FIRST REPORT
SEPTEMBER 1982

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FOREWORD

The National Committee on the Use of Plastics in Agriculture was formed in March, 1981 and has been originally created for a two year period. It was felt that a First Report should be prepared by the Committee for information of the Central and State Governments. The purpose of the First Report is to brief the concerned Government departments and authorities on the potentials of usage of plastics in agriculture, irrigation and water management applications for increased water use efficiency and resulting increase in agricultural production. It is also hoped that these comments and feedback could be used for improvement of the Committee's functioning. (Plastics industry and others concerned with development of plastics in the agricultural sector).

The comments received would also help update/alter/change the findings and recommendations of the Committee which is proposed to be presented in the form of a final report later.

ACKNOWLEDGEMENT

The National Committee on the Use of Plastics in Agriculture received help from many sources and wishes to thank all who contributed to the report. The Committee acknowledges with thanks the help rendered by the plastics resin manufacturers, processors of plastics raw materials and the Agriculture and Irrigation Departments of the Central and State Governments without whose assistance the report could not have been completed in its present form.

Special thanks are also due to the following individuals who have significantly contributed towards the review of the report and participated in working meetings for the preparation of the report:

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CHAPTER 1

INTRODUCTION

The availability of plastics material in the country has increased substantially recently and the future plans of production are likely to make available very large quantities of plastics resins in the country. The use of plastics in the world has increased rapidly and has acquired substantial significance in the conservation of material and energy, and has contributed greatly to increased production of agricultural produce. The Government of India has been considering promotion and development of use of Plastics in Agriculture and Irrigation as a major step in improving agricultural yields and efficiencies.
In order to promote and develop the use of plastics materials in agriculture and associated fields, the Government of India in the Ministry of Petroleum, Chemicals and Fertilisers decided to constitute a National Committee on the Use of Plastics in Agriculture by a Notification issued on 7th March, 1981. The constitution of the Committee is as follows:

1 Dr. G.V.K. Rao - Chairman
Former Member
Planning Commission

2 Dr. S. Varadarajan - Member
Secretary
Department of Science & Technology
New Delhi

3 Dr. K. Aghoramurthy - Member
Adviser (Chemicals & Petrochemicals)
Ministry of Petroleum
Chemicals & Fertilisers
New Delhi

4 The Chairman &
Managing Director - Member
Indian Petrochemicals Corpn. Ltd.
Baroda (Gujarat)

5 Shri M. Sankaranarayanan - Member
Joint Secretary
Ministry of Agriculture
(Dept. of Agriculture & Co-operation)
New Delhi

6 Dr. N.S. Randhawa - Member
Deputy Director-General
Indian Council of Agricultural Research
New Delhi

7 Dr. A.M. Michael - Member
Project Director
Water Technology Centre
Indian Agricultural Research Institute
New Delhi

8 The Director - Member
Central Institute of Agricultural Engineering
Bhopal

9 Shri M. Bhatia - Member
Director (F & FP)
Ministry of Agriculture
(Dept. of Food)
New Delhi

10 Dr. K. Krishnamurthy - Member
Joint Commissioner
Ministry of Agriculture
(Dept. of Food)
New Delhi

11 Shri A.R.S. Murthy - Member
Deputy Secretary
Ministry of Irrigation
New Delhi

12 Shri K. Manjiah - Member
Director (Irrigation)
Central Water Commission
New Delhi

13 Shri Rashpal Malhotra - Member
Director
Centre for Research in Rural and Industrial Development
Chandigarh

14 Shri S. Narayanaswamy - Member
Chairman
Chemicals & Plastics India Ltd.
Madras

15 Shri M. Parthasarathy - Member
Director
Polyene General Industries (P) Ltd
Madras

16 Shri I.P. Anand - Member
Chairman
Shivalik Agro Poly Products Ltd
New Delhi

17 Shri Kedhav Prasad - Member
Wavin India Limited
Madras

18 Shri M.S. Patwardhan - Member
Managing Director
National Organic Chemical Industries Ltd
Bombay

19 Shri M.C. Verghese — Member
Consultant Chemical Engineer
60, Taylors Road
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Madras

The *terms of references* of the Committee are as follows:

i. To review possibilities of use of plastics in agriculture with special reference to:
   a. Plant and crop protection
   b. Irrigation and optimum use of water
   c. Application of plant nutrients and pesticides
   d. Handling and storage of agriculture products
   e. Any other related area
ii. To review the overall economics of application of plastics in different areas under Indian conditions, and to suggest measures for increased use of plastics, consistent with the established practices which are suitable in the Indian context
iii. Suggest in-depth studies on new products and new applications, and on systems required for using plastics materials in the agricultural sector.
iv. Review impact of the use of plastics in agriculture and environment
v. Review existing facilities for the production of plastics products for use in agriculture, including technological back-up for the conversion industry, availability of moulds and tools, and to make recommendations on strengthening the existing system to promote production of these products in the rural sector.

