crops will be produced and what disposal will be made of them. It shows the amount of each crop that will be used for livestock feed, seed, home use, and finally the amount that will be available for sale. The amount available for sale multiplied by the expected price will give the anticipated sale receipts for each crop. Crops used exclusively for animal feed or human food will not show any cash income in the land use plan. The income from crops used for animal feed and the value of the farm produced food used at home will enter the budget later.

It may be pointed out here that each part of the budget is dependent on the other parts. For example, the land use plan can hardly be completed until feed requirements have been determined. The feed requirements depend on the number and kinds of livestock kept. And the number of livestock kept on the farm depends on land and other resources available. Those parts of the budget are interrelated. Each part must be consistent with the other parts.

THE LIVESTOCK PLAN (SEE TABLE 2)

The livestock plan is one of the most difficult parts of the budget to prepare. It is necessary to account for replacement of breeding stock, deaths, purchases, sales, animals born, and animals slaughtered for home use. A careful, systematic approach is necessary in preparing this plan.

Step 1

List all livestock on hand at the first of the accounting or planning period. Usually, this is the first day of the year. Classify animals by type, age, and sex. The detail in the classification will depend on the over-all detail of the farm plan. Place an inventory value on all animals on hand at the beginning of the planning period.

Step 2

Livestock may be added during the year, by purchase and by birth. Make entries in the appropriate columns for these items. If necessary, add more

Table 2. The Livestock Plan

KIND OF LIVESTOCK OR PRODUCTS	BEGINNING OF THE YEAR		TO BE PURCHASED		NO. BORN	DISPOSAL						
	NO.	VALUE	NO.	VALUE		NO. DIED	HOME USE NO.	HOME USE VALUE	NO. FOR SALE	WT. PER HEAD	PRICE PER UNIT	SALE RECEIPTS
Cows												
Buffalos												
Horses												
Donkeys												
Camels												
Goats												
Poultry												
Etc.												
Total												

classifications of kind of livestock. Also, the sale of animal products such as milk and meat can be listed in the same manner.

Step 3

Now show the number of livestock which you anticipate will die; which will be used for home consumption, and which will be sold. The price multiplied by the number for sale will give you the sale receipts for each class of livestock. Some of the animals listed in the beginning inventory will be affected by these disposal processes. These losses must be replaced. It is important to preserve the beginning inventory by adding necessary replacements through purchases or through the natural increase of livestock. Otherwise, a charge must be made for depreciation of the breeding stock. If the original herd is maintained, the total animals disposed of during each time period will be equal to the total number purchased and born. If this equality is not satisfied, it is apparent that a mistake has been made in organizing the livestock plan. Yields and prices used in this step are subject to the same consideration discussed previously regarding the land use plan. The sale prices are not necessarily the same as the purchase prices of animals.

Step 4

List anticipated livestock sale products, for example; milk and eggs, showing anticipated amounts for sale and anticipated prices. The amount multiplied times the price will show sale receipts.

Step 5

Total all columns vertically. The total sale receipts and the value of products used at home will be carried forward to the income and expense summary. The value of purchased livestock will be carried forward to the expense form. The total value of the livestock inventory will be carried forward to the investment summary.

Step 6

Analyze the logical consistency of the entire livestock plan. Are there adequate provisions built into the plan to provide for maintenance for the original investment? Does the amount shown as "Total Sale Receipts" represent a return that one can expect from each planning period, given the specified yields and prices?

THE LIVESTOCK FEED PLAN (SEE TABLE 3)

The land use plan provides a column for allocating crops to animal feed. The livestock plan bases anticipated output on certain technology which includes given levels of animal nutrition. In order to integrate these parts of the budget, it is necessary to prepare a livestock feed plan.

For each class of animals it is necessary to show total feed requirements for the planning period. These requirements should be adequate, of course, to provide for the livestock output budgeted in the livestock plan. The feed plan should show all the feed requirements. It should show the forage, grain, concentrates, and minerals that are needed to meet the production plans.

The total feed requirements for the farm must be compared with the quantity to be raised on the farm. If the particular feed is not raised on the farm and properly allocated in the land use plan, it must be purchased. The total cost of feed to be purchased may then be carried forward to the expense plan in the complete budget. The livestock feed plan should be reviewed to see that it is consistent with the land use plan and the livestock plan.

Table 3. Livestock Feed Plan

KIND OF ANIMALS	NO.	LENGTH OF TIME TO BE FED	FEEDS TO BE FED				
			AUM'S PASTURE	HAY	SALT & MINERALS	CAKE	CROP AFTERMATH
Cows							
Buffalos							
Horses							
Donkeys							
Camels							
Goats							
Poultry							
Etc.							
TOTAL REQUIRED							
AMOUNT TO BE RAISED							
AMOUNT TO BE PURCHASED							
COST OF PURCHASED FEED (Rs.)							

INVENTORY OF DEPRECIABLE ASSETS (SEE TABLE 4)

Modern farms require the use of many items of production which have lives longer than one planning period. For accounting purposes such assets are depreciated over time with a fractional part of the item's original cost charged against the farm business each period. Such a procedure is also useful in budgeting. If the depreciation is set aside in a special fund each year this insures that capital will be available to replace the asset at the end of its useful life.

Depreciable assets include machinery, tractors, work animals, irrigation structures and equipment, machine shop and tools. Theoretically, the cost of any item that tends to wear out but has a life expectancy of more than one planning period should be depreciated or prorated over time.

The columns headed "size" and "date acquired" indicate the type and age of equipment to be used in operating the farm. This is strictly a technical consideration. The original cost of each item is listed for use in the investment summary. The total annual depreciation enters the complete budget as an expense item and is charged against each specified planning period.

The annual depreciation should reflect the decrease in value of the asset. This will, of course, depend on how the asset is used and how well it is maintained. The experience of a particular farm with regard to the life of assets is useful in estimating annual depreciation. In the absence of such experience, agricultural engineering studies may be useful.

The table on page 9 does not take into account the salvage values. Although ignoring salvage value simplifies the budgeting procedure, it is not entirely correct. Greater accuracy could be achieved, if desired, by computing depreciation according to the following formula:

Table 4. Inventory of Depreciable Assets

KIND OF ASSET	SIZE OR CAPACITY	DATE ACQUIRED	ORIGINAL COST	ESTIMATED SALVAGE VALUE	ESTIMATED YEARS OF LIFE	ANNUAL DEPRECIATION
Tractor						
Plough						
Desi Hal						
Rabi Drill						
Kharif Drill						
Karah						
Harrow						
Pore						
Hand tools						
Bins						
Etc.						
Total						

$$\text{annual depreciation} = \frac{\text{original cost - salvage value}}{\text{number of years of expected life}}$$

ESTIMATE OF EXPENSES (SEE TABLE 5)

The estimated expenses for one planning period should be consistent with the crop and livestock technology assumed for the complete farm plan. Past records are perhaps the best source of information for estimating expenses. If they are available, farm management cost studies may be helpful. If these sources of information aren't available, expenses may be estimated by considering the farming or technical operations, the amount of fuel, labor and other items required for each operation, and then adding them together. This is often referred to as the "synthetic process".

Expense items listed as "livestock purchased", "feed purchased," and "depreciation" are to be carried forward from the worksheets previously described. The total expenses represent the "out-of-pocket" costs of operating the farm business. It is customary to subtract these costs from "gross farm returns" to determine "net farm income." Computed on this basis "net farm income" should be considered as a return to the farmer's labor and management and as a return on his equity capital.

INVESTMENT SUMMARY (SEE TABLE 6)

The purpose of the investment summary is to explain the capital requirements and financial structure of the farm plan. The format suggested is designed to meet the needs of an individual propriatorship form of business. With slight modification, it could serve a partnership or an incorporated form of business organization.

Real estate customarily means land, buildings, and permanent improvements. The value assigned to land should represent the present market value of the

Table 5. Estimate of Expenses for one Planning Period

ITEM	AMOUNT
Fuel, oil, and grease	
Custom hire (haying)	
Labor hire	
Machinery repair	
Building and improvement repair	
Seed and fertilizer	
Veterinary expenses	
Telephone and electricity	
Chemicals	
Taxes	
Insurance	
Interest paid	
Etc.	
LIVESTOCK PURCHASED	
FEED PURCHASED	
DEPRECIATION	
TOTAL EXPENSES	

Table 6. Investment Summary

REAL ESTATE	Rs.
Cropland	______
Rangeland	______
Roads, farmstead, and waste	______
Buildings	______
Total Real Estate	______
WORKING CAPITAL	
Livestock	______
Machinery	______
Operating Capital	______
______	______
______	______
Total Working Capital	______
Total Investment	______
LIABILITIES	
Real estate mortgage	______
Accounts payable	______
______	______
Total Liabilities	______
NET WORTH	______

land. The usual procedure for valuing depreciable assets such as buildings and improvements is to determine the "average" value of the asset over its life time.

The reason for using average value is that the original cost of the asset is gradually recovered through time. If the annual depreciation is put into a sinking fund, capital will be available to replace the asset at the end of its life. Thus, the net investment capital required to own the asset starts at "original cost" and, assuming no salvage value, goes to zero. The general formula for computing average investment cost is:

$$\text{average investment cost} = \frac{\text{original cost} + \text{salvage value}}{2}$$ [1/]

Working capital includes the value of all assets used in operating the farm which are not considered to be permanently attached to the land. Some of these assets are depreciable (for example, machinery) and their "average values" are computed as explained in the preceding paragraph.

Livestock is included in the investment summary at full investory value. This is because the livestock inventory is not depreciated. Animals are culled and replaced each year so as to sustain the value of the livestock inventory.

Operating capital is the amount of money needed to pay expenses. Since each is coming in throughout the year from the sale of products the average investment capital needed to pay operating expenses is always less than total annual expenses. How much less depends on the flow of income and expenses during the year.

[1/] It should be recognized that different approaches may be used in valuing land and other assets. For example, the acquisition price of land will usually by substantially different from the salvage value. The salvage value is what a farmer nets from the sale of land after paying selling commissions, title transfer costs, capital gains, taxes, etc. Differences in asset values lead to differences in investment costs.

Liabilities are obligations or "what the farmer owes". Money borrowed to finance the farm business, and accounts owed should be listed here.

Net worth is the difference between total investment (assets) and what the farmer owes (liabilities). In other words, it is a measure of the farmer's equity in the farm business.

FINANCIAL SUMMARY (SEE TABLE 7)

The financial summary brings all the parts of the budget together in order to determine and allocate net farm income. It also provides the information needed for evaluating the economic feasibility of a farm plan.

Gross receipts are brought forward from land use and livestock plans. The value of farm products used at home can also be brought forward from these parts of the budget. Any additional receipts, for example, income from work off the farm, mineral leases, etc., should be shown in the gross receipts portion of the financial summary.

Expenses are subtracted to arrive at net farm income.

Net farm income is a return to the farmer's labor, management, and equity capital. All other costs have been provided for in the estimate of expenses. The allocation of net farm income to the farmer's labor, management, or capital is arbitrary. The design of Table 7 makes the return to the farmer's equity capital (net worth) the residual after subtracting the opportunity cost of keeping the farmer's labor and management committed to the farm business. An alternative procedure would be to deduct the opportunity cost of the farmer's equity capital from net farm income, leaving a residual return to the farmer's labor and management.

PARTIAL BUDGET ANALYSIS OF EXPERIMENTS

The purpose of partial budgeting is to organize information in such a way as to help make a particular management decision. The types of decisions

Table 7. Financial Summary

GROSS RECEIPTS:	
Crop Sales	Rs. ________
Livestock & Livestock Product Sales	Rs. ________
Products Used in the Home	Rs. ________
Miscellaneous	Rs. ________
Total Receipts	Rs. ________
TOTAL EXPENSES	Rs. ________
NET FARM INCOME	Rs. ________
DISTRIBUTION OF INCOME:	
Return to the Farmer for his Labor & Management[1]	Rs. ________
Return to Net Worth	Rs. ________
Rate of Return on Net Worth[2]	Rs. ________

[1]Include unpaid family labor, if any.

[2]Ratio between return to net worth and net worth, multiplied by 100.

with which agronomists will usually be concerned are the choice of fertilizer level, the choice of variety, choice of soil amendments, the choice of seeding data and rate, and so on, or perhaps the choice among alternative packages of such practices. Some of these are "yes or no" decisions and others are "how much" decisions, but all of them may be budgeted in the manner to be described.

To introduce these concepts, let's consider the case of the weed-consciou farmer. He has perhaps seen some experimental results and knows that for the last two seasons, the plots without herbicide yielded an average of 2 tons per acre and the herbicide plots averaged 2.5 tons. His own yields averaged about 2 tons, also, and he thinks he would realize about the same yield increase from herbicides on his own farm.

We don't know the exact sequency of steps the farmer would use to evaluate this choice, but in some fashion he weighs the benefits he would receive from each alternative with the costs which he must give up for each alternative. We will first look at benefits, then costs, and then net benefits.

NOTE: Portions of the following material have been adapted from the publication, "From Agronomic Data to Farmer Recommendations--An Economics Training Manual", authored by R.K. Perrin, D.L. Winkelmann, E.R. Moscardi and J.R. Anderson. Information Bulletin 27. Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City.

The first concept used is:

Net Yield - the measured yield per acre in the field, minus harvest losses and storage losses where appropriate.

Our farmer is satisfied that the yields obtained in the trials are the same as he would obtain, and since he sells his grain immediately after harvest, he need not consider storage losses. We can therefore record 2.0 and

2.5 in line one of Table 8 as a measure of the yields the farmer expects to receive. The next issue is the value which the farmer places on the yield, which we designate as Field Price (of output) - the value to the farmer of an additional unit of production in the field, prior to harvest. Farmers who sell all or part of their grain will be concerned with money field price while those who consume the entire crop will be concerned with opportunity field price. Money field price is the market price of the product minus harvest, storage, transportation and marketing costs, and quality discounts. Opportunity field price is the money price which the farm family would have to pay to acquire an additional unit of the product for consumption.

Our farmer always sells his grain to a trucker who comes by, and he expects to receive Rs. 1100 per ton. However, he also knows that it costs him about Rs. 100 per ton to harvest and shell the crop, so that the field price is Rs. 1000 per ton. Multiplying net yield by field price, we obtain an estimate of the total value or Gross Field Benefit - net yield times field price for all products from the crop. In general, this may include money benefits or opportunity benefits, or both.

In considering the costs associated with this decision, the farmer need only concerned with those costs which are affected by the decision or variable costs. Costs which are not affected by the decision (such as plowing or planting costs in this case) are known as fixed costs. Since these costs will be incurred regardless of which decision is made, they cannot affect the choice and can be ignored for the purpose of this decision. The term "partial budgeting" is a reminder that not all production costs, and perhaps not all benefits are included in the budget - only those which are affected by the decision being considered.

Table 8. Example of a per acre partial budget.

	Present Practice	Use of herbicides
Benefits		
Farmer's yield (net yield)	2.0 tons	2.5 tons
Farmer's value (field price)	Rs.1000	Rs.1000
Total benefit (gross field benefit)	Rs.2000	Rs.2500
Variable cost:		
herbicide:		
amount	-	2 liters
value (money field price)	-	Rs.30
total (field cost of herbicide)	-	Rs.60
Labor for application:		
amount	-	2 days
value (opportunity field price)	-	Rs.10
total (field cost of application labor)	-	Rs.20
Labor for hand weeding:		
amount	10 days	3 days
value (opportunity field price)	Rs.10	Rs.10
total (field cost of weeding labor)	Rs.100	Rs.30
Total variable costs	Rs.100	Rs.110
Net benefit	Rs.1900	Rs.2390

If the farmer is to make a good decision, he must identify all the inputs which would change if he decides to apply the herbicide. In his case this includes only the herbicide and the labor required to apply it, plus the reduction in hand weeding labor (he already has a hand sprayer which can be used). The amount of herbicide required is two liters per acre and based on the amount of time it takes him to apply insecticide, he estimates that application will take two days of his time per acre. The value of the herbicide can be simply expressed in terms of money, because it is money, Rs. 30 per liter, which he must give up to acquire it. This value concept we refer to as Field price (of an input) - the total value which must be given up to bring an extra unit of input into the field. Money field price refers to money values such as purchase price or other direct expenses. Opportunity field price refers to the nonmoney value of inputs which must be given up. The opportunity price is the value of the input in its best alternative use. For farm family labor, the opportunity field price may be the wage which could be earned in off-farm employment, or the value which the worker places on leisure.

Field cost (of an input) - is the field price of an input multiplied by the quantity of that input which varies with the decision. It may be expressed as money field cost or opportunity field cost, or perhaps both, depending on the input.

Thus for our farmer, the field cost of the herbicide is Rs.60 per acre. Regarding his labor, the farmer might perhaps note to himself that he would not do that kind of work for anyone else for less than Rs.10 per day (otherwise he would rather sit in the shade). This means that he values the opportunity cost of his time at Rs.10 per day and therefore, the field cost of the labor for the herbicide treatment is Rs.20 per acre. He also observed that when herbicides were used, the time spent on hand weeding was reduced from 10 days per acre to just 3. The cost of hand weeding was thus reduced from Rs.100 to Rs.30. The total of these values for each treatment is Total field cost or Variable Cost - the sum of field costs for all inputs which are affected by the choice. In partial budgeting we refer only to those inputs which are affected by the decision so that total field cost in fact refers to variable costs, i.e. those costs which vary with the choice. Variable cost can consist of either money costs or opportunity costs or both.

The total variable cost of the herbicide alternative is Rs.110 per acre. The total variable cost of the present practice is Rs.100 per acre. Subtracting these from the benefits received gives Net Benefits - total gross field benefit minus total variable costs.

In the net benefit figure, we want to represent the value which the farmer places on additional production minus the value he places on those things which he must give up to attain the extra production. In the case of the weed-conscious farmer, the net benefits from the herbicide alternative are Rs.2390 per acre versus Rs.1900 for his current practice. Remember that net benefits are not the same thing as profit, because we have left many costs out of the budget because they are irrelevant to this particular decision.

While it may appear that this farmer will choose to use herbicides, this is not always clear since there is uncertainty surrounding his yields, and since money may be quite scarce. We now proceed to apply the concepts just described to make partial budget analyses of some fertilizer experiments.

Table 9 presents the results of 8 maize fertilizer trials conducted in a rainfed recommendation domain. The purpose of these trials was to derive recommended fertilizer levels for farmers of the domain. Here we have presented the average yields obtained from three replications of the treatments. (We have averaged the replicates because these averages are the best estimate of the yield which would be obtained on the entire field in which the experiment was located.)

Although it is obvious that there is considerable variability in yields and yield response from trial to trial, we shall postpone a discussion of the implications of the variability for farmers' decisions. For now, we will consider only the average yields obtained for each treatment over the eight trials, and we will treat the data just as we would a single experiment.

Table 9. Maize yields (tons/ac of 14 percent moisture grain) by fertilizer treatment 8 trials.

Trial	N / P_2O_5	Fertilizer treatment lbs/Ac												
	N	0	50	100	150	0	50	100	150	0	50	100	150	
	P_2O_5	0	0	0	0	25	25	25	25	50	50	50	50	Avg.
1		0.40	1.24	3.63	3.76	0.79	2.58	4.23	4.72	1.67	2.51	3.28	3.66	2 71
2		1.53	2.60	5.14	5.32	1.67	3.79	5.10	6.83	1.41	4.13	5.89	6.27	4.14
3		4.15	4.86	4.80	4.87	4.44	5.00	4.97	5.28	5.12	5.66	6.36	6.62	5.18
4		2.42	3.82	5.23	4.48	2.36	4.54	6.26	7.17	1.61	4.41	5.38	6.58	4.52
5		1.64	1.92	2.08	2.19	2.04	3.21	3.12	2.93	1.44	3.44	3.32	3.62	2.58
6		1.61	2.94	4.14	4.34	1.81	3.92	3.61	3.81	1.18	3.89	5.38	4.92	3.46
7		4.74	5.41	4.29	4.92	4.91	5.22	5.38	5.14	5.10	4.88	4.54	5.28	4.98
8		1.21	2.33	1.97	2.23	1.53	2.78	2.49	2.80	1.37	3.51	3.75	4.35	2.53
Avg.		2.21	3.14	3.91	4.01	2.44	3.88	4.40	4.84	2.36	4.05	4.74	5.16	3.76

The yield curves in Figure 1 provide a graphic picture of the resulting average yield response.

Table 10 provides a convenient format for organizing the partial budget information. We show the alternative choices of fertilizer level as column headings, then the average yield for each, followed by net yield after adjusting downward 10% for assumed harvest and storage losses. The market price for maize in this area is Rs.1200 per ton, but after making corrections for harvest costs, transporation costs, and shrinkage, we determine that the field price of additional yield is Rs.1000 per ton. Resulting gross field benefit

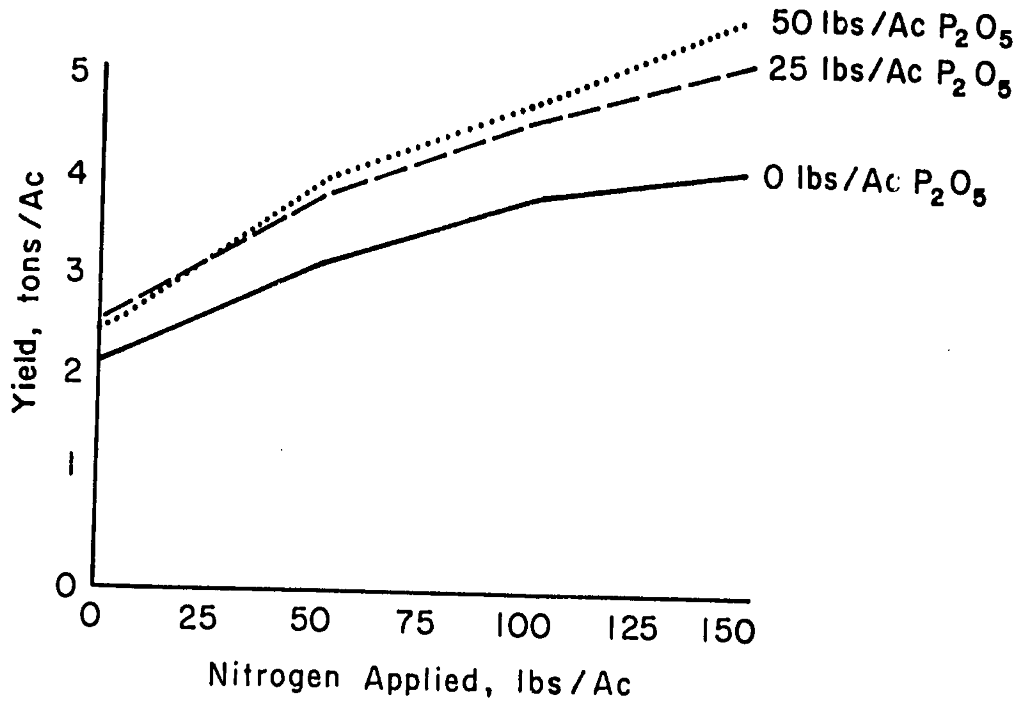


Figure 1. Average Yield Response to Nitrogen

is shown in line #3. Of course, the largest gross field benefit is obtained from the treatment with the highest yields, which in this case is also the highest level of fertilizer.

In considering the costs associated with each choice, we must be familiar with the cultural practices used by farmers if we are to determine which inputs are to be affected by the choice of fertilizer level. In this particular area, bullock technology is the dominant tillage method and fertilizer is applied by hand. Therefore, the only inputs affected by this decision are the amounts of fertilizer and the labor required for application (the value of harvest labor has been deducted from field price) The price of nitrogen at the store is Rs.5 per lb of N and the price of phosphorus is Rs.7 per lb of P_2O_5; but after making adjustments for transportation, we determined the field price of N and P_2O_5 to be Rs.8 and Rs.10 per lb, respectively.

Table 10. Partial budget of averaged data from fertilizer trials (per acre basis).

Item		Fertilizer treatment lbs/ac											
	N:	0	50	100	150	0	50	100	150	0	50	100	150
	P_2O_5:	0	0	0	0	25	25	25	25	50	50	50	50
(1) Average yield (tons/ac)		2.21	3.14	3.91	4.01	2.44	3.88	4.40	4.84	2.36	4.05	4.74	5.16
(2) Net yield (tons/ac)		1.99	2.83	3.52	3.61	2.20	3.49	3.96	4.36	2.12	3.64	4.27	4.64
(3) Gross field benefit (Rs/ac at Rs.1000/ton)		1990	2830	3520	3610	2200	3490	3960	4360	2120	3640	4270	4640
Variable money costs:													
(4) Nitrogen (Rs.8/kgN)		0	400	800	1200	0	400	800	1200	0	400	800	1200
(5) Phosphate (Rs.10/kgP_2O_5)		0	0	0	0	250	250	250	250	500	500	500	500
(6) Variable money costs (Rs/ac)		0	400	800	1200	250	650	1050	1450	500	900	1300	1700
Variable opportunity costs:													
(7) Number of applications		0	1	2	2	1	1	2	2	1	1	2	2
(8) Cost per application (2 days at Rs.25)		50	50	50	50	50	50	50	50	50	50	50	50
(9) Opportunity cost (Rs/ac)		0	50	100	100	50	50	100	100	50	50	100	100
(10) Total variable costs (Rs/ac)		0	450	900	1300	300	700	1150	1550	550	950	1400	1800
(11) Net benefit (Rs/ac)		1990	2380	2620	2310	1900	2790	2810	2810	1570	2690	2870	2840

In these experiments, nitrogen levels in excess of 50 lbs were applied in two doses, and we estimate that two man-days are required per acre for each application. After visiting with farmers in the area we calculated that Rs.25 per man-day is a reasonable estimate of the average value of farmers' time, although we recognize that for some farmers in the area the amount should be closer to zero, while for others it should be more. In lines 7, 8 and 9 of Table 10 we have calculated the cost of labor for each treatment and in line 10 we show the total of all variable costs associated with each treatment.

We have now completed the task of assessing the field benefits and variable costs associated with each of the alternative choices of fertilizer level. But the task of making a choice among them, from the farmers' point of view, is far from complete. Next, we calculate net benefit, gross benefit minus variable costs, and record these amounts in line 11.

The listing of net benefit for each treatment, as shown in line 11 of Table 10, completes the partial budget analysis of the average yields from these experiments. One might be tempted at this point to choose treatment 100-50 as the fertilizer recommendation for this area. But this would be a poor choice because some crucial aspects of farmer conditions, namely capital scarcity, yield uncertainty and risk aversion have been ignored.

The Net Benefit Curve

A very revealing device for summarizing the results of a partial budget is the net benefit curve. This curve shows the relationship between the variable costs of the alternatives and the average net benefits from the alternatives. We can best describe this by plotting the net benefit curve from the fertilizer experiments described earlier.

In Figure 2 we have plotted each of the fertilizer treatments from Table 10 according to the net benefit from the treatment and the variable costs of the treatment. Beside each of the 12 points plotted, we show in parentheses the nitrogen level and phosphate level. It is apparent from the points plotted that some of the fertilizer alternatives would not be chosen by any thoughtful farmer. For example, the phosphate-only treatments (0-25 and 0-50) have net benefits lower than the check treatment (0-0), yet require variable costs of Rs.300 and Rs.500 per acre. No farmer is likely to choose these alternatives when he could receive a higher net benefit with zero variable cost. The same is true of treatments 100-0 and 50-50. The average returns from these two treatments are lower than the return from 50-25 and 50-25 has a lower variable cost. Fertilizer levels such as 0-25, 0-50, 100-0, and 50-50, we refer to as dominated alternatives, because for each of these there is another alternative with a higher net benefit and lower variable cost. In normal circumstances, we would never expect a farmer to choose one of these dominated alternatives.

The choices which are not dominated we have connected together with a solid line. This solid line is the net benefit curve. Two aspects of this net benefit curve are noteworthy. The first is that the curve rises steeply at first, then rises more slowly to a peak and begins to fall. The curve shows diminishing returns to fertilizer expenditures. This is important because it demonstrates clearly that we can reduce costs considerably from the point of maximum met benefits with little reduction in those benefits. Said another way, this demonstrates that the returns from expenditures on initial amounts of fertilizer are much greater than the returns to additional expenditures for larger amounts of fertilizer. Experience shows that this is often the case for fertilizer.

The second interesting aspect of the net benefit curve is its shape between the 0-0 point and the 50-25 point. The two solid line segments drop below the broken line connecting these two points, whereas we would normally expect a fertilizer response curve or net benefit curve to fall above the dotted line. In other words, we normally expect these curves to begin steeply, with the slope gradually falling as expenditure on inputs increases. The irregularity of the curve we observe here may be due to an interaction between nitrogen and phosphate at low fertilizer levels, or it may be due to chance (even though these are the combined results of many trials).

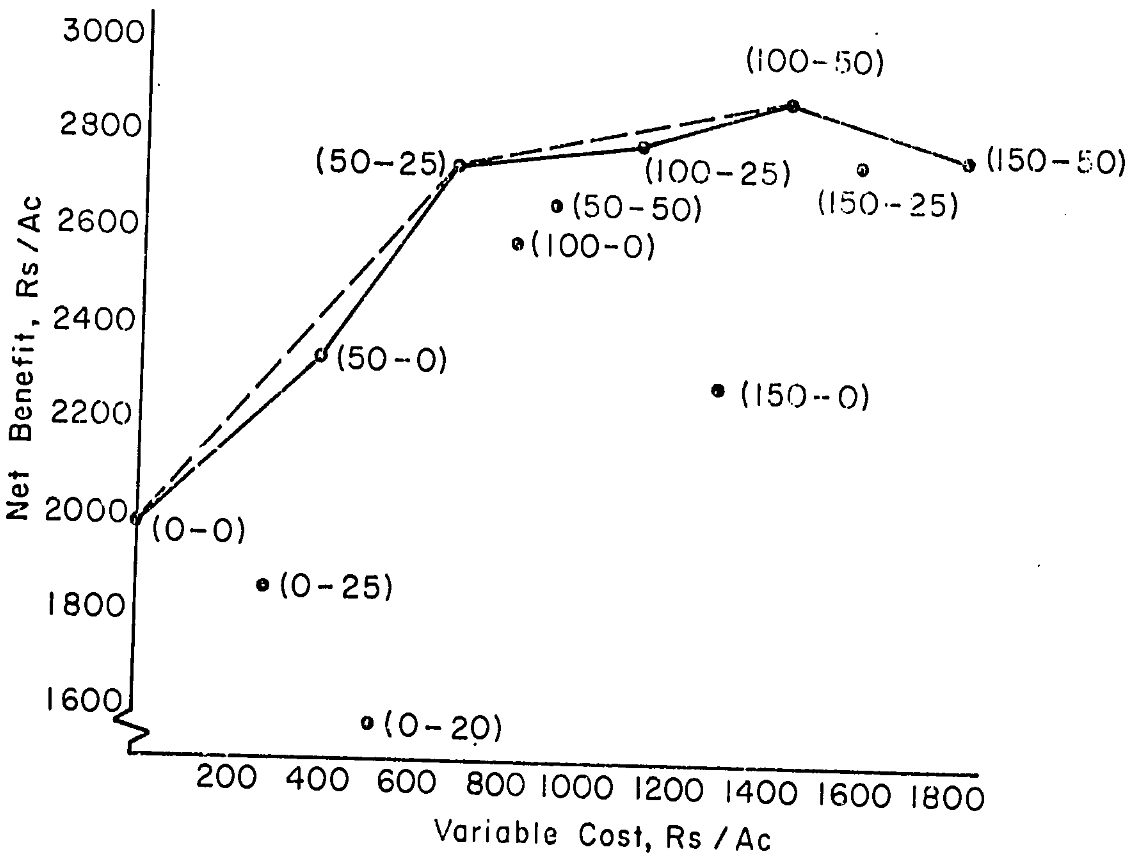


Figure 2. Net Benefit Curve for the Fertilizer Trails. Numbers in parentheses represent lbs/Ac of N and P_2P_5, respectively.

Whatever the cause of this unusual shape, the implications for further experimentation are clear. There is surely no reason to conduct any further trials with fertilizer costs in excess of Rs.650, since it seems clear that net benefits increase little, if any, above that point. On the other hand, intuition suggests that there may be some fertilizer treatments which would result in points above the broken line between 0-0 and 50-25. Since it appears there might be an important interaction between N and P_2O_5, it would seem wise to experiment further with treatments costing between Rs.300 and Rs.500 such as 40-15, 30-15, 25-25, etc. These treatments may result in the discovery of points above the broken line. If so, these are treatments which further reduce farmer costs without appreciably reducing net benefits.

Marginal analysis of net benefits

We have observed that the net benefit curve for the fertilizer data rises quite sharply at first and then more slowly to a maximum. We have found this to be true of most net benefit curves. It implies that the rate of return to the investment in the first units of fertilizer is much higher than the return to the additional units required to achieve the maximum net benefit. In looking at Figure 2, one may be tempted to conclude that not many farmers would want to invest more than Rs.700 per acre for fertilizer (for 50 lb of N and 25 lb of P_2O_5). This is because the first Rs.700 provides an increase in net benefit of about Rs.800, while the second Rs.700 provides an increase in net benefit of only Rs.30. To explore this observation in more detail, we need to introduce the concept of marginal analysis.

The purpose of marginal analysis is to reveal just how the net benefits from an investment increase as the amount invested increases. Marginal net benefit is the increase in net benefit which can be obtained from a given increment of investment. In the fertilizer example, the marginal net benefit from Rs.450 invested in 50 lb of N (the smallest nondominated invest ment included) is Rs.390. The next possible increment of expenditure is to spend an additional Rs.250 for 25 lb of P_2O_5 (taking us to the 50-25 treatment). The marginal net benefit from this increment in expenditure is Rs.41 The marginal rate of return to a given increment in expenditure is the margi net benefit divided by the marginal cost (increment in expenditure). The marginal rates of return of the first two increments in fertilizer investmen capital are determined as:

$$\frac{\text{marginal net benefit}}{\text{marginal cost}} = \frac{2380 - 1990}{450 - 0} = \frac{390}{450} = 0.87 = 87\%$$

The marginal rate of return of the second increment is:

$$\frac{\text{marginal net benefit}}{\text{marginal cost}} = \frac{2790-2380}{700-450} = \frac{410}{250} = 1.64 = 164\%$$

It is clear from the shape of the curve that the marginal rate of return on expenditures above Rs.700 per acre is quite small.

A PROCEDURE FOR ALLOCATING FERTILIZER

The use of economic principles is essential in making decisions about the proper rate of fertilizer to use for a certain crop. These principles apply in times of adequate supplies as well as in times of shortages. When fertilizer or capital are not limited, economic principles can be used to determine the maximum profit point. When supplies of fertilizer are limited or if capital is short, the proper principles can help to determine how much of the available fertilizer should be applied to a specific crop and how to allocate it between crops.

One problem is the lack of yield response data for individual farms. To overcome that problem, soil testing can provide a basis for each soil. Many field trials have been conducted on major crops so data are available for some areas in Pakistan. There is no practical way to have experimental data on each farm but each farmer can soil test and use check strips to verify the validity of recommended data.

To properly evaluate yield response data, whether actual or projected, the following information is necessary:

1. Various rates of fertilizer used to to be used
2. Yields resulting from each rate of fertilizer
3. Cost of the variable input (fertilizer)
4. Price of the product (crop) produced.

One term frequently used is "marginal". In economic or management parlance "marginal" means "additional". If you go from 20 pounds of nitrogen to 30 pounds, the added amount, 10 pounds, is the marginal amount. If that 10 pounds of fertilizer increases gross returns by Rs.400, the Rs.400 is the marginal return.

To evaluate yield-response data, the information should be organized in the manner set forth below:

1	2	3	4	5
Fertilizer Nutri-ent Applied lbs/Ac	Total Yield mds/Ac	Marginal or added yield mds/Ac	Marginal or added return Rs/Ac	Marginal or added cost Rs/Ac

Column 1 - Show the various rates of nutrient that is applied, i.e., N 20, N 40, N 60, N 80, etc.

Column 2 - List the total yield realized from the rate of fertilizer applied.

Column 3 - This column is to calculate the change in yield from one rate of fertilizer to the next as the rate of fertilizer used is increased.

Column 4 - The marginal return or value of the additional yield is calculated by multiplying the marginal yield times the value per unit of the product.

Column 5 - The marginal cost of the fertilizer goes in this column, i.e., the added cost of each additional increment used.

You know have a table, as shown below, to evaluate the most economical level of fertilizer use (Table11). Wheat is the crop used in this example. Marginal returns are calculated on the basis of Rs.40/md wheat. In this example, marginal costs are based on N at Rs.3/lb. It is assumed that adequate phosphate has been applied at the time of seeding.

Table 11 Illustration of the Diminishing Marginal Return Principle used to determine the maximum profit point.

1 Fertilizer Nutrient Applied lbs/Ac	2 Total Yield mds/Ac	3 Marginal or added yield mds/Ac	4 Marginal or added return Rs/Ac	5 Marginal or added cost Rs/Ac
0	32.0	-	-	-
20	34.6	2.6	104	60
40	36.4	1.8	72	60
60	37.4	1.0	40	60
80	37.6	0.2	8	60

The principle of determining the maximum profit point is that you produce to the point where marginal return is greater than or equal to the marginal cost. In this example, 40 lbs of N is most profitable. Here for an additional Rs.60 in fertilizer costs you get Rs.72 in additional wheat returns. If you go to 60 lbs of N in this example you would spend another Rs.60 for N but get a return of only Rs.40. In actuality, the most profitable point would be between 40 and 60 lbs. If you could be so precise you would apply fertilizer until for each Rs.1 worth applied, you would get a return of at least Rs.1. However, we know that in the 'real' world it is impossible to be that precise.