The Committee has, so far, held four meetings on 8th May 1981, 18th December 1981, 5th May 1982 and 5th August 1982. An informal meeting was also held by the Chairman with the Members of the Committee present in Delhi on 7th August 1981. In addition, the Chairman has had discussions with the senior officers of the Government of India in the Department of Agriculture and Co-operation, the Department of Agricultural Research and Education and the Ministry of Irrigation. The scope and objectives of the Committee on the role of plastics in various disciplines of agriculture, irrigation, etc. were explained. At the Chairman's request, Task Forces have been set up by the Ministry of Agriculture and the Central Water Commission (CWC), which will act as sub-Committees of the National Committee.

In the first meeting of the Committee, the work done so far within the country, particularly in the field of agriculture and irrigation, was reviewed in detail. During the last few years, some work has been done, particularly in the field of reservoir and pond lining, canal lining and drip and sprinkler irrigation, mulching, drainage, and other related fields. It was felt that the knowledge of results achieved within the country itself had not been well disseminated and that efforts should be made to see that practices of proved efficacy are adopted to the largest extent possible so that a multiplier effect is developed. The Chairman was requested by the Government to visit some of the States, discuss with senior officers of the Governments, particularly in the field of Agriculture and Irrigation, draw their pointed attention to the work that has already been done, and stimulate a process of further adoption. In accordance with this request, the Chairman visited the States of Andhra Pradesh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, and Tamil Nadu. He had detailed discussions with the Chief Secretaries, Agricultural Production Commissioners, and Secretaries to Governments, in charge of Agriculture, Forestry, Irrigation, Animal Husbandry, etc. In some of the States, he also called on the Ministers in charge of Agriculture, Irrigation, Forestry, etc. The films produced by the Indian Petrochemicals Corporation Limited on 'Plasticulture'*, and other audio-visual materials were shown to the senior officers, detailed discussions were held on the problems faced in the field, and remedial steps suggested. They were requested to draw programmes of action to implement the latest scientific developments in the field of agriculture.

The Minister for Petroleum, Chemicals and Fertilisers addressed a letter to the Chief Ministers of the States, suggesting the setting up of small high-level counterpart Committees in their States to ensure proper co-ordination with the National Committee on the Use of Plastics in Agriculture and to follow up its various recommendations.

*Plasticulture - A term coined by the International Committee on the Use of Plastics in Agriculture (CIPA) Paris, which covers all applications of plastics in agriculture, water management, and related areas.

Fourteen States mentioned below have set up such Committees:

1 Andhra Pradesh
2 Assam
3 Bihar
4 Gujarat
5 Haryana
6 Karnataka
7 Kerala
8 Madhya Pradesh
9 Maharashtra
10 Orissa
11 Punjab
12 Tamil Nadu
13 Himanchal Pradesh
14 West Bengal

The Committee felt that, on the basis of the work done so far, a First Report indicating the exact steps to be taken on the use of plastics in agriculture within the country might be prepared. This could become a reliable reference document to be circulated to all persons concerned, so that further steps to initiate adoption of plasticulture could be taken up. The production of such an First Report would rectify the existing lack of accurate information in the field.

The intention of the First Report is to review the use of plastics in agriculture, water management, and related areas. The work done so far, particularly the successes achieved in some States, and the action proposed to be taken by others would be indicated. Some of the problems faced will also be highlighted. The circulation of such a First Report will assist the departments concerned, both in the Central and State Governments, and the manufacturers to initiate efforts to spread the use of plastics in agriculture and irrigation on as wide a scale as possible. It is also likely that as a result of the implementation of some of these steps, a number of problems faced by the departments and the manufacturers would be raised, which could be considered by the Committee before submitting a final report.

The intention of the Committee is to highlight steps and procedures which will help in the better use of water, a scarce natural resource. The better use of water by preventing seepage losses, and by adopting methods of lining of canals which have been given effect to in some projects can easily be applied to most of the major irrigation projects in the country. Similarly, the use of plastics, particularly in the field of drip irrigation, sprinkler irrigation and mulching, will require to be taken up on a very much larger scale than done at present by the Departments of Agriculture and Universities of Agricultural Sciences. In the field of storage of foodgrains, considerable work has been done, but there are a number of problems which still require to be tackled.

In order to arrive at a practical and workable action plan for popularisation of Plasticulture applications in the country, the Committee has proceeded in a logical sequence, tracing the history of plastics in India, use of plastics in the major sectors, status of Plasticulture applications and identification of potential areas for propagation of these applications and has made specific observations and recommendations on the use of plastics in the Agricultural sector, which can be immediately implemented.

CHAPTER 2

History of Plastics in India

Although the foundations of the Plastics Industry were laid in India during the fifties, with the establishment of facilities for the manufacture of Polystyrene and Low Density Polyethylene (LDPE), based on industrial alcohol, the petrochemicals industry prospered only during the 1960s. The first Naptha Cracker was installed by Union Carbide (India) Ltd. (UCIL) towards the end of 1966, and the integrated petrochemicals complex of National Organic Chemical Industries Ltd. (NOCIL) was commissioned in January 1968. However, there was a long gap after this quick succession of developments, and during 1978, the Olefins Complex of Indian Petrochemicals Corporation Ltd. (IPCL) went on-stream, producing a range of petrochemical products, including LDPE and Polypropylene (PP).