If the price of fertilizer changes or the value of the product changes, it is easy to recalculate the marginal return and marginal cost columns. They must then again be compared to determine the new maximum profit point if there is a new one.

It may be noted that in our example, we have included only that part of the production function in which the yields per added increment of fertilizer is declining. It may be recalled that in our earlier discussion of production functions that in economics one is concerned with the area of the production function that falls between the point of diminishing returns and negative returns. This is known as the area of 'economic relevance'.

In our example, the marginal returns changed from Rs.104 to Rs.72 to Rs.40 and to Rs.8 as more fertilizer is added. This points out an additional consideration that must be made by the farm manager when his fertilizer supplies are limited. For instance, if 20 lbs of N would give a marginal return of Rs.85 in fodder production you would still use the first 20 lb increment of N in wheat production, but the second increment would provide a greater return in fodder production than would another increment in wheat. Thus, it is necessary to prepare estimates of costs and returns for all of the enterprises in which fertilizer might be applied.

A worksheet for calculating marginal returns and marginal costs is attached. The table is set up so that you may use data appropriate to your farm for the crops of your choice.

Fertilizer Allocation Worksheet

Application of_____Fertilizer to_____Crop

Fertilizer Nutrient Applied lb/A	Total Yield Units/A	Marginal or added yield Units/A	Marginal or added return Rs/A	Marginal or added cost Rs/A

Maximum profit points is where MR is greater than or equal to MC. This occurs at _____lbs. of nutrient.

Application of _____Fertilizer to_____Crop

Fertilizer Nutrient Applied lb/A	Total Yield Units/A	Marginal or added yield Units/A	Marginal or added return Rs/A	Marginal or added cost Rs/A

Maximum profit point is where MR is greater than or equal to MC. This occurs at _____lbs. of nutrient.

Application of_____Fertilizer to_____Crop

Fertilizer Nutrient Applied lb/A	Total Yield Units/A	Marginal or added yield Units/A	Marginal or added return Rs/A	Marginal or added cost Rs/A

Maximum profit point is where MR is greater than or equal to MC. This occurs at _lbs. of nutrient.

Subject: ECONOMIC ANALYSIS OF SELECTED FARMS

Trainer Agricultural Economist
Class Room 3 hours
Field 2 Days

OBJECTIVE

To train the student in farm interviews, prepare the schedules for farm budget analysis and make recommendations to the selected farmers. Suggestions will be made on crop and livestock enterprises and general farm reorganization.

MATERIALS NEEDED

Farm management survey schedules.

TRAINING AIDS

None.

PRESENTATION

The trainees will be divided into teams consisting of two to three individuals. The schedules previously developed will be used to secure the needed data from the selected farmers to prepare the complete and partial budgets that will be used in the farm analysis.

After securing the farm data, each of the teams will return to the classroom for the individual farm analysis. Once the analysis is completed, the teams will return to their respective farmers and present their observations and recommendations to them.

Subject: RURAL SOCIOLOGY

Trainer Rural Sociologist
Class Room 2 hour
Field ____________ Days

OBJECTIVES

1 - To define and illustrate basic social science concepts.

2 - To use these concepts to develop a perspective for understanding the role of social, cultural, and economic factors in programs of planned change.

3 - To show the significance of social/cultural factors for the success of a program to improve water management, and the need for a change agent (extension officer, engineer) to take these factors into account.

MATERIALS NEEDED

TRAINING AIDS

Excerpt from "The Water User Association Research Project: An Interim Report"*

INTRODUCTION

Increasing agricultural production through improving water management practices is not simply a technical problem; it is also a social problem. As a social problem it has two facets:

1. organization of farmers for working together on rehabilitation and maintenance of their watercourse;

2. educating farmers--changing their perceptions to make them more receptive to new ideas, and teaching them new techniques that will help them increase production and income.

Since the problem is social as well as technical, training in purely technical skills alone will not prepare you for your job. You also need:

a) a clear understanding of social structure and processes;

b) a clear understanding of social/cultural constraints on behavior;

c) social skills and strategies that can be used to induce change.

Learning these things will be a continuous process on the job; the purpose of the "rural sociology" part of your training is to orient you to these problems, raise your consciousness of social/cultural factors, and give you the basic background to build on when you begin working at your jobs.

PRESENTATION

Two fundamental concepts of social science are the concepts of society and culture.

By "society" is meant the total system of social relationships. Notice the word system: since a society is a system it means there is a pattern or structure to it, just as there is a structure in material things. And just as material things differ not just or even primarily because of different constituents (atoms, molecules) but because of different relationships, structures (different patterns of relationship among a limited number of elements) societies differ primarily because of different patterns of relationships among the constituents--different structures. Thus, one difference between Pakistani and American society is in the structure of relationships that constitute the "family". For example, in Pakistan, a father has more authority over his wife and children than in America, but unlike America, his father continues to have authority over him even after his marriage.

By "culture" is meant the system of values, beliefs, rules, perceptions, attitudes, etc. that are in peoples' heads, and in terms of which people behave, and interpret other peoples' behavior. Culture is learned from childhood as people grow up; it is learned in a social context--one learns ones culture from family members, relatives, playmates, teachers, etc. as one is growing up. Most of this learning is unconscious, just like learning a language. Indeed language is part of culture; and just as you learn your language by imitating adults and having them respond to you when you make understandable noises, (and not be memorizing rules of grammar, as you do when you learn a foreign language), so you learn most of your culture by this smae unconscious process. Because you learn your culture in a social context, people in the same society share their culture to a large extent. The degree of sharing varies with degree of social contact and similarity of the social context: people in one family will share more values, beliefs, etc. than persons from different families; and people from rural farmer families in Punjab share more with each other than with people from Punjabi cities even though they are in the same "society".

This unconscious facet of culture is more important in determining peoples behavior than those facets which are conscious and public. For example, the principles of Islam taught by the Holy Quran are shared at a conscious level by most Pakistanis; but that does not mean these principles guide and determine behavior in the way we may wish; rather they provide a set of principles by which we often measure and evaluate behavior; it sets ideals which people may or may not live up to, but does not determine people's actual behavior.

To sum up so far: society is a system of social relationships; these have a pattern of structure. Culture is the set of beliefs, rules, values, attitudes, etc. which people learn in a social context; it is to a large degree shared and unconscious.

For the purpose of understanding the structure of rural society and the problems of carrying out changes and development projects, it is important to understand that society--that is the system of structured relationships constituting society--has an economic basis. It is important to understand that control over the means of production--primarily land here--to a large degree shapes the structure of society. Patterns of land ownership and control determine the structure of the family, relations among employers and employees, owner and tenant, powerful landlords and less powerful small farmers. For example, one can argue that the large joint family often found in villages is based in part on the need for large amounts of labor to farm the land; in America, where farmers do most of the work with machines, joint families are less common. Land in Pakistan is the basis for raising capital (to buy a tractor for example) and for controlling labor. (In America, there are other sources of capital and workers have alternative sources of jobs, so control of land alone is insufficient to control other people.) Large joint families are more common among farmers than among casual laborers, again illustrating the role of land the economics. Just think for a minute about the differences in social relationships in an area where a large landlord controls the land, and most pther people are dependent on him either as laborers or tenants; as opposed to an area where there are a large number of small farmers owning their own land and not dependent on any one person.

The figure below illustrates the basic model of society that has been presented here:

MODEL OF SOCIOCULTURAL SYSTEM

CULTURE	(shared, mostly unconscious, beliefs, values, perceptions, etc.; also language)
↑ ↓	
SOCIAL STRUCTURE	(family, biraderi, leadership, etc.--patterns of relationships)
↑ ↓	
ECONOMIC BASIS	(control of land, and following from this, labor, capital)

⟶ primary effect

- - → secondary effect

APPLICATION

The perspective presented here has important implications for the success of the water management project. One implication is that a farmer's behavior is the result of the social and economic position in which he finds himself--his position in the social structure. In a community where a few farmers have more land than all others, for example, the leadership, or at least the ability to prevent others from being effective leaders, will usually be in the hands of these powerful few; this means you must work with them and get their support to be successful (without favoring them so much that others become resentful).

Another implication is that a change agent must be consciously aware of both the socio-economic structure (land holding patterns, groups such as biraderis, families) and also the culture of the community. For example, a primary cultural value that will affect the success of any cooperative project is izzat (honor, prestige, reputation). This is discussed further in the next class.

(If there is time remaining, the instructor will lead a class discussion of the problems faced in "chak B" described in the attached excerpt from the Interim Report, focused on how the socio-economic structure and culture of the watercourse affected the watercourse improvement project there.)

QUESTIONS

As a home assignment, besides reading the excerpt from the Interim Report (the instructor should have asked that trainees read this before this first class), each trainee will write a short analysis comparing one of the "successful" watercourses (Chak A or C) with one of the less successful ones (Chak B or D) and turn it in at the trainer's convenience. If Chak B has been thoroughly discussed in class then trainees will do D in their reports.

TRAINING AID

Excerpt from "The Water User Association Research Project: An Interim Report" by AH. Mirza and D.J. Merrey. (from 1979 Annual Technical Report)

Watercourse Social Structure

1. Social Structure

a. Chak A

Table 3 shows that despite the multi-caste nature of the village, the Gujjars are numerically absolutely dominant on the watercourse. All except two of the households have their total landholdings on this watercourse; these two exceptions have their major holdings located on the other (also improved) watercourse in the village. On this watercourse, there are large, medium and small holdings. Table 7, on the distribution of size of landholdings in sample villages, shows that six farmers out of the total 21 own more than 25 acres total. The four farmers with the smallest holdings (2-6 acres) are all located at the head. The remaining eleven are medium sized, ranging from 11 to 23 acres. The largest holdings are generally located in the middle of the watercourse. With their large kinno orchards, the income of the larger land owners is probably substantial. Most of the non-Gujjars' land is located on the tail of the watercourse. All but one of the households in this village are settlers. Two of the three watercourse committee members from Chak A have more than 25 acres of land in the middle section of the watercourse; the third has 18 acres in the tail section. The Numberdar, with the largest land holding on the watercourse, is not a committee member, but the third member in fact is allied with him.

b. Chak B

Table 4 shows that this watercourse is multi-caste in structure. All the major agricultural castes and subcastes of the village are represented on the watercourse, except the five Kariale and one Khokar households. However, three out of the five Kariale households in the village in fact do not possess any land. None of the village Shia households have land on this watercourse, all 32 households are Sunni. This village is predominantly a settler village.

Nineteen of the 32 households, nearly 60%, have total land holdings of more than 25 acres.[1/] Of these, the largest holding is 80.5 acres, but ten are owners of 50 acres or more. However, only three of these own more than 25 acres on this watercourse. Two of these, one Bore (38.5 acres) and one Tiwana (31 acres) have all their land on this watercourse whereas the third, a Mekan, has 40.5 out of his total 50 acres on this watercourse. These three were watercourse improvement committee members. The fourth committee member, a Jatriane, owns 14.5 acres on this watercourse out of a total 50 acres. Thus, it appears that size of land holding was a major criterion in choosing watercourse committee members.

1/ The Mona Project is not governed by the rule that at least 75% of the farmers must own 25 acres or less, as is the OFWM Project. Also, in the legal records, many of these holdings are undoubtedly in the names of more than one person.

Table 1. Basic Watercourse Data

	Chak A Distt: Sargodha	Chak B Distt: Sargodha	Chak C Distt: Faisalabad	Chak D Distt: Faisalabad
1. Improving organization	Mona Project	Mona Project	OFWM, Punjab	OFWM, Punjab
2. Tubewells	SCARP II	SCARP II	Cooperative	None
3. Name of canal	Lower Jhelum--Northern Branch	Lower Jhelum--Northern branch	Jhang Branch	Rakh Branch
4. Name of distributary	Ratokala	Fatehpur	Khai	Lakhuana
5. Branches (sarkari)	Single	Single	Single	Multiple
6. Major crops	Kinno, wheat, rice	Kinno, wheat, sugarcane	Sugarcane, wheat, cotton	Sugarcane, cotton, maize
7. Total culti. area--village	1363 acres	674 acres	965 acres	2525 acres
8. Commanded area, village	1363 acres	674 acres	890 acres	1825 acres
9. No. of moghas	2	2	3	4
10. No. of improved w/c	2	2	3	1
11. Sample w/c commanded area	463 acres	337 acres	290 acres	375 acres
12. Discharge: Mogha Tubewell Total	1.76 cusecs 1.33 cusecs (approx.) 3.09 cusecs	1.11 cusecs 1.50 cusecs 2.61 cusecs	1.58 cusecs 1.41[1] cusecs 2.99 cusecs	1.48 cusecs 0 cusecs 1.48 cusecs
13. Total length w/c (sarkari)	9,000 feet	10,000 feet	9,840 feet	17,850 feet
14. Date completion improvement	October 76	May 77	December 77	April 78
15. Date studied	June 78	July 78	July-August 78	Aug.-Sept. 78

1/The 2JB cooperative tubewell is run far less frequently than SCARP tubewells.

Table 2. Summary of Social Structure of Sample Villages

Village	Chak A		Chak B		Chak C		Chak D	
No. and percent	No.	%	No.	%	No.	%	No.	%
Agric. household	70	33	48	27	154	55	477	73
Non-Agric. "	142	67	132	73	127	45	181	27
Total	212	100	180	100	281	100	658	100
No. and percent Agriculturists who are								
Owners	60[1]	86	37	77	131	85	347	73
Tenants	2	3	0	0	3	2	0	0
Owners-Tenant	8	11	11[2]	23	20	13	130	27
Total	70	100	47	100	154	100	477	100
Locals	0	0	0	0	0	0	477	100
Settlers	54	77	48	100	153	99	0	0
Refugees	16	23	0	0	1	1	0	0
Total	70	100	11	100	154	100	477	100
No. of Agric. subcastes	7		11		3		6	
No. & % Agric. households in largest subcaste	(Gujjar) 35	50	Jat Kahoot 16	33	Jat Randhawa 150	97	Jat Athwal 450	94
2nd largest subcaste	(Sayid) 13	19	Jat Attar 6	13	1	1	Jat Hanjra 12	3

1/ Includes village chowkidar who gets 2 acres land as remuneration.
2/ Includes 3 households of 1 zat not engaging in agriculture at the moment.

Table 3. Chak A Wa:ercourse Structural Structure

S. No.	Major Caste	Sub-Caste	No. of house-holds	Religious sect	Settle-ment status[1]	Tenancy status
1.	Gujjar	Same	15	Sunni	Settler	Owners
2.	Malik	Khokar	1	Sunni	Settler	Owners
3.	Sayyed	Same	2	Shia	Settler	Owners
4.	Rajput	Raja	1	Sunni	Refugee	Owners
5.	Jat	Jaisak	1	Sunni	Settler	Tenant
6.	Muslim Sheikh	Same	1	Sunni	Settler	Tenant
	Total		21	Sunni 19 Shia 2	Settler 20 Refugee 1	Owners 19 Tenant 2

1/Settlers are those who settled the village during British times as part of the colonization schemes.
Refugees are persons who came from India as a result of Partition.
Locals are original inhabitants, predating the canal system.

Table 4. Chak B Watercourse Structural Attributes

S. No.	Major Caste	Sub-Caste	Total No. of house-holds	Religious sect	Settle-ment status	Tenancy status
1.	Jat	Kohoot	10	Sunni	Settlers	All owners
2.	Jat	Attar	3	Sunni	Settlers	All owners
3.	Jat	Bore	2	Sunni	Settlers	All owners
4.	Jat	Mekan	1	Sunni	Settlers	All owners
5.	Jat	Badhor	3	Sunni	Settlers	All owners
6.	Jat	Jatriane	2	Sunni	Settlers	All owners
7.	Jat	Marth	1	Sunni	Settlers	All owners
8.	Malik	Tiwana	5	Sunni	Settlers	Mixed
9.	Arain	-	1	Sunni	Refugees	Owner
10.	Kasai	-	1	Sunni	Settler	Tenant
11.	Musalli	-	1	Sunni	Settler	Tenant
12.	Tarkhan	-	1	Sunni	Settler	Owndr
13.	Jat	Mianey	1	Sunni	Settler	Owner
Total			32	Sunni Shias	Settler 31 Migrant 1	Owner 25 Tenant 2 Mixed 5

Table 5. Chak C Watercourse Structural Attributes

S. No.	Major Caste	Sub-Caste	No. of house-holds	Religious sect	Settle-ment status	Tenancy status
1.	Jat	Randhawa	20	Sunni 15		Owner 16
				Ahle-Hadith 2	Settler	Mixed 2
				Shia 3		Tenant 2
2.	Arain	Arain	1	Sunni	Refugee	Tenant
3.	Mochi	Mochi	1	Sunni	Settler	Tenant
	Total		22	Sunni 17	Settler 21	Owner 16
				Ahl-e-Hadith 2	Refugee 1	Tenant 4
				Shia 3		Mixed 2

Table 6. Chak D Watercourse Structural Attributes

S. No.	Major Caste	Sub-Caste	No. of house-holds	Religious sect	Settle-ment status	Tenancy status
1.	Jat	Athwal	46	Sunni	Local	Owners
2.	Jat	Hanjra	6	Sunni	Local	Owners
3.	Jat	Isra	2	Sunni	Local	Owners
4.	Jat	Saboke	1	Sunni	Local	Owners
5.	Rajpur	Kharal	1	Sunni	Local	Owners
	Total		56			

c. Chak C

This is basically a single-caste village and watercourse. Table 5 shows that all the land on the watercourse is owned by Jat Randhawas; there are one Arain and one Mochi tenant. All but the Arain are settlers. Two of the Randhawa are Ahl-e-Hadith and three are Shia, but informants say there has never been any religious conflict in the village.

Only three farmers have total holdings larger than 25 acres; but one of these, the Arain, is a tenant. The largest holding is 37.5 acres; all of this land is on the watercourse under study. All of the other holdings are small, but not so small as to be economically nonviable. Nine farmers have some land on other watercourses, but even these farmers' major holdings are on this watercourse. Presumably this dependence on one watercourse encourages a greater commitment to the efficient operation of this watercourse.

d. Chak D

Table 6 shows that all the shareholders on this watercourse are Sunnis, locals, and own the land they cultivate. One Jat subcaste, the Athwal, dominates the watercourse. Forty-eight of the 56 shareholders have all thier land on this watercourse. The holdings are generally small: there are 11 medium sized holdings (12 to 24 acres). Of these, five have a greater part of their holdings on another watercourse. There are just three holdings of 25 or more acres; and 28 (50%) holdings of five acres or less.

e. Comparison: Size of Land Holdings

Table 7 shows the distribution of size of land holdings, both on the watercourse and total size for the four sample watercourses. Both of the Mona Project villages have relatively high percentages of large holdings. Both of the OFWM villages are well within the eligibility guidelines, having small percentages of farmers with 25 or more acres. However, there is a major contrast between the two Faisalabad area villages: while the Chak C watercourse has no farmers with uneconomically small (less than five acres) holdings, in Chak D half of the total holdings are below five acres.

f. Comparison: Distribution of Power and Influence

We used a formal technique to elicit data on sample farmers' perceptions of the "power and influence" of other farmers on the watercourse. Briefly, we asked each person to rate all the others on the watercourse on their influence within their village and biraderi, and with Government officials, then scored the responses on a zero to four basis. The higher the percentage of a person's possible score achieved, the greater is his influence (see Appendix for a discussion of the method in more detail).

The "Centrality Ratio" refers to the percentage of farmers achieivng 60% or more of their possible scores; the higher the percentage, the larger the percentage of farmers who are perceived as influential by their fellow shareholders. The "Concentration Ratio" refers to the percentage of farmers' scores, beginning with the highest, whose sum equals one half of the total power and influence score of all shareholders. The closer this percentage is to 50, the greater is the equality of farmers' influence.

In Chak B as Table 8 shows, no one is perceived as having any significant influence, either within the village, or with Government officials. This is consistent with the extremely fragmented, multi-biraderi structure of the village and watercourse. Chak C exhibits the highest percentage of persons with significant influence in their village and biraderi (31.8%). Furthermore, unlike the other three watercourses, no one in Chak C is perceived as having zero or negligible influence: all command at least some respect among their fellows.

Chak A has the second highest centrality ratio on the village and biraderi parameter (19%), but the highest on the influence with Government officials parameter (19%). Chak D has a relatively low centrality ratio on both parameters.

The differences among the four villages in concentration ratio is less significant: in village influence the highest is Chak C (36.3%), the lowest Chak A (19%). Influence with Government officers is generally concentrated in even fewer hands than influence within the biraderi.

2. "Progressiveness" of Sample Farmers

"Progressiveness" is very difficult to measure. In general, the concept refers to openness to new ideas, willingness to experiment, and a desire to improve one's way of life. One indirect measure of the overall progressiveness of a village is to look at the institutional services available. Table 9 shows that Chak C has the most services, followed by Chak A. The other two villages have significantly fewer services. There seems to be no correlation between availability of services, and differences in the number of large land holdings or distance from the city.

We have also tried to measure "progressiveness" of sample farmers by examining their educational level, and use of radio, since these are frequently associated with willingness to modernize. Education above the primary level is likely to be indicative of progressiveness; primary education is probably insufficient to change attitudes since persons with a primary education are often functionally illiterate.

Table 10 shows that the educational achievements of sample farmers are consistent with the number of institutional services available in the village; Chak C and Chak A respondents have significantly higher educational levels than the other two villages; fewer than ten percent of the Chak D farmers have any education at all. Table 11, showing frequency of radio listening by sample farmers, is also consistent with the above trends, but no decisively so.

The final measure of "progressiveness" we have experimented with involves asking sample farmers about the helpfulness of ten kinds of government employees they are likely to come into contact with. Their answers were converted to numerical scores and added together. Table 12 gives the results, which again are consistent with other measures. While over 70% of the respondents in both

Table 7. Distribution of size of land holdings on sample watercourses

Size of land holdings	Chak A		Chak B		Chak C		Chak D	
On sample watercourse	No.	%	No.	%	No.	%	No.	%
25 acres or more	6	28.6	4	12.5	3	13.6	1	1.8
12-24 acres	10	47.6	14	43.7	10	45.5	6	10.7
5-11 acres	2	9.5	4	12.5	7	31.8	12	21.4
Under 5 acres	3	14.3	10	31.3	2	9.1	37	66.1
Total	21	100	32	100	22	100	56	100
Total land holding								
25 acres or more	8	38.1	19	59.4	4	18.2	3	5.4
12-24 acres	8	38.1	8	25.0	10	45.4	11	19.6
5-11 acres	2	9.5	5	15.6	8	36.4	14	25.0
Under 5 acres	3	14.3	0	0	0	0	28	50.0
Total	21	100	32	100	22	100	56	100

Table 8. Summary and Comparison of Power and Influence on Sample Watercourses

	Chak A		Chak B		Chak C		Chak D	
	Village/ Biraderi	Govt. Off.	Village/ Biraderi	Govt. Off.	Village/ Biraderi	Govt. Off.	Village/ Birader	Govt. Off.
Centrality Ratio[1]	19% (4/21)	19% (4/21)	0	0	31.8% (7/22)	13.6% (3/22)	11% (6/56)	5.35% (3/56)
Concentration Ratio[2]	19% (4/21)	14.3% (3/21)	21.9% (7/32)	15.6% (5/32)	36.3% (8/22)	22.7% (5/22)	27% (15/56)	14% (8/56)

1/Percentage of farmers achieving 60% or more of possible score.
2/Percentage of farmers score equal to half the total power/influence score.

Table 9. Institutional services available in village

Service	Chak A	Chak B	Chak C	Chak D
1. On pakka road	yes	-	yes	yes
2. Bus stop	yes	-	yes	-
3. Train station	-	-	-	-
4. Boys' primary school	yes	yes	yes	yes
5. Girls' primary school	yes	yes	yes	-
6. Boys' middle school	-	-	yes	-
7. Girls' middle school	-	-	yes	-
8. Boys' high school	yes	-	yes	-
9. Girls' high school	-	-	-	-
10. Medical dispensary	-	-	yes	-
11. Veterinary dispensary	-	-	yes	-
12. Bank branch	yes	-	yes	-
13. Cooperative Society	-	-	yes	-
14. Post Office	yes	yes	yes	yes
15. Fertilizer Agency	-	-	yes	yes
16. Resident Field Assistant	yes	yes	yes	yes
17. Electricity	yes	-	yes	-
Total	10	5	15	5
Miles from nearest city	8	6	10	10

Table 10. Distribution of Sample Farmers by Educational Achievement.

Education completed	A No.	A %	B No.	B %	C No.	C %	D No.	D %
None	4	26.67	4	25.00	2	11.77	20	90.91
Primary (1-5)	2	13.33	7	43.75	1	5.88	0	0
Middle (6-9)	3	20.00	3	18.75	8	47.00	2	9.09
Matriculate (10-11)	4	26.67	1	6.25	4	23.53	0	0
F.Sc/F.A (12)	0	0	1	6.25	1	5.88	0	0
Graduate (BA/B.Sc)	2	13.33	0	0	1	5.88	0	0
Total	15	100	16	100	17	100	22	100
Total middle or above education	8	60.00	5	31.25	14	82.35	2	9.09

Table 11. Use of radio by Sample Farmers.

Times listened in a week	A No.	A %	B No.	B %	C No.	C %	D No.	D %
Frequently	4	26.67	6	37.50	8	47.06	2	9.09
Sometimes	3	20.00	1	6.25	2	11.77	0	0
Never	8	53.33	9	56.25	7	41.17	20	90.91
Total	15	100	16	100	17	100	22	100

Table 12. Sample farmers' perceptions of helpfulness of government services[1]

Score	A No.	A %	B No.	B %	C No.	C %	D No.	D %
Very helpful (10-22)	4	26.7	0	0	6	35.29	3	13.64
Some help (5-9)	7	46.7	7	43.8	6	35.29	8	36.36
Little help (1-4)	4	26.7	9	56.2	3	17.65	7	31.82
None/harmful (0 or below)	0	0	0	0	2	11.77	4	18.18
Total	15	100	16	100	17	100	22	100

1/We asked farmers to rate the helpfulness of the following: Agricultural Officer, Field Assistant, Bank/Credit people, Cooperatives Department, Revenue Patwari, Canal Patwari, Zilidar, Canal SDO, Overseer, Watercourse Area Team, Watercourse Committee. The answers were scored as very helpful = +2, harmful = 2, no contact or no help or harm = 0, +1 and -1 were also used for less extreme statements. The scores awarded to each service by each respondent was totalled.

Table 13. Summary of "Progressiveness" Ranking

Parameter	Ranking 1	2	3	4
Avail Institute Services	C	A	D[1]	B[1]
Educational level	C	A	B	D
Frequency Radio listening	C	B	A	D
Helpful Government Services	A	C	D	D
Overall rank (score)	C (15)	A (12)	B (8)	D (6)

Scoring: Each instance of rank No. 1 = 4, No. 2 = 3, No. 3 = 2, No. 4 = 1. Maximum score is 16, minimum is 4.

1/Chaks D and B rank equally on institutional services so both are awarded 2 points.

Chak C and Chak A rates Government services as of some help or very helpful, 50% or fewer of the respondents in the other two villages rated government services so highly. It is notable that in both the Faisalabad villages some farmers rated government services negatively-harmful--overall, while no farmers felt so negatively in the Mona Project area.

Table 13 shows the ranking of each village by the four "progressiveness" measures used, and the ranking "score" achieved: it shows Chak C ranking as the most "progressive" followed by Chak A, Chak B and D.

3. Intergroup Relations Before Improvement

In order to predict the likelihood of success of a watercourse improvement program (or any other social action program) it is necessary to understand the basic relationships among key individuals and groups. Therefore, in this section, short descriptions of these relationships are presented.

a. Chak A

Even though the Gujars are numerically very dominant, Chak A is still a multi-caste village. However, the existing factions are not based completely on caste structure. There are two leaders in the village who, in order to achieve dominance, have organized factions around thier personalities. "X" is a religious-minded person who is interested in welfare-oriented projects. All of his land is on the other watercourse. One day we observed that he was personally supervising repair of the link road and also construction of a kacha link between the metalled road and the village. By and large, his support seems to come from small farmers and kamis.

The other major leader "Y" is a graduate (B.A.) and believed his education qualifies him as a leader. He projects an image of "progressiveness", and has successfully cultivated relations with various Government officials, though both leaders claim to have influence in the Government. Both are relatively large owners and commercially-oriented progressive farmers. In general, the larger farmers tend to support "Y".

Both of them use every opportunity to enhance their own reputation at the other's expense--or at least to blacken the other's reputation. For example, a man recently put a drum into the distributary to obstruct the water flow and thus steal extra water. Leader Y is said to have reported this to the police, with the cliam that he was X's man. Although X has been helping this man, he claims that he had no hand in his obstructing the water.

Similarly, during improvement of the first watercourse, Y served meals which turned out to be insufficient in quantity. The next time X served and pointedly prepared a surplus. The intention was to demonstrate his superiority to the other.

In the factional lineup, about 35 percent of the Gujars are in Y's group, which besides the Malik Khokhars, includes the Sayids and the Jaisak Jat. One reason for the split among the Gujars is that there is another rival Gujar leader who wants to establish his own leadership, and has allied himself with Y. He too is a big owner and has influence in the Government bureaucracy. Significantly, unlike the other two, all of his land is on the sample watercourse. He is therefore, not forced to cooperate or compete with the other two over watercourse-related issues.

The tension between the two groups is very active, but has not resulted in any fights or even public incidents. Both the leaders are reported to plot behind the scenes to reduce the prestige and honor (izzat) and thus the number of followers of the other; but the differences do not prevent them from cooperating on road and watercourse construction and maintenance, or from presenting an appearance of unity to outsiders.

An undercurrent of tension and hostility was also noticed on the part of the small farmers against the big and the influential. This is not inseparable from the factional division as noted above. The small farmers complained of manipulation by the influentials to have Government officers act in their favor. As examples, the small owners pointed out that buffalo bathing tanks were built near the deras of the influentials. Of the total five on the two watercourses in the village, they say three were built very close to the deras of each of the three most influential farmers, for their exclusive use. Small farmers also complain that the big landlords manage to get tubewell water supply for them is interrupted even during their normal running times. Again, this tension between the small and large owners is not public and does not prevent cooperation on projects or presenting a unified front to outsiders.

b. Chak B

The level of tension and hostility among some of the Jab sub-castes seems very high at both the village and the watercourse level; one of our research officers noted that even the children rarely play in groups, apparently because of the tension. However, the villagers were reluctant to discuss these matters, and in the short time available, we were unable to penetrate their defenses and learn the details of their disputes. The Attar group is divided four households versus two over a land dispute, whose details are not clear. The Kariale and the Bore have ach taken separate sides in this dispute as a result of a long-standing competition for influence in the village. There have also been several murders in Chak B resulting from these inter-biraderi disputes, but our data onthese are also contradictory. Some smaller farmers (and tail farmers) expressed unhappiness with, and fear of, some of the larger owners. The absence of any influential leaders, as discussed in the power and influence section above, is both a result and an indication of the relationship among the residents of this village.

c. Chak C

This village is dominated by Randhawas. The Randhawa are not divided into named or bounded groups and emphasize their unity to outsiders. However, in fact, two "groups" have formed around two men competing for leadership in the village. Only one of these has land on this watercourse; the other has land on other watercourses. Both men are cousins (mother's brother's son/father's sister's son). Their competition led to one incident eight years ago in which shots were fired and several men wounded, leading to a court case.

Chak C has a Cooperative Society established about 60 years ago with contributions of Rs. 10 to 20. During the 1960's, the Society invested Rs. 40,000 on three tubewells at the heads of three watercourses in the village;

shareholders buy water at a rate of Rs. 4 per hour. Five thousand rupees was also spent on building a girls' primary school and 5,000 on the Union Council office. In addition, loans have been made to farmers.

The Society is under the control of one of the competing leaders (the one not on the sample watercourse) and is another issue dividing them. There is difficulty in recovering farmer loans, and the opposition to the controlling leader say they wish the Society to be dissolved. Some accuse the Secretary of the Society of misuse of funds, claiming he refuses to show the financial records to them. This tension was, however, had no effect to cooperate to maintain the three improved watercourses in the village.

d. Chak D

The dominant subcaste, the Athwal, are divided into two factions. The larger group is led by one of the four numberdars in the village. Though he has the nominal support of perhaps 90% of the Athwal, must of it is apparently not very committed. The other faction, though smaller, is led by an "obstructionist" who is willing to use violence to intimidate others and achieve his ends; and he is said to have a great deal of influence with the police. Most people are therefore afraid of him. He abducted the daughter of the leader of the other group which led to a shooting incident about seven years ago, resulting in injuries on both sides. Ten people were charged by the police and have spent time in jail; their cases are still being appealed.

The leader of the larger group has attempted to compromise, by attending prayers at the death of a member of the opposition party, for example, and also be offering to settle the court cases between them. These attempts have failed and the two groups do not attend each others' marriages or funerals.

Another numberdar, a watercourse committee member, is the former chairman of the Union Council and presently a member of the Rabita Committee." He projects an image of "progressiveness" and is credited by some with having tried to bring improvements to the village. He tried to get a girls' primary school and electricity for the village while Chairman of the Union Council, and contributed land for the building of the boys' Primary School and for the Union Council building. This apparent "progressiveness" led to a vote of no confidence in him in the Union Council because of resistance to establishing a girls' school. He has also tried to bring about compromise in the above conflict but one of them refused, so he remains aloof from this conflict.

Neither of these numberdars is a strong leader, able to control his followers; hence the larger faction is not a bounded or unified group in any sense. There are jealousies and competition even within the group. Much of the tension and conflict is individual-based; and cooperation on joint projects is difficult because they do not have any effective mechanism for resolving disputes and controlling obstructionists.

4. The Process of Watercourse Improvement

a. Chak A

The other watercourse in Chak A was among the first improved by the Mona Project. Its success led three farmers on the sample watercourse to apply to the Mona Project for renovation in August 1976; these three subsequently became the committee members.

Table 14 reveals that the majority caste has two representatives on the committee. Two members are among the most influential men on the watercourse; the third, though not very influential himself, is a close relative of the numberdar. The Sayid is a close friend and ally of leader Y, and therefore is also associated with the Chairman of the committee.

The lined section was not in the original WAPDA plans (even though it passes through the village). The watercourse members themselves decided that they would pay for pakka nakkas provided the section of the watercourse through the village was lined instead. WAPDA agreed to this.

The general formula for dividing the improvement work was assignments in proportion to land holding. The committee oversaw all of the work. Two general meetings were held: one for fixation of the location of pakka nakkas and one to make a decision on having a lined section and paying for pakka nakkas.

There was no significant conflict among the Chak A farmers during the improvement project. With regard to just one decision, a change in the watercourse route, one farmer opposed it, but later agreed, though unhappily. This was a man owning 20 acres of land split into two parcels, 16 acres at the head and 4 acres in the middle. He lost some land as a result of rerouting while his brother gained. He considers the change illegal and complained to the researchers, but had not pursued the case further.

Although the leaders of Chak A claimed that decisions were taken by simple majority vote rule, small owner informants claimed that decisions were made not by a voting rule but by committee members who, along with other influentials, so dominated the situation that free expression was not possible. All decisions were taken by the committee which was dominated by the most powerful farmers in the village.

This watercourse also irrigated portions of nine squares of land at the tail located in another village, "E". There are 27 E farmers on the watercourse, divided into four different castes. All of them seem to be small land holders, with little or no education.

Although the E channels appear to be part of the "sarkari khal" (the Mona Project maps are contradictory on this point), this part was left unimproved. When contacted, the farmers of E claimed that before the improvement began they were told their portion would also be improved, and therefore one committee member was selected from among them. The E farmers did their share of the work but when the work was completed up to the end of Chak A land and the beginning of theirs', eht Mona Project personnel refused to extend the construction further. The Mona Project people we contacted claimed that the E farmers were not willing to improve the tail portions irrigating their land. However, informants in Chak A supported the viewpoint of the E farmers.

Another reason given by Mona Project People was that only the main channel was to be improved under their plans and E's portion was considered to be a branch line like the other two branches in Chak A and hence not improved. The E farmers expressed great dissatisfaction and claimed that they are suffering from a severe water shortage. They claim that they get less water than before improvement; some of them tried to improve their watercourse themselves, but without success. Further, they accuse two Chak A farmers (both committee members) of stealing water during their time and claim the tubewell is shut off during their time. The Chak A leaders, who refer to the E farmers as "jangalis", may have played a role in misleading them. The E farmers certainly believe this to be true. Be that as it may, our research assistants arranged a meeting between Mona Project personnel and these E farmers, but it appeared they were too divided among themselves to cooperate on a heavy cleaning and maintenance project on their portion of the watercourse. The E farmers are not included in our random sample as we learned of them only near the end of our stay in Chak A and their committee representative was not available. If they had been included, the generally positive image of this watercourse would have been somewhat reduced.

b. Chak B

On this watercourse the farmers were apparently pursuaded by the Mona Project extension staff to improve their watercourse. The first meeting of the watercourse members was held in December, 1976; then an application for renovation was filed on January 18, 1977. The criteria for selection of the watercourse executive committee members are unclear, but as discussed above, and as the data summarized in Table 15 suggest, size of landholding seems to have been the main criterion. No chairman was ever selected. The Mona Project staff apparently monimated the members in a general meeting. The largest subcaste, the Kahoot, is not represented; nor were the farmers at the tail of the watercourse represented directiy. Three of the four members have the three highest scores in biraderi/village influence.