Most of the plastics used in agricultural applications all over the world are now being produced in our country. Though some of these plastics are in short supply, the proposed petrochemicals complexes in the pipeline would be able to more than bridge the gap between the demand and supply position. In fact, the commissioning of IPCL has already eased the availability of LDPE.

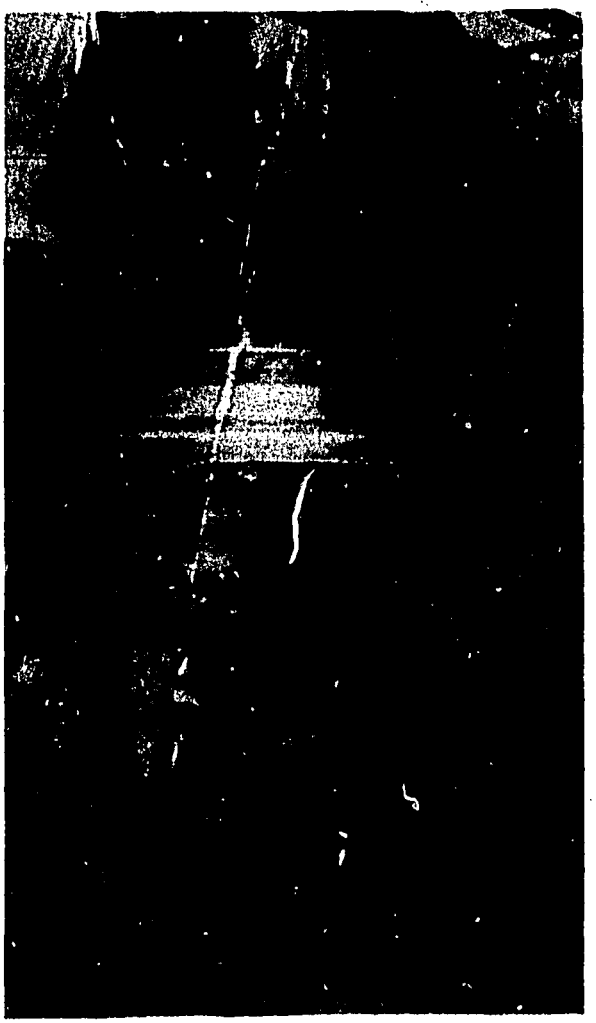
The plastics most commonly used in agricultural applications are Low Density Polyethylene (LDPE), Ethylenevinyl Acetate (EVA), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC) and Polypropylene (PP).

In certain applications, Polystyrene, Polyamide (nylon) amd Polyethylene Teraphthalate, can also be used.

To obtain an insight into the plastics industry in the country, the history of manufacture and availability of this useful range of plastics in the country is presented below:

Low Density Polyethylene (LDPE)

Low Density Polyethylene, commonly known as 'Polythene' is the plastic raw material with which most people are familier. For many years, it has been widely used in everyday household items, and perhaps the best known application of LDPE is in plastic bags and wrappings. LDPE remains the most widely used plastics film in agricultural applications.



LDPE blown film manufacturing plant in operation.

Weathering and Stabilisation

Unlike some other plastics materials, LDPE contains very few additives. For instance, whereas flexible PVC contains a plasticiser to impart flexibility, LDPE does not require this additive. However, anti-oxidents and ultra-violet absorbers are often added to combat the effects of outdoor weathering. Ultra-violet light causes the film to deteriorate, and an unstabilised film will tear like paper after a few months exposure to sunlight. Despite this, there is rarely any discoloration or clouding of the film. Degradation will be greatest at points where the film is stressed over supports and near points fixed to wooden frame-work. Ultra-violet inhibited film can be manufactured in the country, but so far no resin producer has supplied any UV inhibited LDPE resin for outdoor exposure applications.

LDPE film is used for lining applications, mulching, greenhouse, and tunnel cladding, nursery bags, liners for packaging, heavy duty packaging sacks, krishi hose, drip irrigation lateral tubings, land reclamation, etc.

Production of LDPE started in 1959, when Alkali and Chemical Corporation of India Ltd. (ACCI) established a 2,500 metric tonnes per annum manufacturing facility at Rishra (West Bengal), based on fermentation alcohol as a source of ethylene. The capacity has been subsequently increased to 12,000 MTA.

In 1961, Union Carbide (India) Ltd (UCIL) established the second manufacturing facility of 3,000 MTA at Bombay, using fermentation alcohol as a source of ethylene. High Pressure tubular process is used for polymerisation of ethylene. In 1965, UCIL established naptha-based ethylene facility, and later increased LDPE capacity to 20,000 MTA. Indian Petrochemicals Corporation Ltd (IPCL), (A Government of India Undertaking), commissioned a 80,000 MTA plant at Baroda (Gujarat) in mid-1978. High pressure tubular reactor process is used for polymerisation of ethylene. Thus the total installed capacity in the country at present is 112,000 MTA.