Table 16 lists the decisions during watercourse improvement that led to controversy:

i. The four farmers who opposed cutting of the trees are from three different biraderis and located at the head, middle and tail. All four have relatively large landholdings. The main argument they put forward is that the trees are Government property. Ultimately, all agreed to remove their trees except one, a Kahoot owning land at the head of the watercourse.

ii. WAPDA decided digging for Kacha improvement should begin at the tail; four head farmers were opposed but finally cooperated in the digging.

Table 14. Characteristics of Chak A Committee Members.

Caste	Landholding Vill.	Landholding W/C	Locat.	% B/V[1] Score	% G/O[2] Score	Any other position
Gujjar	37½	37½	Middle	48	32	-
Gujjar	29	29	Middle	91	89	Chairman
Sayid	18	18	Tail	96	93	-

1/B/V = "Biraderi Village" - percent of possible score in power/influence.
2/G/O = "Government Officer"-percent of possible score in power/influence.

Table 15. Characteristics of Committee Members

Caste/ subcaste	Landholding Vill.	Landholding W/C	Location on W/C	% B/V[1] Score	% G/O[1] Score	Any other position held
Bore	38½	38½	Middle	57	40	-
Jatriana	50	14.6	Head	16	11	-
Tiwana	31	31	Head	42	35	-
Mekan	50	40.5	Middle	50	28	-

1/See notes to Table 14.

Table 16. Distribution of Support and Opposition on Lecisions During the Process of Watercourse Improvement.

Issue	Supporters/ gainers	Opposition birader/ acres/ position			Final decision
a. Uprooting trees	All others	1 Kahoot	50	H	All but one cut his trees
		1 Badhore	25	M	
		1 Marth	50	M	
		1 Kahoot	50	T	
b. Point from which digging to start	All others	1 Kahoot	50	H	Acceptance of WAPDA decision to start at tail
		1 Tiwana	80½	H	
		1 Qasai	2	H	
		1 Badhore	12½	H	
c. Rerouting watercourse	A Bore (Committee member)	1 Badhore	12½	H	Acceptance of Irrigation Department decision in favor of the Bore
		1 Mekan			
		1 Bahore	25	H	
		1 Kahoot	29	M	
d. Nakka location and No.	All others	1 Kahoot	50	H	Compromise with WAPDA
		1 Badhore	25	H	
		1 Kahoot	29	M	
e. Division of work	All	None			2 did not work; others did their share
f. Section to be lined	-	-			No section lined

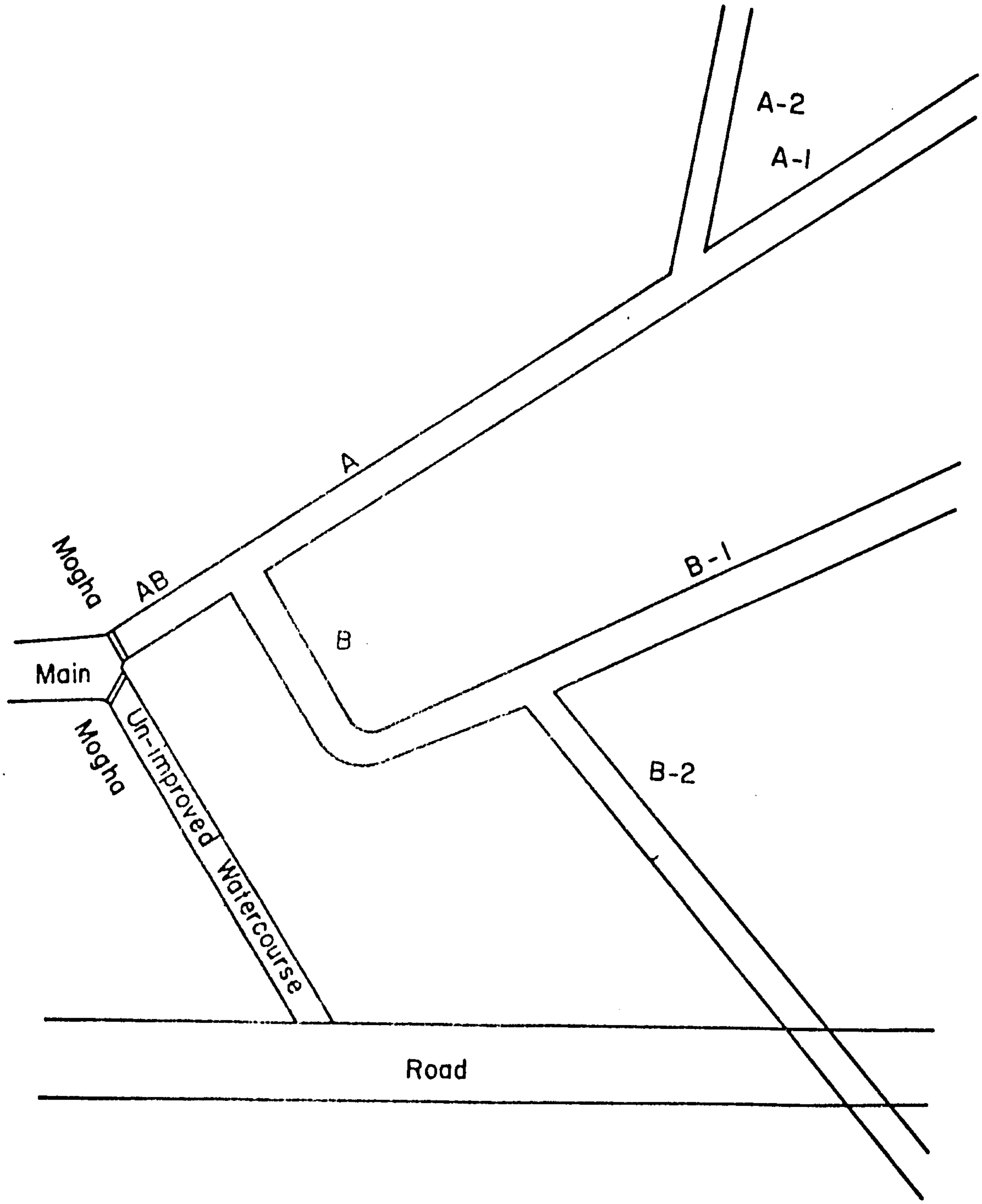


Figure 1. Map of Improved Watercourse at Chak B

iii. A dispute arose between two farmers, a Core, and a Badhore, over the route of the watercourse in the middle sections; the Bore claimed the old route was wrong, and the watercourse should be rerouted through land belonging to the Badhore. Two other farmers, a Badhore and a Kahoot, apparently supporting the Badhore, proposed the work continue on the old route, but the Bore refused until the case was settled. Ultimately, the Irrigation Department was called on to make a decision, which was made in favor of the Bore; that is, they sanctioned the new route. Mona Project personnel supported this decision and the watercourse was built on the new route. At the time of our research, there was still bitterness between the Bore and the Kahoots (who had strongly supported the Badhore, in pursuit of their own aims) over this incident.

iv. Three farmers, two Kahoots and a Badhore, all with relatively large land holdings, opposed the WAPDA plans in regard to the number and location of pakka nakkas, hoping to get more for themselves. Informants say Mona Project personnel compromised to settle the dispute.

Two farmers also did not do their share of the work on kacha improvement, but others did if for them, so this did not lead to trouble. It is notable that, as Table 16 reveals, most of the obstruction and conflict was initiated by head farmers. Some informants also complained that committee members were partial toward their own supporters, and the influential farmers were favored by the WAPDA personnel, who exempted one farmer from cutting his trees, and allotted additional nakkas to certain farmers. It is difficult to judge the extent to which these accusations are true, because the high level of animosity and jealousy among the Chak B farmers leads to a tendency to try to tarnish the reputation of their competitors.

To conclude, we may say that the process of improvement was accompanied by a great deal of conflict. This is not surprising in view of the pre-existing tensions among the various biraderis in this village.

c. Chak C

Improvement of this watercourse was initiated because of the effort of one farmer, the largest landowner on the watercourse: after seeing an improved watercourse in Thikriwala, he convinced others of its benefits. The improvement location, and uprooting of trees, were initiated in August, 1977.

Table 17 presents the data on the characteristics of the committee members. Three of the four members have the highest scores in power/influence within their village/biraderi, and these are the only three with scores above 60% in influence with Government officials.

The fourth member has little influence, and is the only member with land at the tail. In fact, five of the seven persons scoring high on power and influence have their lands at the head of the watercourse; another has his land at both the head and middle; and the seventh has land in the middle. Two of the committee members made most of the decisions pertaining to watercourse construction themselves; and no one expressed any dissatisfaction with their decisions.

During construction, the only controversy that arose was one farmer's refusal to cut a valuable jamun tree on the watercourse route; when OFWM stood firm that it must be cut in order to continue, all the other farmers convinced him to remove the tree. We may conclude, then, that the process of watercource improvement was remarkably smooth and conflict-free. This lack of conflict during improvement is consistent with the relatively low level of tension and competition among the people of this village.

d. Chak D

The numberdar projecting a relatively "progressive" image described above, is credited with initiating the improvement project. Uprooting of trees began on November 15, 1977, and kacha improvement on December 2; the kacha improvement was completed on February 20, 1978. The lined section (branch AB; see map) was completed March 12, and installation of pakka nakkas on April 25, 1978.

As can be seen from Table 18, Branch A had no representative on the committee. The Chairman of the committee, and most influential person, is at the very head of the watercourse. Informants say selection of committee members was on the basis of patti (persons paying land revenue, historically, through one numberdar).

During construction there does not seem to have been much conflict over uprooting of trees, division of work, or location of nakkas. A few trees were left standing with the agreement of OFWM. There was at least one conflict over the route which was solved by referring it to the patwari; and there was some delay in installing nakkas and culverts when some farmers hesitated to pay the masons. There was also conflict between the brother of the "obstructionist" farmer and OFWM personnel.

According to OFWM informants, the initiating farmer, despite his "progressive" image, often dod not come on site to manage the work. In fact, OFWM personnel seem to have been somewhat misled by his image of "progressiveness." The "obstructionist" is reported not to have done his share of the work; but it was done for him so this did not lead to severe conflict. His holding on this watercourse is not large, so that his share of the work was not a large percent of the total.

Most of the farmers expressed considerable dissatisfaction about the process and results of improvement. First, they say, the point from which improvement began is not in fact the mogha: there is a long "main" watercourse which has two branches; neither this main branch nor the other branch have been improved. Some trees had however been removed from part of the main branch. It was difficult to discover why the main branch was not improved. One possible reason is that farmers now cut its banks to irrigate adjacent lands; this would be difficult after improvement as no nakkas are sanctioned on it. Indeed, the influential head farmer has managed to get a "private" pakka nakka installed on this main branch near his dera, though it is not

Table 17. Characteristics of Committee Members

Caste	Landholding Vill.	Landholding W/C	Location on W/C		% B/V[1] Score	% G/O[1] Score	Any other position
Randhawa	15½	12	H		91	92	-
Randhawa	6¼	6¼	H T	3¼ 3	41	25	-
Randhawa	37½	37½	M H	25 12½	88	75	W/C Committee Chairman
Randhawa	30	25	M		84	66	-

1/See notes to Table 14.

Table 18. Characteristics of Committee Members

Caste	Landholding Vill.	Landholding W/C	Location[1] Branch	Location[1] Posi	% B/V[2] Score	% G/O[2] Score	Other score position
Athwal	25	25	AB	Head	100	100	Chairman W/C Comm.
Athwal	4	4	B-1	Tail	53	47	-
Athwal	23	8	B-2	Tail	74	69	Numberdar
Athwal	6	6	B-2	Tail	37	20	-
Athwal	4	4	B-2	Tail	46	29	-
Athwal	17	8	B-2	Tail	89	88	Numberdar
Athwal	12½	12½	B-2	Tail	42	23	-

1/See map of Chak D watercourse.
2/See notes to Table 14.

legal. Another reason suggested by some farmers is that conflict of some farmers with OFWM lead to its nonimprovement; another, related factor may have been an alleged link between an OFWM officer and the "obstructionist" (see below).

The farmers complained about the behavior and alleged incompetence of one of the Government officers while praising others. They felt he was rude and insulting toward them; and they claimed the watercourse level was incorrect in some places so that some land gets less water than before.2/

Finally, farmers accused one officer of getting involved in their factional politics on the side of the "obstructionist." The farmers on the other branch applied to have thier watercourse improved, too. This man, who has the bulk of his land on the middle portion of this watercourse, objected; informants attribute his opposition to a desire to continue his practice of cutting the watercourse banks to steal water. Also, his "enemy" favored it and he therefore, "automatically" opposed it. It is alleged by our informants that the "obstructionist" and the officer in question have a mutual friend in Faisalabad. The farmer is said to have approached the officer through this man and even though other farmers had uprooted all their trees, and an overwhelming majority (49/56 - 88%) favored improvement in a formal vote, he managed to prevent improvement of that branch.3/

The farmers on the improved watercourse are also unhappy with the number of nakkas, saying with their fragmented holdings (and lack of unity) there ought to be more nakkas. The OFWM response is that no more are sanctioned by the Irrigation Department. The result is that farmers are cutting the banks in some places, causing degradation of the watercourse.

e. Comparison

These short descriptions simplify what is really often a complex and long process. Table 19 shows just how long this process can be. The fastest improvement was doen by the Chak A farmers in two months; the OFWM watercourses both took longer than the Mona Project watercourses. At Chak C informants reported problems of cement supply delayed the project; Chak K's watercourse is much longer than the others, and its improvement was not a smooth process; it took over five months to complete.

It is not possible for twenty or fifty people, whose pre-existing relationships are so complex and so long-standing, to cooperate on a watercourse project without conflict. The cultural mechanisms for cooperation on such projects are not well developed, and often nonexisting, in Pakistan. Nevertheless, these short vignettes illustrate both the existing social relationships among the shareholders and their importance, and how the type of relationship that develops between the farmers and the Government officers can significantly effect the success of the project. Awareness of these two factors, and deliberately planned strategies to deal with them, can significantly improve the success of such community self-help projects.

2/ Informants suggest this is due to the design, which is based on average slope of the watercourse, and does not consider undulations--alternating high and low fields; it may be speculated that the design here might have included check and drop structures. We emphasize here that the truth of the above allegations is not confirmed, and is not relevant to our purpose, which is to report farmers' perceptions.

3/ Again, we are reporting informants' perceptions which have a significant impact on their attitude towards Government programs.

Table 19. Time Required to Complete the Improvement Process

	A	B	C	D
a. Date begun uprooting trees	12. 9.76	10.2.77	8.77	15.11.77
b. Kacha improvement completed	12.10.76	15.3.77	10.77	20. 2.78
c. Pakka nakka installation completed	10.11.76	14.5.77	12.77	25. 4.78
d. Total time (a-c)	2 months	3 months	4 months	5 months

Table 20. Perceived Sources of Losses Before and After Improvement

Source of loss	No. of responses							
	Before improvement				After Improvement			
	A	B	C	D	A	B	C	D
a. Spills over sides	14	9	11	14	0	1	0	0
b. Seepage	14	15	10	11	0	6	0	0
c. Water standing in ditches	14	12	9	12	0	6	0	0
d. Vegetation in channels	13	14	9	20	1	7	0	1
e. Silting	15	14	12	20	1	6	0	1
f. Illegal cuts	0	1	2	15	0	2	0	3
g. Improper level	0	1	0	0	0	1	0	4
h. Rat holes	1	0	0	0	3	0	9	6
i. Livestock crossing	2	1	6	0	0	1	0	0
j. Kacha nakkas	0	0	1	0	0	0	0	0
k. No loss	0	0	0	0	11	7	8	14
No. of respondents	15	16	17	22	15	16	17	22

The experience of Chaks B and D illustrate the pitfalls of working in villages with relatively high levels of tension--especially when the worker is ignorant of these, or takes sides. Chak A and Chak B illustrate a frequeny problem: the tendency to appear to favor the influential minority over the less articulate, and noninfluential majority.

Subject: SOCIOLOGICAL DETERMINANTS OF SUCCESS OF WATERCOURSE IMPROVEMENT PROJECTS

Trainer Rural Sociologist
Class Room .2 hour
Field ____________ Days

OBJECTIVES

1 - Increase trainees' consciousness of significant aspects of rural social structure.

2 - Identify specific sociological characteristics of watercourses that may determine the success or failure of an improvement project.

TRAINING AIDS

Excerpt from Water User Association Interim Report as in Lecture 1.

MATERIALS NEEDED

INTRODUCTION

All the trainees are certainly aware, in a general way, of the significant roles and groups in rural areas--biraderi, wadera, khan, landlord, tenant, etc., and are generally aware of the associated behavior patterns. However, not having studied sociology you probably have never done a systematic analysis of rural social structure on a conscious level; much of this information is part of your "culture"--unconscious and taken for granted. The purpose today is to raise your consciousness of some of these factors, and then to identify the specific factors that seem to determine the success or failure of a watercourse improvement project.

PRESENTATION

There seem to be significant differences among the provinces and even within each province in the social structure and culture of rural areas. Language differences are only one visible parameter of the differences. Nevertheless, the basic structural characteristics of rural areas in the various provinces also exhibit certain important similarities.

In all rural areas of the country, power distribution among people and groups is largely based on land control. Related to this is that although there is a great deal of variation, rural areas are generally characterized by inequality of power--some people have more power than others; some people are more dependent on others for help and support than others. This inequality is based on differences in land holding.

In all areas, family and kinship relationships are the basis of group formation, alliances, etc. The family is the major production unit; the object of individuals primary loyalty; and the basic unit of competition and cooperation with similar units.

In all areas, families are part of larger kin-based groups or categories within which marriage usually takes place, and which also ideally command loyalty, and are units in cooperation and conflict. There is a cultural ideal of loyalty to and unity of these groups, but they also are vulnerable and are often divided by conflict and rivalry among their members.

In all areas there are relatively powerful people who either are leaders or have the potential for being leaders; some of these may prove to be constructive leaders who will support a watercourse project; others will prove to be obstructionists--people who will try to sabotage a project even if they themselves lose its benefit.

Related to this latter point is a common feature of the culture of rural areas in Pakistan: the emphasis on honor, reputation, prestige, that is izzat, of individuals and families. Izzat is a major cultural value and concern of rural (and also urban to a lesser extent) people; it is a value that leads more often to competition than to cooperation. Much behavior of people on watercourses--patterns of conflict and cooperation--can be understood in terms of peoples' desire to increase their own izzat (at others' expense), reduce others' izzat (thereby in fact increasing their own), or at least, to maintain their own izzat (keeping others from gaining at their expense). Experience shows that if a person feels his izzat is threatened by the project, he will oppose it, or sabotage it, even if it means giving up substantial potential benefits for himself.

These features characterize rural areas in Pakistan despite differences in specific aspects. Punjab is generally characterized by ethnic homogeneity-most people regard themselves as Punjabi and speak Punjabi. The major kinship group is called a biraderi; on watercourse projects biraderis are general the major unit of cooperation--and also conflict. The change agent must identify the biraderis and their relationships with each other (as well as internal relationships) on a watercourse before he can work with the people on the watercourse.