The past and future supply/demand/consumption of LDPE in India has been presented in Annexure 1.

Beginning 1962, the growth in India's consumption of LDPE for the first ten years has fluctuated significantly, but not below 10%. It was only in 1974, 1975 and 1976 that, due to four-fold increase in world oil prices, leading to economic recession, the growth-rate was extremely low, and, in fact, it was negative.

It is expected that between 1982-83 and 1987-88, new applications of LDPE products in significant sectors of our economy, such as canal lining, irrigation, water management, ensiling of cattle fodder, milk packaging, etc., would form the major part of growth of LDPE consumption in the country.

High Density Polyethylene (HDPE)

High Density Polyethylene has greater rigidity as compared to LDPE but is more brittle at lower temperatures. The use of HDPE, therefore, is more extensive in pipes and moulding applications.

HDPE is used for irrigation piping, construction of tubewells, film-lining of canals and farm ponds, blow-moulded articles for storage and transportation of pesticides, films for packaging, transportation, woven sacks for fertiliser packaging, drip irrigation piping, portable pesticide sprayers, etc.

Production of HDPE started in India in 1968. At the present, Polyolefins Industries Ltd (PIL) are the only manufacturers of HDPE in India. From an earlier licence for 20,000 MTA production, PIL has now enhanced its capacity to 30,000 MT per annum. The past and future supply/demand/consumption of HDPE in India has been presented in Annexure 2.

Polyvinyl Chloride (PVC)

Polyvinyl Chloride is possibly the best known plastics material, after polyethylene. Films of plasticised PVC are some of the most interesting and useful materials for use in covering applications, lining, packaging, etc. The main applications of PVC in agriculture in our country appears to be in the form of pipes, reinforced PVC hoses, and water stops. PVC is also being tried in gobar gas plant holders and conveyance piping system.

In contrast to polyethylene, PVC is little effected by oxidation, but in common with other polymeric materials, it is subject to degradation by light and heat. Resistance to weathering may be obtained by the use of a suitable stabiliser system to inhibit against ultraviolet light. The production of PVC in the country started in 1961 when Ahmedabad Manufacturing and Calico Printing Company established their manufacturing facilities in Bombay.

Details of the other units which are producing PVC in the country and other units expected to produce PVC in the near future are given below:

Company	Location	Licenced capacity (MT)	Installed capacity (MT)
Calico Chemicals	Bombay	20,000	6,000
Chemplast	Mettur	20,000	20,000
NOCIL	Bombay	20,000	20,000
* Plastics Resins and Chemicals	Tuticorin	12,000	12,000
Shriram Chemicals	Kota	60,000	40,000
Sub-Total		1,32,000	98,000
Indian Petrochemicals Corporation Ltd.	Baroda	55,000	–
West Bengal Industrial Development Corporation.	Haldia	45,000	–
Sub-Total		95,000	
GRAND TOTAL		2,27,000	98,000

* At present, PRC is closed.

The past and future supply/consumption/demand pattern of PVC in India is given at Annexure 3

It is projected that PVC would find significant inroads into new areas of applications in the agricultural sector such as lining and piping, biogas storage and conveyance systems which would increase its use in the core sector of the economy significantly. Development of greenhouses also may call for use of PVC film on a large scale.

Polypropylene

Polypropylene is an olefin polymer, i.e., belonging to the same family of polymers as LDPE/HDPE.

Polypropylene is obtained by polymerisation of propylene. It has better mechanical properties than high and low density polyethylene but it is more affected by low temperatures and is more vulnerable to degradation by ultraviolet radiation. It is used especially in antifrost nets, woven sacks for fertilisers,in drippers for trickle irrigation, synthetic binder twines and for pots and containers.

Till 1978 polypropylene was not manufactured in the country and was to be totally imported. In 1978, IPCL commissioned the first polypropylene manufacturing unit having an installed capacity of 30,000 MTA. The import and production of polypropylene in India is given at Annexure-4 .

CHAPTER 3

Consumption of Plastics in Plasticulture Applications in India

During 1974-75, Mr. A.D. Clarke, UNIDO plastics expert, had visited India for assessing the plastics industry in the country. As a part of the study, he has also estimated the plastics consumption in the country in the agricultural sector. As per his assessment, around 16,058 MT of plastics was consumed in the country during 1974-75 in the agricultural sector. Out of this, thermoplastics constituted 14,500 MT in the following sectors of application:

Sl No		Area of Application	Consumption in MT
1	Nets:	Monofilament HDPE for ropes and nets for fishing industry	2500
2	Film:	PE Planting bags for cotton, tea and forestry plants	800
3	Film:	PE film for rain guards for rubber trees	60
4	Film:	PE film laminated to jute for fertiliser sacks	3450
5	Film:	PVC flexible, lay-flat tubing for lift irrigation (krishi hose)	2280
6	Moulding fabrication:	Portable pesticide-spray equipment	67
7	Pipe:	LDPE pipe for irrigation in coffee estates	210
8	Pipe:	Hose for lift irrigation	1000
9	Pipe:	Recycled LDPE pipes for lift irrigation	4150
10	Pipe:	PVC rigid pipe for spray irrigation	20
11	Pipe:	PVC rigid pipe for tubewell	18
		Total	14555

Mr Clarke's study was a major eye opener to the plastics industry in the country in realising the great potential that exists in the country in the application of plastics in agriculture, water management and related areas.