In NWFP most areas are also ethnically homogeneous--most people are Pathans--though there are irrigated areas with Punjabi and other settlers. In general, loyalties are to one's tribe or the local section of a tribe to which one belongs. There is an ideology of--a cultural value on--equality of tribal members, but in fact, inequality of land holding and therefore power and influence are characteristic.

Sind is characterized by ethnic diversity--there are Sindhis, Urdu speaking muhajirs, Baluch, Punjabis, Pathans, etc., all speaking different languages usually, and all having a rather negative opinion of other groups. Sind, more than the other provinces, is also characterized by a sharp division between landlords and tenants--waderas and haris. Related to this is a greater feeling of class consciousness based on this diversion, and a very strong dependence of haris on owners. In Sind, more than the other provinces, the role of the tenants in a watercourse project will be much greater than in Punjab and NWFP.

The strategies for, and likelihood of success of, organizing farmers to improve and maintain their watercourse varies with the general social structural features of the area and specific watercourse than it does province-wise (except to the extent one type of social structure is more prevalent in one province than in another). Different typologies of watercourse social structure can be made according to the criteria used. If one uses landholding, the following typology seems reasonable:

1. one large owner, and many small owners or tenants/laborers.
2. several competing large owners, and many small owners or tenants (who will tend to be dependent on and thus allied to particular powerful people).
3. relative equality of landholding--economically viable holdings.
4. relative equality of landholding--very small holdings.

If one uses biraderi (or zat or tribal) structure, one may identify a watercourse as single-biraderi; double (2 about equal); or multi-biraderi (three or more, each with some power).

Finally, the leadership structure may vary:

1. one respected leader.
2. several respected leaders who can and do cooperate.
3. several respected leaders who are in competition/conflict.
4. no significant leaders--many people have some influence.
5. no significant leaders--no one has much influence.

Another lecture will consider some strategies for dealing with these situations; the point here is simply that these differences are found in all the provinces and the strategies to deal with them will vary.

<u>Determinants of success of watercourse improvement projects</u>

In a comprehensive study carried out in Punjab, a number of sociological characteristics were identified as having a significant effect on the likelihood of success of a watercourse improvement project, not only for successful rehabilitation, but also for subsequent maintenance. These factors are listed here; the next class plus two days of field work will be devoted to learning how to identify these (and other) social factors that could effect the success of watercourse improvement. Watercourses having some or all of the following characteristics tend to be good candidates for a watercourse improvement project:

1. A large majority of landholdings of medium size--in Punjab, within the 6.5 to 25 acre range.
2. Equal distribution of power and influence.
3. A large percentage of farmers perceived as having some influence.
4. Relative concentration of power/influence toward the tail or middle of the watercourse.
5. Cooperation on previous collective projects, and no serious recent conflict.

6. A small number of shareholders on the watercourse.
7. Domination of the watercourse by a single biraderi.
8. "Progressiveness" of the community as measured by the percentage of farmers with a better than primary education, and the number of institutional services available in the community.
9. Single-branch watercourse.
10. A high level of interest in and enthusiasm for the project.

APPLICATION

Discuss in class is there is time (or have trainees write brief reports on) the extent to which the four cases described in the training aid fulfill the above criteria, from the data given. Rank the cases from most to least likely to succeed and compare to the success of the project as described.

Subject: RESEARCH METHODS: CHOOSING A WATERCOURSE AND LEARNING ABOUT ITS SOCIAL ORGANIZATION

Trainer Rural Sociologist
Class Room 1 hour
Field 2 Days

OBJECTIVES

1 - To introduce the trainees to the basic skills required to learn about a community or watercourse social organization.

2 - To familiarize the trainees with the "Pre-improvement watercourse survey".

3 - To give the trainees field experience in meeting farmers, and gathering social data, using the "pre-improvement watercourse survey".

TRAINING AIDS

All students should have copies of the "Pre-improvement watercourse survey" developed by A.H. Mirza and D.J. Merrey (attached).

MATERIALS NEEDED

INTRODUCTION

Up to the present the discussion has been somewhat theoretical; basic concepts such as "social structure", "culture", and the crucial importance of understanding the social structure and culture of a community as a pre-requisite to working there have been discussed. Basic sociological characteristics that affect the success of a watercourse project have been presented.

Now we move to the field; the practical application of the theory. This class, and the two field days, are designed to provide you with the basic skills you need to gather information on and evaluate the social structure of a watercourse.

PRESENTATION

There are two basic methods for gathering social/cultural data: formal or informal interviewing; and participant observation.

Interviewing: In this method, the researcher sits down with a respondent or "informant" and asks him questions. This si usually done with set questions, which may or may not be contained in a questionnaire or schedule carried by the researcher. Frequently, rural Pakistanis are intimidated by written questionnaires and either resist being interviewed or mislead the questioner for various reasons. You should try to develop an ability to talk to people informally, ask the questions you wish subtlety, and write down the information later. This is of course hard to do when gathering lists of names and the like but is relatively easy when asking about events, opinions, etc.

Participant observation: In this approach, the researcher takes part in group activities to some extent, and attempts to observe behavior as unobtrusively as possible. This approach is more time consuming but often helps in establishing rapport. Ideally, both methods will be combined as one tries to learn about a community.

Basic hints in data gathering: Your first approach to a village or watercourse will be through the established channels and leaders; if you try to bypass these the leaders may be resentful and oppose the project. On the other hand, avoid being dominated by and becoming dependent on the leaders; establish contacts with as many people as you can.

Explain your purpose and the project thoroughly and openly with people. Take a gradual approach: do not begin right off by asking questions about conflict or income or amounts of land or other questions that people may be reluctant to answer truthfully to a stranger. You must take time to gain peoples' trust.

Talk to knowledgeable outsiders such as teachers and field assistants who may have less interest in biasing what they till you about the community.

Mix socially with people--at daras, at the mosque, in the fields, etc. Express an interest in all of their problems, and if there is some kind of problem that you can help with do so even if it is unrelated to water management (but avoid helping one faction against another).

Avoid becoming identified with one biraderi, leader or group.

Explanation of the survey form: (Read over the survey form with the trainees, translating each item if you are using the English version. If would be preferable for the trainees to have versions in their local language, of failing that, in Urdu. They must be able to ask each question in the farmers' language. Ask trainees from each province represented to model, that is demonstrate, how he would ask each question.)

APPLICATION

(Divide the trainees into teams of two or three; each team will be sent to a different watercourse. These may be previously improved watercourses. Each team will spend two days gathering the data called for in the survey form in the village to which it is assigned. It is preferable that the trainees stay in their assigned village for one night, and have maximum contact with the villagers.

Based on the data gathered, each team will submit a brief report describing the significant features of social organization of the watercourse; an evaluation of the watercourse in terms of the criteria given for determining the likely success of a project; and suggestions on how they would proceed to set up a committee and initiate a watercourse improvement or cleaning project on that watercourse. These reports will be discussed by the trainees and trainer in the next class.

These same watercourses should be chosen for a comprehensive cleaning and maintenance program later in the course.

Pre-Improvement Watercourse Survey

Instructions

The purpose of a pre-improvement watercourse survey is to facilitate gathering basic social data that can be used by On-Farm Water Management personnel both to select watercourses that have the greatest potential for a successful improvement program, and to facilitate the improvement process by giving the OFWM workers basic information on the people with whom they will be working. The survey forms are simple to use, and short. More space may be required for some answers than is provided on these sample forms.

There are four basic forms: form A is for doing a 100% census of the watercourse members, and finding out about the basic social structure of the candidate watercourse. It is self-explantory.

Form B, is to be completed by interviewing key informants, that is, knowledgeable village residents who are willing to give accurate information. The information should be confirmed from several informants, preferably located at various social positions (different biraderis, different points on the watercourse), and reasons for differences, if any, ascertained. A community in which no one is willing to give the basic data sought would probably not be a good candidate for improvement.

Form C, on the distribution of power/influence in the village, is very important and should be done carefully. Sometimes farmers are reluctant to answer these questions; the interviewer will have to explain carefully that he is just trying to get an idea about how many people on the watercourse are influential, etc.

Form D is a tabulation sheet for summarizing the results of the survey.

After pre-improvement surveys have been completed for several watercourses, and the results tabulated, the watercourse (s) judged most likely to be successfully improved and maintained should be selected. Listed below, in order of importance, are the attributes that seem most conducive to a successful improvement and maintenance program. It is not necessary for a watercourse to have all of these characteristics, but the more of them it has, the greater the likelihood of success. The first six attributes listed are probably the most important.

Factors Conducive to Success

1. A large majority of landholdings within the 6.5 to 25 acre range.
2. Equal distribution of power and influence.
3. A large percentage of farmers perceived as having some influence.
4. Relative concentration of power/influence toward the tail or middle of the watercourse.
5. Cooperation on previous collective projects, and no serious recent conflicts.
6. A small number of shareholders on the watercourse.
7. Domination of the watercourse by a single biraderi.
8. "Progressiveness" of the community, as measured by the percentage of farmers with a better than primary education, and the number of institutional services available in the community.
9. Single-branch watercourse.

A final important factor is of course, the level of interest in the project; the more widespread and enthusiastic it is, the better.

The Tabulation Sheet (form D) provided is meant to summarize the data in terms of the above listed factors and to facilitate the decision on whether to improve particular watercourses. However, the final decision is a matter of judgement; no strict and invariable formula can be applied. It is hoped that the procedure outlined here will facilitate making more informed and objective judgements.

PRE-IMPROVEMENT WATERCOURSE SURVEY

Form A

100% Census of the Watercourse Members

This form should be completed with the help of key informants, and should be in the same order as the warabandi (head to tail).

Serial No.	Name	Father's name	Caste/Biraderi	Landholding village/w-c	Location H, M, T	Education beyond 5th class (yes/no)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.						
23.						
24.						
25.						
26.						
27.						
28.						

PRE-IMPROVEMENT WATERCOURSE SURVEY

form B

Village and Watercourse Level Data

This form should be completed with the help of knowledgeable and helpful key informants; the information should be checked with several informants.

1. Village ________________ 2. Tehsil and District ________________

3. Number of watercourses in village: total _______ improved _______

4. Institutional services present in village

service	present? (check)
a. paved road	_______
b. railway station or bus stop	_______
c. post office	_______
d. fertilizer agency	_______
e. field assistant	_______
f. boys' school--primary	_______
middle	_______
high	_______
g. girls' school-primary	_______
middle	_______
high	_______
h. govt. medical dispensary	_______
i. bank branch	_______
j. veterinary dispensary	_______
k. electricity	_______
TOTAL NUMBER	_______

5. Active organizations in village (yes/no)

mosque committee	_______
islahi committee	_______
cooperative society	_______
Union Council	_______
other (specify)	_______

PRE-IMPROVEMENT WATERCOURSE SURVEY

(Form B continued)

6. Collective projects undertaken in the village in recent years: (Give details: who initiated it, what was the project, who benefited, how was money or labor collected/contributed, number of years ago, degree of success of the project.)

Project 1. ______________________________

____

____

2. ______________________________

____

____

3. ______________________________

____

____

7. Caste and Biraderi Structure (farmers)

	Caste	Biraderi	Number of households: Village level	Number of households: Watercourse
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				

8. Organization of cleaning and maintenance of watercourse at present.
   a. distribution of shares among farmers: ______________
   b. frequency of cleaning; ______________
   c. sanctions for noncompliance: ______________
   d. effectiveness of cleaning program: ______________

9. Presently prevailing conflicts/tensions in village and on the sample watercourse. This section will require much tact, and should not be asked until after some rapport is established with informants; one can learn a lot about conflicts from comments dropped while other matters are being discussed. For each conflict, try to find out which groups and key individuals are involved, the severity (insults, fights, murders, court cases), reasons for the conflict, and what effect it would have on the improvement program's success.

PRE-IMPROVEMENT WATERCOURSE SURVEY

Form C

Measurement of Power/Influence

List all the farmers' names and serial numbers (from 100% Census, Form A) before interviewing. Randomly choose about 50% of the farmers, stratified by Head, Middle and Tail, and ask each of these farmers to rate all the other farmers on the watercourse with respect to their power/influence in decisions pertaining to biraderi, village and watercourse affairs.

	Farmers' No. and Name	Power/Influence Score*													Total
		Informant:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.. .20	score
Head:	1.														
	2.														
	3.														
	4.														
	5.														
Middle															
Tail															

*Code for power/influence: 4 = much; 2 = some; 1 = little; 0 = none. The overall measure of power/influence of each farmer (total score) will be: $\frac{\text{sum of all his scores (Total score)}}{\text{no. of sample farmers}} \times 100.$

PRE-IMPROVEMENT WATERCOURSE SURVEY

form D

Tabulation Sheet

This form is to be completed based on forms A, B, and C.

1. Percentage of holdings (village level) of watercourse members in the 6.5 to 25 acre range (form A).

2. Distribution of power/influence among watercourse members (form C).
   Method: Rank all the farmers' total scores from highest to lowest and find the sum; then calculate the number of farmers' scores, from the top, required to equal half the total score. Convert this to a percentage of total farmers; the higher it is, the more equal is the distribution.

3. Percent of farmers perceived as having some influence (form C).
   Method: Calculate the number of farmers who achieved 50% or more of their potential total score; convert to a percentage of total farmers.

4. Distribution of power/influence according to location on the watercourse (form C). H
   Method: For Head, Middle and Tail separately, the average score per farmer; alternate method: calculate the percent of farmers at each location scoring 50% or more of potential total score. Higher scores at the Tail and/or Middle than the Head suggests the watercourse may be a good candidate. M

   T

5. a. Cooperation on previous collective projects (form B). yes/no

   b. Serious conflict/tension in the community (form B). yes/no

6. Number of shareholders on the watercourse (form A).

7. Single-biraderi (form A & B). yes/no
   Note: if 90% of the shareholders belong to a single biraderi whose members hold approximately the same percentage of the land on the watercourse, count as a single-biraderi.

8. "Progressiveness": a. education--percentage of farmers with 6th class or better education (form A).

   b. Number of institutional services (form B).

9. Single-branch watercourse (map). yes/no

Subject: HOW TO WORK WITH FARMERS: LESSONS LEARNED FROM THE SURVEYS CARRIED OUT BY TRAINEES

Trainer Rural Sociologist
Class Room 1 hour
Field ________________ Days

OBJECTIVES

To reinforce the lessons learned from the field experience, and trainees' sociological understanding.

TRAINING AIDS

Trainees' reports on watercourse surveys.

MATERIALS NEEDED

INTRODUCTION

Now the trainees have been introduced to the theoretical background, and also have some practical experience in approaching farmers and gathering data. This class will consist of a discussion of trainees' reports on their field work, and experiences, in order to clarify points made in earlier lectures, sharpen perceptions of sociological problems involved, and prepare the way for the next step--organizing farmers.

PRESENTATION

There will be no lecture. Trainees will report on the watercourses they studied--their basic social characteristics; an evaluation of each in terms of the criteria for success presented, and an evaluation of these criteria; and begin discussion of strategies for organizing committees on these watercourses.

The instructor should endeavor to get the trainees to see the connections between their data and the basic concepts presented earlier; the potential for leadership on each watercourse; and the effect of inequalities on the watercourse on the likelihood of success. The trainees should try to rank the watercourses studied from most to least likelihood of success of a watercourse improvement program.

Subject: INSTITUTIONAL DEVELOPMENT: THE CONCEPT OF WATER USER ASSOCIATIONS

Trainer Rural Sociologist
Class Room 2 hour
Field 0 Days

OBJECTIVES

To introduce to the trainees the idea of formal Water User Associations to help solve the problem of organizing farmers for improved water management.

TRAINING AIDS

Excerpts from Proceedings of Seminar on "Water Users Associations for Improving Irrigated Agriculture": speech by G. Radosevich, "Water Users Associations: World Wide Case Study Applicable to Pakistan", and "Recommendations of the Seminar. . .held at Faisalabad"; and figures illustrating the concept of water user associations (attached).

MATERIALS NEEDED

INTRODUCTION

The present OFWM Program depends on organizing informal watercourse committees. The next class will be devoted to discussion of the procedures for organizing these committees, and some of the problems you may face. Here it is sufficient to state that these committees have not proven as effective as had been hoped, either for improvement, or for maintenance of the watercourses. In response to this problem the idea of establishing formal, legal

Water Users Associations (WUA) has been discussed, and seems to be an idea whose time has come. Even though such WUA are not being organized presently, they may be in the future, and it will be useful if you are already familiar with the idea since you may be the ones who will be responsible for their organization.

PRESENTATION

Two basic approaches may be identified as solutions to the problem of organizing improved water management projects.

The first is a centralized, authoritarian approach. In this approach the government has the major responsibility for rebuilding and managing and maintaining the irrigation system, including the watercourses. However, such an approach in the conditions of Pakistan is likely to fail; it will be expensive and ineffective. This is because it would involve building a large bureaucracy which would both cost money and be prone to becoming corrupt. Such a bureaucracy would also be inefficient and ineffective because of the difficulties of administering 80,000 watercourses and enforcing standards of maintenance and management.

Further, farmers would feel no sense of pride or responsibility for the watercourse; this may lead to abuses (as it does with distributaries which farmers often cut, and destroy by bathing their animals) and inefficient use.

Related to this point is that when we talk abot the "development" of the country we usually mean more than building physical structures: development really consists of increasing the capacity of poor people to progress by their own efforts. A centralized approach to water management would not contribute to development in this sense.

The other approach is one which is decentralized and relatively democratic: the idea of Water Users Associations.

In this approach the size of the government bureaucracy would be smaller, and thus the costs to the government less, as well as the opportunity for corruption. Such an approach would mean farmers have a very important role in managing the system, thus increasing their sense of pride in and responsibility for it. This would lead to better maintenance and more responsible use of the system by the farmers.

Such an approach would be a real contribution to the "development" of the country too: it would increase the farmers' capacity to improve their agricultural production, incomes, and standard of living.

WUA: framework and functions:

A legal framework is vital for the success of a WUA; informal associations would have the same weaknesses of the committee system used presently. Such a legal backing would establish the responsibilities of the farmers as a group (as well as those of the government), and provide them the authority to carry out these responsibilites. Such a law would also have to be designed to insure that all farmers do their share; that there are no "free loaders" or "obstructionists".

It is also important to note that such WUA would work with engineers, extension officers, other technicians, and government officials. For example, in reconstructing a watercourse, much of an engineer's time presently is taken up by such administrative matters as procurement of materials; if the farmers were responsible for this he could be more engineering and thus his professional skills would be utilized more efficiently. Also, the Agriculture Officer would be able to work more effectively through an organization than he can now with individuals only.

As the accompanying charts show, it has been envisioned that there would be a federal structure to WUA: local level WUAs would be organized on watercourses; these would be federated at the distributary or minor canal level; and these organizations would in turn be federated at the major canal level. The federal structure has several purposes: the larger organizations can provide support to local organizations, especially those which are weak or having difficulties; the higher level organizations could have a role in the management and improvement of the larger irrigation system; and these higher levels could provide a place for appealing disputes at local levels for quick and fair settlement.

The actual structure of and functions of the local level WUA may vary among the provinces, and there may even be some intra-provincial variation, for example with regard to the role of tenants. Generally, it has been suggested that there be a "general assembly" consisting of all the members, which will meet periodically to make overall policy, approve budgets, set fees, and elect the "board of directors" or "executive committee". This committee would be responsible for day to day management of reconstruction, maintenance, etc. Aside from reconstruction and maintenance of the watercourse, the WUA would provide a vehicle for developing and improving the watercourse further (perhaps with the aid of bank loans); scheduling of water; setting up cropping patterns; installing tubewells; and very important--as a mechanism for further educating farmers in the efficient operation of their system and efficient utilization of the water supply. The extension officer would work closely with the WUA and organize meetings, demonstrations, field days, etc. through these organizations rather than dealing mainly with a few local informal leaders as at present.

QUESTIONS

(This class will hopefully lead spontaneously to a discussion in the class of the idea of WUAs, and their advantages and disadvantages. It is also assumed the trainees will have read the training aids before class.)

1. What is your opinion of the idea of establishing legal WUA? Give reasons to support your views.

2. Recall the previous discussions of social structure and culture. Given the relative inequalities of land holding, or power/influence, and the concept of izzat, how will these matters affect the introduction and operation of a WUA? What are likely to be the best conditions for success?

3. The two readings, Radosevich's speech and the recommendations of the Faisalabad WUA seminar, disagree on several points; one of these points is the need for separate legislation for organizing WUAs. Why do they disagree? What is your opinion on this question? Give your reasons.

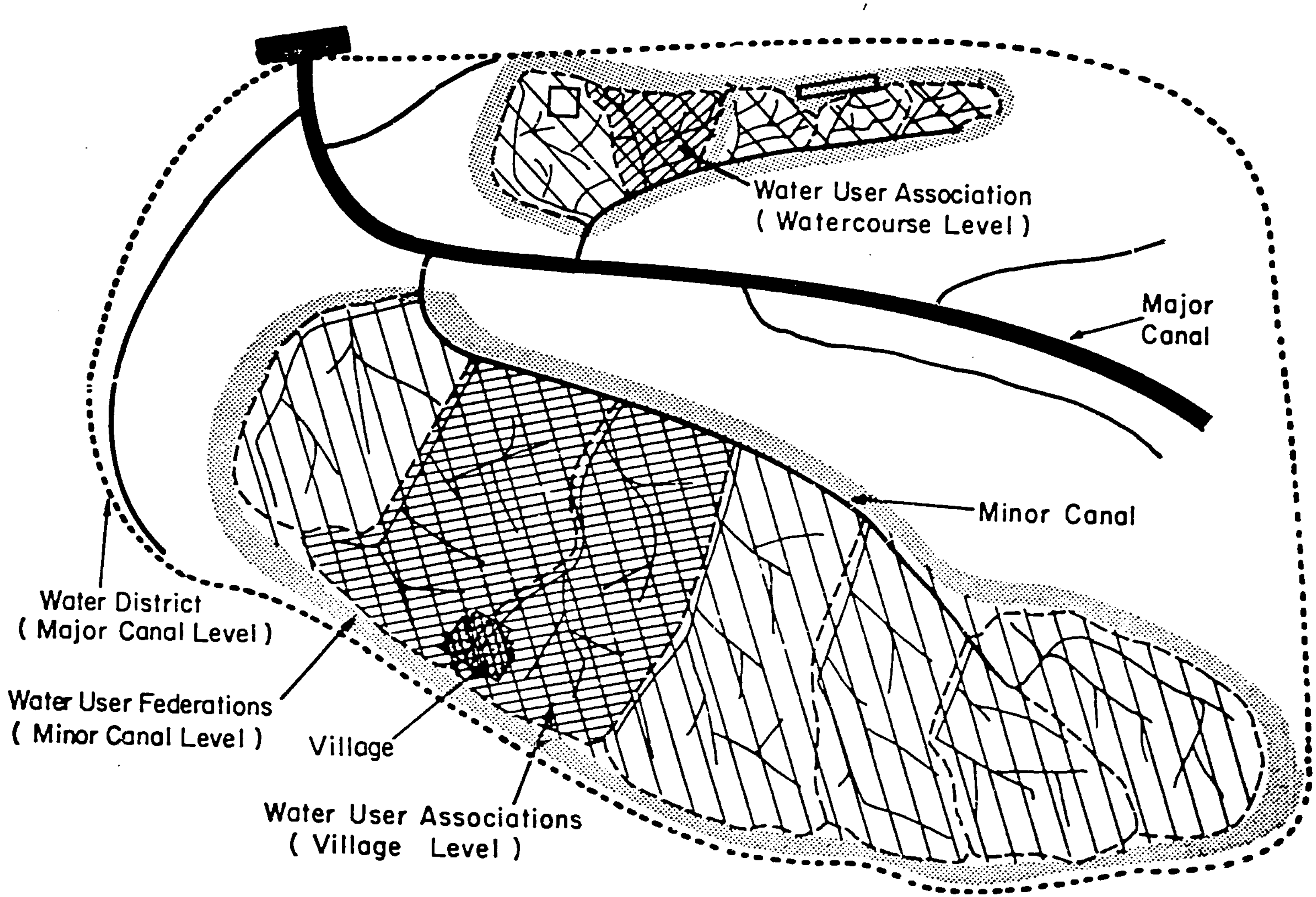


Figure 1. Water User Organizations for Pakistan: Development Scheme.

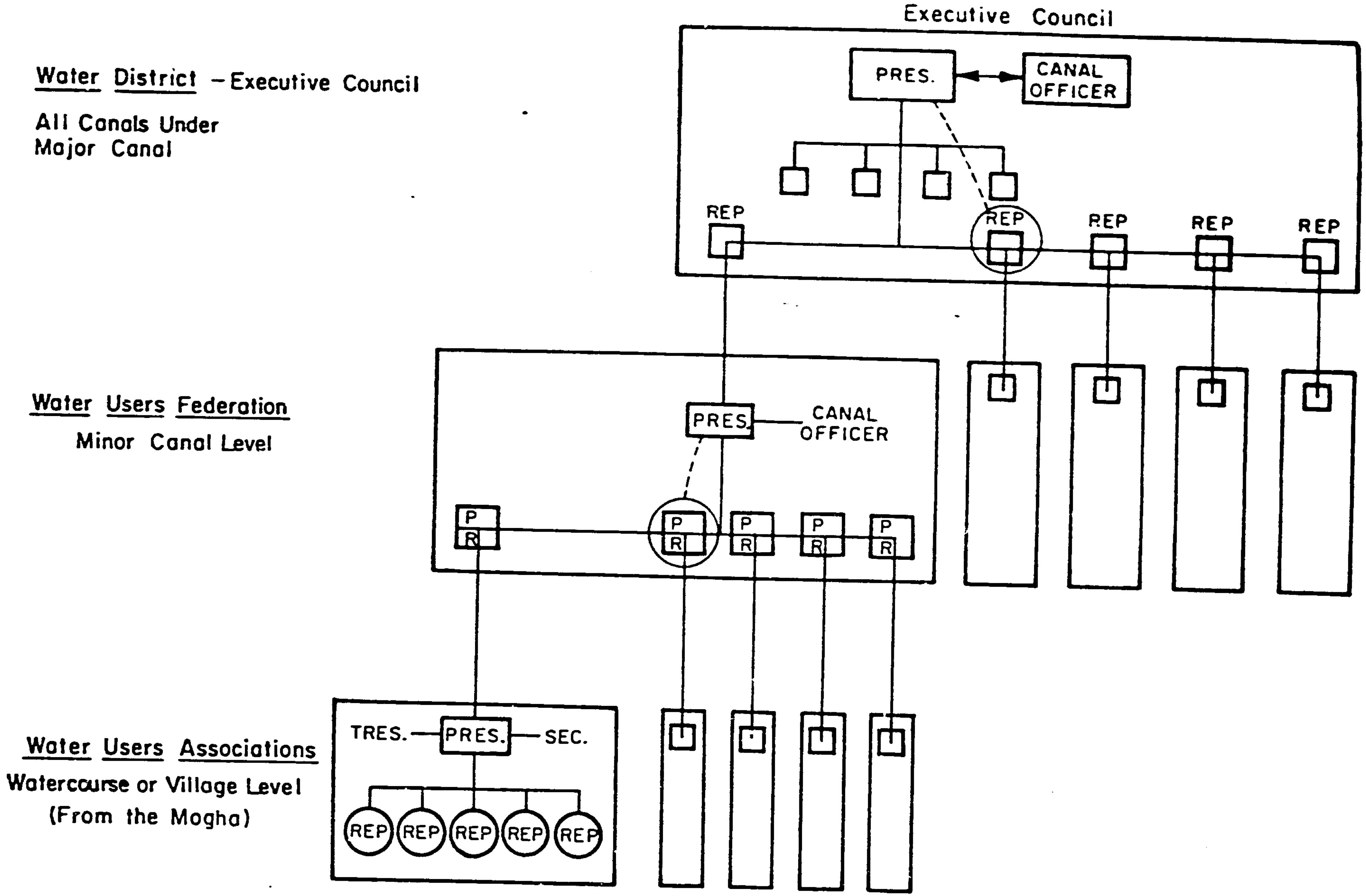


Figure 2. Water User Organization for Pakistan: Organizaticnal Scheme

Excerpts from Proceedings of Seminar on "Water Users Associations for Improving Irrigated Agriculture"--Radosevich's speech; and recommendations of Faisalabad seminar (1978).

WATER USERS ASSOCIATIONS: WORLD WIDE CASE STUDY APPLICABLE TO PAKISTAN

by

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ROLE OF WATER USERS ASSOCIATIONS

Agriculture is the backbone of the economy of Pakistan and most other countries, and yet it is the sector that is most vulnerable to changing geoclimatic, economic and political conditions. In Pakistan, research and demonstration have provided technological improvements in three areas: reduction of water conveyance and application losses, increased production from land leveling and improved agronomic practices and extension capabilities.

These improvements are being made available through the On-Farm Water Management Programme. The focus of this program is on water and how to help the farmer get the most out of his allocated supply. But in order to be successfully implemented, there is a definite need for an institutional structure to represent the irrigators in carrying out the activities. In some 37 countries examined, this local entity is often called a Water User Associations, Irrigators Association, Community of Irrigators or some similar name. The name is not important, but the objective is. The basic objective should be to operate, maintain and rehabilitate the water distribution system in as efficient and effective manner as possible and assist in proper application of water on the farm. From this objective, we can evolve many secondary objectives.

It is necessary to provide the water users with the incentive to improve their water use and the mechanism by which they can implement new technologies, practices and programme. Material support, e.g. equipment, loans, construction materials and obvious benefits would form the incentive. The mechanism at the grass-roots is the water users association.

The role of the association is as follows:

1. To serve as the legal device for the water user contracting with the government in order to undertake watercourse and land levelling improvements.

2. To provide assurance that the watercourse will be properly operated, maintained, and improved after construction of the physical components.

3. To provide a vehicle for farmers to gain an important identify in the country and an opportunity for them to develop and assume individual and collective responsibilities in the use of the nation's natural resources.

4. To enable water users at the watercourse level to gain economies of scale in the use of all resources available to them.

5. To reduce the risk of all users by simultaneously spreading the responsibility in a more equitable fashion.

6. To resolve disputes over water within the watercourse and seek proper assistance from Irrigation and Revenue Departments or Civil Courts.

7. To serve as a channel of communication between the water users and the water managers, i.e., Irrigation Department.

8. To increase the water supply by having association tubewells strategically located throughout the watercourse, where necessary.

9. To expand the benefits of cooperation and collective action into other related activities common to the irrigators, i.e. obtaining credit and purchasing sprayers, seeds, fertilizers, etc.

What is Happening in Other Countries?

Problems of water supply in arid areas are similar throughout the World, e.g., more land that can be cultivated than water to irrigate, conveyance and application losses and disputes between competing water users. Water laws in almost all countries attempt to set out the policy for water use, basis and method of allocation of water, distribution requirements and use conditions.

At the local level, countries with the more successful irrigated agriculture have adopted some form of Water User Association. And, although many of the physical problems are similar, a review of the approaches taken provides a wide variety of examples to examine in light of the conditions in Pakistan. The organizations generally occur either from spontaneous or independent action of the water users and hence develop over time and become recognized as having customary law significane; or are government influenced or induced. When they can be traced to being sanctioned by the government, they may be created either the top-down approach, which is mandatory formation through some development scheme; or bottom-up approach, which is a voluntary organization of water users at some level according to a law or regulation, especially providing for their creation. The organizations may range from private to public, simple to complex and single to multi-purpose.

Although a number of irrigation organization approaches were examined for applicability of their features to Pakistan, only the approaches of two countries, Spain and the Philippines, will be briefly discussed here.

Spanish Community of Irrigators

The hierarchy of the irrigation associations begins with a very simple entity serving a small area from a lateral or sub-watercourse to a federation of irrigation associations on the river. At the base of the hierarchy is the simple community (simple communidad). The next level is the general community (communidad general) which takes on very formal organizational characteristics and consists of simple communities and users served from a public conal and diversion works. The general community must defend the interests of the simple communities within their water delivery area. They are also responsible for the control and distribution of the community waters.

The communities may be organized voluntarily by action of water users of a common canal or watercourse, or by direction of the Comisario de Aquas in the basin.

When the waters are granted to a community it is charged with the control of the distribution of the water among its members. It administers the waters. If a person leaves the community he loses his right because he is leaving the lands. The right to use the waters is on the members of the community. The community, even when granted the water, performs only a distributive function.

The organic structure of the community of irrigators illustrates a logical functional diversion of activities particularly relevant to water control and management. It consists of three organs:

1. Junta general (general assembly).
2. Sindicate de Riego (board of directors).
3. Jurado de Riego (jury of water users).

Each member of the community must pay the assessments allocated to him according to the quantity of water delivered. Although the water is not metered, a "duty of water" for various types of crops is established by the sindicato. That quantity is distributed through canal outlets calculated to deliver a certain flow for a certain period of time. The junta approves the budget and fees charged to the members.

There are four basic concepts of the association which enable local control and self-imposed management.

(a) An association's existence is justified by a need to deliver water to a specific parcel of land in a more efficient and effective way.

(b) Concept of proportional distribution, practiced in Pakistan under the warabundi, theoretically favours no man, but rather provides to each irrigator a portion of water according to the size of the holding.

(c) Concept of individual responsibility to community for maintenance of his part of the watercourse and duty not to waste water makes each irrigator unique and significant. Infractions may result in fine or nondelivery of water.

(d) Concept of collective responsibility through internal organs of the association placed the capability and success of effective control and management upon the irrigators themselves.

One final feature of the Spanish system of water users associations is their method of resolving disputes and how it ties to Pakistan. When the Moors invaded the Iberian Peninsula in 1892, they brought with them the islamic principles of water use, the system of local administration, and the Islamic custom of resolving disputes at the entry way of the mosque. The principles of community property and equitable apportionment of water are reflected in the community of irrigators as well as local self-determination. To resolve disputes, the presidents of the community of irrigators of Valencia (there are eight) would meet before the entry of the mosque or just inside, at noon on every Thursday, and listen to complaints, accusations and rebuttles from the irrigators. This "Tribunal of Waters" would decide the disputes expeditiously and fairly before the eyes and ears of God.

When the Spanish Christian conqueror, El Cid, recaptured Valencia in 1232, he was so impressed with the Muslim practices, that he decreed they should be adopted. The mosque was, however, replaced with the Apostles Cathedral and the "Tribunal of Waters" moved to the door of the Cathedral for its weekly "trials". Today, over one thousand years later, the Tribunal of Waters meets every Thursday at noon of every week to hear complaints and other problems of water use and to resolve these disputes.

Philippine Irrigation Service Associations

The Spanish system has been tried and tested for over ten centuries and has stood up well, serving as a model for many countries in North and South America. In 1975, the Philippine government created an autonomous organization, the Farm Systems Development Corporation (FSDC) to implement a government policy of increasing self-reliance and productivity of the small farmer and to expand his participation in country development. A program called Barangay Irrigators Service Associations (BISA) was adopted with two major components--improve the efficiency of communal gravity flow irrigation systems and introduce small pumps, properly located to provide supplemental water supply or in some cases, the sole source.

To implement the program, approximately 70 farmers in an area of 100 to 200 acres could voluntarily create an Irrigator Service Association (ISA). The ISA was eligible for loans and grants to carry out the work, with the irrigators providing at least 10% of the cost sharing through labor or cash, and repaying the loan over 10 years after a 10 year period of grace.

Formation of the ISA is voluntary, but once agreed upon by a fixed % (i.e., 70 or 80%) of shareholders, membership is mandatory. All irrigators, whether landholders or tenants, are members. The members make up the General Assembly. Every 70 farmers along a lateral elect a representative to the Executive Board. The ISA is legally constituted and is registered with the Securities and Exchange Commission. At first, the ISA is single purpose, i.e. delivering water, but can later expand to obtaining credit and purchasing sprayers, fertilizers, seed, etc. Ditch tenders and pump operators are employed and the ISA is responsible to operation, maintenance and rehabilitation of the watercourses.

It was difficult to get the program started the first year because the FSDC staff had no examples to show the farmers the benefits of the program, often the pumps were late arriving or didn't work and it was a new experience also for the staff. The staff had to persuade the farmers to participate on faith and trust. By December 1977, 40,000 farmers were organized into 600 ISA's, however.

The benefit for Pakistan of the experiences other governments and farmers have had to carry on a successful program of productive and efficient irrigated agriculture are:

1. concentrate on a concrete goal that can be achievable in a limited time, e.g., on farm water management improvements which include improving water coneyance;

2. focus on a goal or task that an individual is unable to do himself but collective action of those with common bounds can accomplish;

3. limit the size of the group to those with a common relationship;

4. start with a simple program and let it evolve to the complex is the water users so agreed; and

5. without considerable and conscientious inter-departmental cooperation of government agencies, the program will be short-lived. A "Memorandum of Agreement" is considered important for commitment to this inter-departmental cooperation.

What Can be Done in Pakistan?

Informal executive committees have already been organized on many watercourses participating in the OFWM Program in the Punjab, Sind, and N.W.F.P. The receptiveness of their charge indicates this informal approach can be used to implement the scheme--in the short term.

To insure long term success of the program and effect upon the country's agricultural output, it is highly recommended to formally organize the associations by giving legal recognition to their creation and existence. This can be done by amending (1) the Cooperative Societies Act or (2) the Companies Act or (3) enacting a separate special Water User Association Act.

The key to a successful improved irrigated agricultural program in Pakistan rests with six steps:

1. perception of the problems,
2. guidance to determine solutions and programs,
3. guidelines formed to carry out the programs,
4. commitment of the government and irrigators to program benefits,
5. attitude of cooperation and role each person, whether government official or farmer has in increased production, and
6. interaction to carry out the program objectives.

How to Organize Water Users Associations?