Subsequently, several independent bodies, including Indian Chemical Manufacturers Association (ICMA) and Reconstituted Working Group on Petrochemicals (RCWGPC), have gone into assessing the application wise use of plastics including agricultural applications. The RCWGPC had estimated the past consumption and future demand for plastics in the agriculture and water management areas as per details given below:

Area of Application	Resin used	1977	1983	1988
IRRIGATION AND WATER MANAGEMENT				
— Canal lining	LDPE	300	2600	5650
	F.PVC	20	1000	1310
— Irrigation tubing	LDPE	335	1000	1300
— Irrigation pipes	HDPE	2000	7605	13550
	R.PVC	500	3000	7650
— Tubewell Irrigation	R.PVC	450	2000	6010
— Land drainage	R.PVC	50	350	1095
Sub-Total		3655	17555	36565
AGRICULTURE				
— Mulching	LDPE	30	500	2500
	F.PVC	10	300	545
— Nursery Bags	LDPE	2875	5500	8600
Sub-Total		2915	6300	11645
PACKAGING & STORAGE				
— Foodgrain Cover/Pusa Bin	LDPE	3725	6500	12600
— Seed Packaging	LDPE	200	450	800
— Pesticide Packaging	LDPE	1400	3150	6000
— Foodgrain storage	F.PVC	300	1000	1970
— Produce Packaging	LDPE	300	850	2100
— Fertiliser packaging	LDPE	7650	13850	25500
— Processed Foods	F.PVC	800	4500	8200
	LDPE	4300	14750	21000
Sub-Total		18675	45050	77170
OTHER APPLICATIONS				
— Silage	LDPE	5	100	3100
— Fishing nets	HDPE	685	1200	2095
	Nylon	NA	NA	NA
— Biogas silos	R.PVC	150	1000	1970
— Biogas Plant	F.PVC	20	200	545
Sub-Total		860	2500	7710
Grand Total		26055	71405	133090

Key: LPDE: Low Density Polyethylene
HDPE: High Density Polyethylene
F.PVC: Flexible Polyvinyl Chloride
R.PVC: Rigid Polyvinyl Chloride

The quantitative demand figure for numerous other applications, such as latex groove protection cover, air layering, poultry feeding trays and tubes are not available, and therefore, have not been included above.

A breakthrough has already taken place in the field of canal lining with polyethylene film in State of Gujarat, Madhya Pradesh, Punjab and Haryana where the irrigation departments have taken concrete steps to incorporate canal lining with LDPE film on priority basis. For example, Gujarat Irrigation Department has emphasised that LDPE film should be used as a lining material in all the World Bank-aided projects. Similarly, Punjab State has decided to line at least 25% of their lining work with LDPE film in their projects of modernisation of canal and distributaries. In case all the State Government Irrigation Departments opt for plastics film lining in their modernisation schemes as well as in new projects, the demand for plastics film may outstrip the forecasted demand.

Currently, there are several drip system operating in the country. The Government of Gujarat also has opted for drip system in a 500 ha land and the success of these trials can bring a break through in introduction of drip system in the country. The introduction of drip system would lead to a spurt in demand for PVC pipes. LDPE tubings as well as Polypropylene (PP) emitters on a large scale.

HDPE pipes are being used on a large scale in the conveyance of irrigation water. Even in tube-wells, PVC pipes can be used in the inlet tubing as well as strainer. Though PVC pipes are being produced in the country, its penetration in tubewell irrigation has been limited because of non-availability of trained personnel who can handle these pipes during installation as there are possibilities of damage during installation as well as removal for servicing and maintenance of the tubewells. The PVC manufacturers have to develop trained personnel in all the States so that PVC pipes can be more widely used in the numerous minor irrigation schemes in the country.

The forest departments are the major users of plastics nursery bags. The growing concern for conservation/preservation of eco-systems has led to conscious efforts for large scale afforestation and social forestry programmes. Demand for nursery bags, thus, is bound to grow because of the advantages it offers over conventional alternatives, such as clay pots, for planting in the soil.

Plastics Cover and Plinth (CAP) storages were developed by Food Corporation of India (FCI) and it has saved them of considerable losses. Even, state level marketing agencies are now evaluating CAP covers for utilisation as outdoor temporary store. It is estimated that the cooperative marketing federations of Punjab alone would require around 1000 MT of LDPE per annum for outdoor storage of foodgrains.