Level of Formation

Based upon an evaluation of the most efficient means for organizing water users and a preliminary evaluation of village surveys, it is recommended that the associations be formed, at the lowest possible unit which would be the watercourse level, or, where feasible, at the village level if there is only one watercourse serving the village or where farmers on more than one watercourse are roughly of equal size.

Nature and Structure of an Association

There are in existence in Pakistan many de facto organizations for distribution of water among local users. The de facto organization which exists by virtue of customary practice in agreement among the users should always remain a viable possibility to the water users. However, it is suggested that a formal de jure entity be formed in order to give it legal status. This status would enable the entity to sue and be sued, seek loans for improvements, undertake programs offered by the government such as the water management loan program, and in general, give the organization a legal characteristic equivalent to the rights and obligations of an individual.

The structure of the water users association should consist of two bodies performing three functions. The first body would be the assembly consisting of all of the water users in the association. These water users would be shareholders and members of the association. The primary functions are the election of officers to the second body, which would be the board, and raising and deciding issues of common importance to the association.

The assembly would act as a general directive body. All the members would elect a board, approve organizational policies, approve assessments and collection of assessment, select collectors and ditch walkers, etc.

The second body would be the board of directors or watercourse committee. The board would have two functions. The first, to manage the association according to the creating documents and by-laws enacted by the assembly, and supervise construction and maintenance of the physical structures, which would also include hiring the necessary personnel to undertake this work.

The second function of the board would be quasi-judicial. This function is to resolve disputes within the watercourse among the water users. In this sense, they perform similar functions to the Community of Irrigators in Spain.

The board of directors would manage and operate the water users association, exercise normal powers to carry out the purposes of the association and have emergency powers for water regulations. The board would be responsible for contracting with the government on the programs, disseminate information on water availabilities, and other types of information pertinent to the farmers and carry the issues raised by the farmers back to government officials in the promotion of the association's interest.

The board would be organized into the offices of the chairman, the secretar and treasurer--the chairmanship should be rotating. Regardless of the office held by any representative, the representative would have no additional power or authority by virtue of holding that office over other representatives.

Functions and Powers

As a general proposition in the formation of the association, the following functions and powers should be granted:

1. Rehabilitation of watercourse, as under OFWM program,
2. Operation and maintenance of the main watercourse,
3. Sanctions for upgrading and maintaining farm field ditches and outlets,
4. Improving on-farm water management practices to include land leveling,
5. Establishing water delivery schedules and supervising water allocation within the watercourse,
6. Consideration of tubewell placement in order to optimize the water resources from both surface and ground sources in a conjunctive manner,
7. Set assessment methods and rates, and then collect assessments,
8. The association must be granted the power to conscript membership and make assessments in order to undertake emergency repair work, and
9. In general, promote improved water control and management by water users in an effort to reduce the unnecessary losses and increase agricultural output.

Membership

The formation of the association should be voluntary in order to leave the ultimate decision in the hands of the water users and to psychologically stimulate their reaction to improving their water use. However, once formed, membership in the association should be mandatory for all farmers cultivating lands commanded by the watercourse. Membership may include not only the absentee and operating landlords, but also the tenants in such a manner that through their membership they can voice their opinion on issues concerning water delivery, use and removal.

Voting

Voting privileges is one item of extreme importance in order to encourage participation in the decision-making process and protect the interests and rights of all water users. The system varies among the water users associations in other countries, from number of votes per person directly proportionate to size of irrigated landholding in the community, to one person/one vote for the working landowner or tenant. It is not suggested that either of these approaches be applied because of the obvious favouritism to either large holding landowners or multitude of small holding farmers.

The graduated voting rights system is a more ideal and equitable approach. Graduated voting will protect the interest of the small landholder or tenant by ensuring that he has a minimum number of votes. A minimum acreage should be set to qualify for a vote in order to discourage further fractionization of land holdings.

Election of Representatives

Representatives who will serve as officials on the board should be elected by members of the association and have a geographic distribution throughout the watercourse. It is recommended that one representative be elected from the head, two from the middle and two from the tail end of the watercourse. In the case of larger watercourses, the number may increase in proportion to this scheme.

Another consideration is the minority group, or the system of baradri (brotherhood). In this case, it may be decided that a representative would be elected by a baradri holding a certain percent (e.g., 20 percent) interest in the watercourse, or the baradris may be given additional votes in a graduated system of voting.

Assessments

The authority to levy assessments must be granted to the association. The assessments should be based upon the construction, operation and maintenance costs for improving the system and allocated among the water users either according to the water they used or the acreage under their control. The latter would coincide with the voting rights of the members. Payment of the assessment should be made either in cash or in kind (i.e., some product that the farmer is producing).

Registration Requirements

It is recommended that all associations be registered with the Provincial Irrigation and Agriculture Departments. If the association is formed under the Companies Act it would also be registered with the Registrar of the Companies. A roster or registry of associations will greatly facilitate communications between government agencies and users.

Hierarchy of Associations

The next level in the hierarchy of the agriculture sector of water users association is the federation of associations. It is suggested that the water users federation should be formed either at the village level where the watercourses are organized into associations, or the association could be organized at the minor canal or distributary level.

The Chairman of the water users associations within the federation area would serve as the federation board. The primary purpose of the federation would be to gain greater economies of scale for improvements in the larger area where this is necessary and to serve as the channel of communication at the distributary and higher canal levels.

Summary

Water Users Associations can become the most important instrument in Pakistan to implement improved technologies and techniques in irrigated agriculture. They can, as they have done so in many other countries, be the instrument that keeps the water distribution system at the farm levels in as efficient condition as possible under the varying conditions and constraints faced by the irrigator. Efficient water use over time is what is important. This fact, plus proper use of other inputs, make a nation's agricultural sector viable.

RECOMMENDATIONS OF THE SEMINAR ON WATER USERS ASSOCIATIONS FOR IMPROVING IRRIGATED AGRICULTURE HELD AT FAISALABAD ON JUNE 11-12, 1978

1. Establishment of Water Users Associations (WUA) is necessary for each watercourse.

2. There is necessity of framing a separate WUA Act as legal foundation for WUA. A Committee including people from OFWM and farming community should frame this Act.

3. WUA Act should include:

   (a) solutions to specific problems such as trees, conflicts and delays, maintenance.

   (b) registration authority since cooperatives have failed and registration with the Cooperatives Department may obstruct progress.

4. WUS should focus on water and may get involved in other activities like seed, fertilizer, etc. later on if they wish and feed capable.

5. If 70% of farmers on a watercourse agree to form WUA, others must join. 50% of executive committee members should be changed by election each year.

6. Abiana rebates for tubewell installation should be enhanced for WUA to 50% to help the small farmers.

RECOMMENDATIONS

A 2 days Seminar on "Water User Associations for Improving Irrigated Agriculture" was organized by the Punjab, On-Farm Water Management Development Project with the assistance of Federal Ministry of Food and Agriculture (Water Management Wing), Agricultural Research Council and USAID at Faisalabad on 11th December, 1978. About 200 participants including delegates from USAID, different Nation Building Departments, representative of Federal Ministry of Food and Agriculture (Water Management Wing) and members of the Executive Committees of the informal Water User Associations organized by Punjab On-Farm Water Management Development Project attended the Seminar.

In order to achieve concise and comprehensive recommendations of the Seminar, the participants/delegates were divdied into 5 Groups dealing with different disciplines of On-Farm Water Management, i.e.:

1. Agriculture
2. Irrigation
3. Cooperative
4. Revenue
5. Water Laws.

The 5 groups of the Seminar discussed in detail the problems pertaining to organizing Water User Associations for Improving Irrigated Agriculture; the function, legal status and the effective organizational set-up. The groups also made certain recommendations in the light of the terms of reference provided to each group for making recommendations for planners and Policy Makers, for coordinating Departments and for the farmers. The recommendations of individual groups were discussed in the concluding session of the Seminar. The final recommendations of the Seminar in respect of each group are as follows:

Group 1 - Agriculture

(A) Proposed Objectives of Water User Associations

(1) To assist and cooperate with the Department of On-Farm Water Management in their task of improvement of watercourse through motivating and organizing the farmers for collective work.

(2) To supervise and arrange the cleaning and maintaining of the watercourse, from the head to the tail and, through fixing individual and collective responsibilities of each farmer on the watercourse.

(3) To bargain for the procurement of strategic inputs (fertilier, pesticides, improved seed, implements, etc.) complimentary to the use of additional water in increasing agricultural production, on behalf of the members of the association and deliver them before the sowing time.

(4) To search and exploit additional sources of irrigation water such as tubewell near the cattle pond or collecting sewerage water and pumping to the watercourse.

(B) Laws

(1) An act should be enacted to give a legal status to the activities of the Department of On-Farm Water Management. This act should also provide for the creation of a water user association in each of the village where watercourses are improved or to be improved.

(2) The Water User Associations should be recognized as legal entites and preferably all farmers on the watercourse should be members of the association. This association should have an Executive Committee for achieving the objectives given at "A". The members of the Executive Committee should be elected by giving the representation to various "Biradries/Patties" on the mogha. The strength of membership in the Executive Committee from each Biradri/Patti should be in accordance with the number of farmers in each Patti.

(3) The Executive Committee should be empowered to punish the defaulters in the use and management of water and encourage the efficient use of water.

(4) One nominee from the On-Farm Water Management should be the ex-officio member of the Executive Committee. His job would be to provide technical guidance.

Group 2 - Irrigation

(1) The Irrigation Department will provide Chak Plans showing levels of fields, alignment of watercourses with location of nakkas, and other relevant record to On-Farm Water Management staff. The canal patwari will be directed to render cooperation to Water Management staff in the field and in implementation of the improvement programme. The Water Management staff can obtain any type of help from the Divisional, or Sub-Divisional Canal Officer including supply of authenticated statistics, record and in the solution of any co-related problem.

(2) Irrigation Department should direct canal patwaries to attend the meetings of the Water User Associations and the Water Management staff, held in connection with the improvement of watercourses.

(3) The Irrigation Department should give special consideration to the demands of the Water User Association regarding change of nakkas, mogha, etc. On a request from Water User Association, the Divisional Canal Officer should take immediate action under Canal and Drainage Act against the defaulters who do not maintain the improved watercourses.

The Committee also strongly recommended that considering the magnitude of watercourse improvement work all over the Punjab, the On-Farm Water Management activities should be expanded.

Group 3 - Cooperatives

(1) The name of the Society will be "Water Users Cooperative Association" and iwll be registered under the existing Cooperatives Act of 1925, for the time being. In the meantime, the University of Agriculture is requested to conduct research in this regard and suggest some better and viable arrangements.

(2) Every water user will be the member and shareholder. If 70% of the members agree to join the association, the rest will be bound for that.

(3) There may be separate association for each watercourse.

(4) Funds will be collected on the basis of land holding and contribution rate will be decided by members themselves.

(5) Donations and Government Aid will be used through the Association.

(6) Warabundi should be proposed by the Association and the Irrigation Department should approve the proposal of the association.

(7) If there is a shortage of canal water the association will manage to install the tubewell provided the subsoil water is fit for irrigation. The Irrigation Department will provide all the facilities to the association as provided to individual even with respect to rules and regulations.

(8) Any problem related to watercourse or mogha concerning any Department will be moved through the association.

(9) The association shall have the authority to fine or give some other punishment to the noncooperating member.

(10) Training courses should be organized for the farmers to acquaint them with the importance of On-Farm Water Management.

(11) The functions of Water Users Cooperative Association should be vital for the present but other services such as provision of agricultural inputs could be introduced later on when the association is well established.

Group 4 - Revenue

(1) A 5 members Executive Committee of the Water User Association should be constituted on each watercourse to get necessary coordination from Revenue Department. Irrigation Department and On-Farm Water Management Development Project. This Committee will also be responsible for improvement and maintenance of the improved watercourses.

(2) In case of noncoordination from any member of the Water User Association regarding Watercourse Improvement and Precision Land Leveling, the Committee should have the right to impose fine and in case of nonpayment, the matter should be reported in writing to the On-Farm Water Management authorities and the Revenue Department for realization of this fine with land revenue. It is further proposed that some legal foundation should be provided to this Executive Committee for getting work from members of the Water User Association.

(3) The fine will be collected by the Revenue Department and deposited in the committee account for utilization on the watercourses. It was also proposed that some legal representation should be given at the district level to facilitate the implementation of decisions against defaulters and effective collection of fine, etc. imposed against the defaulters by the Committee.

(4) The Revenue Department should appoint some patwaries who should specifically give particulars regarding alignment of watercourse and identify the removable trees owned by different agencies on the watercourse. They should also be responsible for precision land levelling and watercourse improvement.

Group 5 - Water Laws

(1) Without changing the existing laws as such, a separate and special law should be enacted to establish the Water Users Association in

all maters with regard to their establishment, contituting power and appeal should be provided. Proposed changes in existing laws should also be incorporated in the same special law. The rules of operation will also be made under the same Act.

(2) The legal foundation will be provided by enactment of the special law mentioned in recommendation (1) above.

(3) The registration of Water Users Association may be made under the new Act mentioned in (1) above with the Water Management Wing of Agriculture Department.

Subject: INSTITUTIONAL DEVELOPMENT: ORGANIZING WATERCOURSE COMMITTEES

Trainer Rural Sociologist
Class Room 1 hour
Field 1 Days

OBJECTIVES

1 - To prepare trainees for organizing watercourse committees: procedures, strategies, pitfalls.

2 - To provide trainees experience in organizing farmers for a cleaning and maintenance program.

TRAINING AIDS

MATERIALS NEEDED

INTRODUCTION

The major reason why watercourses need to be rebuilt is their poor maintenance in the past. This poor maintenance is the direct result of inadequate social mechanisms to insure that maintenance is carried out regularly and that all do their share of the maintenance. Therefore, improving water management is as much organization and institution-building as it is physical reconstruction. Experience shows that reconstruction without effective organization will not pay off in increased agricultural production and incomes; both are necessary.

PRESENTATION

According to OFWM rules, the farmers must organize a watercourse committee before their watercourse can be improved. The responsibilities of this committee are to:

1. organize and direct the labor of the farmers;
2. resolve disputes among farmers arising from the improvement process;
3. be responsible for water rescheduling if necessary during reconstruction;
4. determine work assessments per land holding;
5. act as the spokesman for the farmers in relation to the OFWM department; and
6. establish and direct a watercourse maintenance program after reconstruction.

It has been observed that sometimes these committees exist only on paper and do not fulfill these minimal obligations. This de-emphasis on the committees and on the farmers' role and responsibility in the project is an error in the long run: if the farmers do not have a significant role and investment of their time (and money), they are less likely to maintain it in the long run. The committee system is not and never can be as effective as legal water users associations; but you must make the best of the present situation by trying to encourage the establishment of effective committees, and then working with the committee actively to keep it operating for maintaining the watercourse. Unless you keep working with the committee as a committee (and not with the individual members as particular leaders) after reconstruction, the committee will not carry out its maintenance responsibility.

Steps in organizing a committee:

1. application by the farmers for a rehabilitation project.

2. pre-improvement watercourse survey, and informal contacts, to ascertain the social structure and evaluate the likelihood of success.

3. general meeting with farmers on the watercourse at a time and place of their convenience; at this meeting you will explain the program, using visual aids if possible to show the benefits; and you will clearly explain exactly what the government's role and contribution will be, what the farmers' responsibilities will be, and the basic design including constriants on the number of and placement of nakkas, etc.

4. a second general meeting, at which, if the farmers want to rebuild their watercourse, a watercourse committee will be set up. Informal discussions among farmers and between farmers and yourself should have preceded this meeting, and consensus reached on the committee members; careful attention should be paid to selecting leaders who represent the major groups (biraderis) on the watercourse; the various positions on the watercourse (with a fairly influential tail person if possible), different villages if the watercourse has farmers from more than one village; and the members should be influential enough to be able to lead others. Sometimes there are senior or powerful persons whose support is needed to succeed but who themselves are too busy or old to take an active part in the day to day work; these people should be put on the committee or given a role that shows respect to them, while some younger and more active people are also included who will do the actual committee work.

5. After the committee is established you should meet with it and discuss with them the design, construction strategy, labor, finances, provision for sanctions against persons who do not cooperate, anticipated problems, and

strategies to deal with these. Remember you are working with the committee and more generally the farmers; you are not directing or bossing them.

6. The above steps apply specifically to a watercourse that is to be reconstructed; but the same steps apply to a cleaning and maintenance program, whether on a previously improved, or unimproved, watercourse.

Suggestions for dealing with different types of watercourses

In the second lecture, a typology of different types of social structure of watercourses was presented. Here a few suggestions are made on how to deal with the likely problems on different types of watercourses.

1. Watercourse with one large owner and many small farmers dependent on him: on this type of watercourse, you cannot succeed without the support of the big owner; the more actively he supports it, generally the better the success. Nevertheless, some of the other farmers should be involved as much as possible so they will not come to think of the project as the government's or the big owner's. If the small farmers are in fact tenants of the big owner, and not owners themselves (such as is often found in Sind) the watercourse may be ineligible for improvement under OFWM rules.

2. Watercourse with several competing big owners (and others as dependents on these): on such a watercourse, the question is whether the big owners can forgo their competition for their mutual benefit, or whether they are so competitive that the watercourse project will be turned into another arena for their competition. If they cannot cooperate, such a watercourse should not be chosen.

3. Watercourse with relatively equal land holdings, and mostly of a viable size: this type of watercourse is potentially the most promising

although initial organization of the farmers may proceed slowly. Using the power/influence scores from the survey try to identify the best potential leaders and encourage them to be members of the committee.

4. Watercourses with relatively equal but very small holdings: organizing a successful program on such a watercourse may prove difficult, but if successful, could greatly benefit a lot of poor people. You should ascertain whether there are any potential leaders (from the power/influence scores) and encourage them to be on the committee. If there are none--the power/influence scores are uniformly low--such a watercourse will be very difficult to organize under present circumstances and you should consider whether it is efficient use of time and resources to do this one.

Aside from the landholding (and leadership) variables, one should also consider the previous history of cooperation, the biraderi structure, and the location of leaders along the watercourse.

Generally, a single biraderi watercourse will be easiest to organize, but this is not a hard and fast rule: the biraderi may be divided and unable to cooperate; and if there are several biraderis on a watercourse they may in fact have good relations.

Previous and recent success in a cooperative project is a good indication of an ability to do a cooperative project. On the other hand serious recent conflict may doom attempts at a watercourse project: such a project may provide an arena for further conflict and lead to escalation rather than easing of tensions and conflict.

APPLICATION

(The trainees should be divided into teams of two or three as they were for the watercourse survey. Watercourses should be chosen for cleaning and maintenance programs which have been surveyed by trainees. Not only the one day allotted, but several evenings should be devoted to organizing watercourse committees on these watercourses in preparation for cleaning and maintenance. This cleaning and maintenance should then follow the period of organizing committees closely.)

QUESTIONS

1. What are the three most important problems you encountered in organizing a watercourse committee?
2. What are the best solutions?