Fertiliser, Pesticide, Seed and Agricultural produce packaging are other important areas of application which absorb a high volume of plastics in a single application.

While appreciating the fact that plasticulture applications are not new to our country and that many of the applications are commercially being adopted on a large scale, it must be realised that more plastics must move into this core sector of our economy so as to modernise the existing agricultural practices, improve its efficiency level and also to utilise the plastics material for productive purposes.

CHAPTER 4

Growth of Plasticulture Applications

A study of the demand potential for plastics applications in the agricultural sector would indicate that there exists a vast difference between the demand potential estimates for agricultural applictions of palstics and the actual consumption in these sectors. For example, the demand potential for plastics for canal lining application has been estimated at a total of 181,000 MT whereas the actual consumption is forecasted at 2600 MT for 1983 which is even less than 2% of the total potential existing in this sector. This observation could be also applicable to other applications such as water course lining, Krishi Hose and Pusa Bin etc.

Apart from the difference which exists between potentials and actual consumption, one can observe the distinct difference in penetration level between the applications. For instance, CAP covers, nursery bags, HDPE/PVC pipes, fertiliser packaging - loose liners as well as woven sacks have been accepted at commercial level whereas mulching, greenhouses, canal lining, orchard nets, pond lining, and most of the other applications have achieved minimal/negligible penetration compared to the total potential that exists in these application areas.

The reasons for success of some of the applications could be:

i The manufacturers had taken up intensive market development and had created consciousness at grass root level;

ii The Government policy in terms of subsidy helped some products break the initial consumer resistance because of over riding cost benefits and thus achieved take-off stage;

iii The product provided techno-economical benefits which conventional material could not fulfil.

The very slow rate of growth of most of the other agricultural applications could be attributed to:

i The demand for plastics products in India had always far outstripped the supply of raw material and thus plastics applications have been confined to the urban market segment which is easy to penetrate.

ii Further it is a proven fact that our rural/agricultural market, even if so vast, is very complex and requires a different approach for extension of these applications. It requires intensive and relentless efforts to convince the rural consumer. The ready availability of the urban market and plastics raw material situation being what it was, the plastics raw material manufacturers could hardly find enough incentive to promote the rural/agricultural market on a large scale.

The analysis of success and failure of the applications would help us in better understanding of the communication gap and bottlenecks which have deterred the wider acceptance of the agricultural applications so that in the future development programmes, adequate care can be taken for effective communication and distribution network which would help the fast acceptance of these identified applications by the cultivators and interested parties.

CHAPTER 5

Rationale of Plasticulture in India

Starting from the beginning of this century, three major phases can be identified in our agricultural evolution. The first phase from 1900 to 1947 was marked by a near stagnation in farming as is clear from a growth rate of about 0.3 percent per annum achieved in agricultural production during this period. The second phase extending from 1950 to 1980 has been marked by considerable advances in the process of modernisation of agriculture, thanks to the steps taken in the development and spread of (a) technologies based on scientific research; (b) wide range of supplies and services; (c) increasing areas under irrigation; and (d) public policies in land reform, pricing, procurement and distribution. As a result, agricultural production grew at an annual compound rate of 2.8 per cent during 1967-68 to 1978-79. The third phase which has begun in the eighties will be marked by the need for greater attention to marketing and trade, and to institutional frameworks which can help to minimise the handicaps of small and marginal farmers and maximise the benefits for intensive agriculture offered by small holdings.1

In keeping with the planned objectives, the maximisation of benefits in the agricultural sector calls for optimum allocation of scarce resources which starts with timely availability of adequate quantity of irrigation water, maximisation of benefits from fertilizer application, plant protection, safe storage of foodgrains, etc. The viability of small holdings would very much depend on increase in revenue per unit area. This in turn would call for modern inputs which would help in optimum utilization of available resources at the cultivators' command.

Plastics materials pose a range of unique blend of properties which render them one of the most useful agricultural inputs which would go a long way in water conservation, conveyance and management, plant growth, plant protection, food grain storage, packaging of agricultural produce and numerous other applications, where day-by-day more and more conventional materials are being replaced by plastics materials.

One of the most important applications of plastics is in irrigation and water management areas. Plastics materials being corrosion proof, flexible and practically totally impermeable to moisture, these can be deployed for lining of conveyance systems, tubings for water conveyance, land reclamation, mulching and storage pond lining as well as other water management applications.

Besides the direct benefits derived from the use of plastics in agriculture, irrigation and various water management practices the use of plastics in agricultural sector would result in development of small scale industries at village or taluka level, employment potential for rural population, energy saving and last but not the least, environmental protection.

Development of Small Scale Industry

Plastics processing is mostly in the small scale sector. The plastics processing unit is a clean industry and does not generate pollution. Village workers can be trained to run plastics processing units as the skill requried is minimal. A study of the processing units in various parts of the country bears ample evidence in support of the above. With increased use of plastics film and other items at village level there would be opportunity for the setting up of plastics processing units at taluka level. Besides encouraging local population for entrepreneurship these units would also generate employment for the rural poor.

Energy Saving

Plastics consume less energy for conversion from raw material to finished goods. For example, energy requirement for production of one metre of cast iron pipe is five times more energy consuming as compared to manufacture of 1 metre of PVC pipe. Similarly paper sacks and glass bottles require 70% and 130% more energy for production as compared to polyethylene sacks and PVC bottles respectively.

The use of plastics in irrigation and water management results in very high energy saving which can be gainfully used elsewhere or in irrigation itself for increasing the total irrigated area.

1 Source: Sixth Five Year Plan 1980-85

In minor irrigation schemes plastics pipes have been observed to give as much as 35% more water output with the same consumption of energy (both fossil fuel and electricity). The use of plastics pipes in the inlet and outlet piping results in less frictional losses and the smoothnes of the pipe does not deteriorate like metal pipes. With proper handling the life of such pipes can far outstrip the life of metal pipes and thus economy in investment is also achieved. In view of the energy saving which can be achieved through the use of plastics pipes it is of national interest that the irrigation authorities adopt these materials in their current and future projects.

Environmental Protection

The rapid increase in land use as well as the exploitation of natural resources such as forests is resulting in ecological imbalance leading to soil erosion, adverse change in climate, etc. Use of plastics materials may go a long way in retarding this process of deterioration and thereby restoring the environment to its original level.

Modern irrigation practices such as sprinkler and drip systems help in irrigating land without disturbing the top soil. This practice not only improves agricultural production but also it retards soil erosion. Soil structur remains undisturbed and thus water retention capacity remains high.

In many parts of the country such as Himachal Pradesh deforestation is being taken up ruthlessly for the manufacture of wooden crates used for transportation of fruits from the upcountry production centres to the city centres.

Use of alternate mode of packaging such as plastics crates can reduce the burden on exploitation of the forest resources and that would help restoration of the environment, reduce soil erosion and indirectly help in reducing siltation of downstream hydro-projects. Plastics nets can be used fo. protection of steep slopes and serve as anchorage for foliage which would ultimately reduce soil erosion.

Rural Entrepreneurship

Already there exists a vast network of agro service centres all over the country which are headed by technical graduates - engineers and agricultural graduates. These networks can be further utilised for serving as the outlet for plastics materials to be used in agriculture and water management areas. These centres would be thus revamped to serve as nucleus training centres for propagating the use of plastics in agriculture, water management and related areas.

CHAPTER 6

Development of Irrigation in India

Water suitable for human consumption, livestock and irrigation is limited. Since precipitation and ground water are the only sources of all fresh water and since it varies from place to place, season to season and year to year, water must be collected, stored and transported, if it is to be available when and where it is required. With the increasing population and a corresponding increase in requirement for foodgrains, there is an urgent need to scientifically manage our water resources to meet our future demands.

Since the annual rainfall is our only source of fresh water supply, which also varies from year to year, after considering evaporation, transpiration, and percolation lossess in the ground, the quantum of surface flow has been estimated to vary from 144 million hectare metres to 188 million hectare metres per annum.

Most of the surface water runs into the sea. The maximum utilisable water resources has been estimated by the Irrigation Commission for any given year is as follows :

Surface water	:66.6 million ha. metres
Ground Water	:20.4 million ha. metres
Total	:87.0 million ha. metres

This amounts to only 46-60% of the total available surface water. Projecting our needs for the year 2000 AD, the demand-supply situation for surface water appears adequate. However, in case of ground water resources, the demand will exceed the supply as given in the Table below:

Table-1

Projected Demand for Water 2000 AD (Million hectare metres)

Type of Resource	Utilizable resource of water	Projected Demand - 2000 AD		
		Irrigation	Other uses	Total
Surface water (major, medium and minor irrigation schemes)	66.6	45.6	3.4 to 9.8	49 to 55.4
Ground Water	20.4	21.0	4.5 to 6.5	25.5 to 27.5

It is, therefore, of utmost importance that water resources are conserved, preserved and prudently used so that maximum benefits are derived from their usage.

Development of Irrigation in the Country:

On the eve of independence there were 28.2 Mha area receiving irrigation, which constituted 24 per cent of the net cultivated area in the undivided India. Partition resulted in a substantial reduction in the proportion of irrigated area to 20 per cent of the cultivated area. The situation called for tremendous efforts to make up the leeway and meet the requirements of a growing population. The five year plans accorded a high

priority to development of irrigation. The gross irrigated area increased from the pre-plan level (1950-51) of 22.6 Mha to 44.20 Mha at the end of Fourth Plan (1973-74). By the end of 1978-79 the gross irrigated area increased to 54.46 Mha and 56.60 Mha by end of 1979-80.

The projection of future irrigation development in the country is presented below:

(in Mha)

Year	Surface Water	Ground Water	Total
1985	36	25	61
1990	41	28	69
1995	46	31	77
2000	51	33	84
2025	70	40	110

The development of irrigation can be considered under the four broad sub-divisions as follows:-

-Major and medium irrigation

-Minor irrigation

-Command area development and water management

-Flood control

Heavy emphasis has been laid on tapping the water available to the country through high investments in major, medium and minor irrigation projects. The plan outlays on irrigation projects are presented below:

	Outlay/Expenditure (Rs. crores)			Irrigation potential cumulative (M. Hectares)		
	Major and Medium Irrgn.	Minor Irrgn** (State)	Total	Major and Medium Irrgn.	Minor Irrgn**	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pre-plan benefits				9.71	12.90	22.61
First Plan	380*	66	446	12.20	14.06	26.26
Second Plan	380	161	541	14.33	14.75	29.08
Third Plan	581	443	1024	16.57	17.01	33.61
Annual Plan ('66-69)	434	561	995	18.10	19.00	37.10
Fourth Plan ('69-74)	1237 (b)	1174	2411	20.70	23.50	44.20
Fifth Plan ('74-78)	2442	1411	3853	24.77	27.30	52.07
Annual Plan (78-79)	2337	987	3324	26.61	30.00	56.61
Annual Plan (79-80)						
Annual Plan (80-81)	1305.55 (Actual)	587.94 (Actual)	1893.4	27.49 (Anticipated)	31.50	58.99
Annual Plan (81-82)	1544.28 (Anticipated)	636.17 (Approved)	2180.45	28.51 (Anticipated)	33.05 (Anticipated)	61.56

*Includes Rs 80 crores incurred during the pre-plan period.

**Government outlays only

***Source: Sixth Five Year Plan (1980-85) document.

(b) Excludes Plan outlay of Rs 50.54 crores on approved Cauvery Basin projects.

Major and Medium Irrigation Projects:

During the sixth plan (1980-85) highest priority will be given to the improvement of productivity per unit of water in the areas already covered with the irrigation arrangements including attention to the problems arising from salinity and water logging. Command Area Development as well as popularisation of crop-soil-water management will also receive priority during the current plan period.

It has been envisaged that high priority has to be given to analysing and identifying the problems in each project under each zone so that there would be optimisation of benefits from the irrigation resources already created in future. It has been proposed in the plan that the above activities would be achieved through:

i) Minimising the losses at the storage/diversion point;
ii) Minimising the losses in the distribution system;
iii) Efficient use of water on the fields.

The losses at the storage or the diversion point have to be kept to the minimum by judicious operation of storage reservoirs. Utilisation of storage supply to the maximum extent before the onset of hot season will be the aim for efficient use of storage waters.

Losses in the distribution system shall be minimised by resorting to selective lining, looking into the performance of each reach of the distribution system. Lining with alternative materials like rubber or plastics sheets or similar materials also may be tried if found technically and economically justified.

The efficient use of irrigation water on the field involves study of many factors including the soils, their physical and chemical conditions, water requirements of various crops, irrigation practices and drainage needs etc. For eliminating field to field losses, proper water channels are to be constructed and suitable methods of irrigation to help efficient use of water have to be evolved.

There are a number of old irrigation projects and even those constructed recently, which are not able to meet the irrigation requirements of the cropping patterns developed, due to excessive transit losses and inadequacy of regulatory structures. It is important to remedy these defects by undertaking a modernisation programme, which would include lining and construction of regulatory structures, etc. so that requirements of crops in the peak periods are met with and productive agriculture coupled with the use of fertilisers and other inputs becomes possible.

Provision of adequate drainage facility is as important as building the irrigation system. It is necessary that the main drains and the intermediate drains are constructed first, preferably as a part of the irrigation project as the functioning of the field drains is dependent on the prior construction of intermediate and main drains.

An outlay of Rs. 8,448.36 crores is proposed to be invested on major and medium irrigation projects. Bulk of this outlay will be in the State sector with only a sum of Rs. 90 crores being in the Central sector. The break-up of outlays proposed are:

	Rs in crores
States	**8301.46**
Union Territories	**56.90**
Central Sector	**90.00**
Total	**8448.36**

An additional irrigation potential of 5.7 million hectares is proposed to be created. Some of the major on-going irrigation projects of the Sixth plan which are likely to be completed during the Plan period are:

Andhra Pradesh
Nagarjunasagar
Sriram Sagar Stage-I
Tungabhadra HLC Stage-II
Gujarat
Mahi Stage-II
Damanganga
Panam
Ukai
Karnataka
Bhadra
Tungabhadra
Madhya Pradesh
Mahanadi Reservoir Phase-I
Tawa
Chambal
Manipur
Loktak Lift Irrigation
Maharashtra
Jayakwadi Stage-I
Bhima
Orissa
Rengali Dam
Rajasthan
Rajasthan Canal Stage-I
Uttar Pradesh
Sarda Sahayak
Kosi Irrigation
West Bengal
Kangsabati Reservoir
Teesta Barrage

Plastics film has been successfully used in several irrigation projects in the country as a lining material. We also have information from USA, USSR as well as several other countries on the economics and efficacy of plastics film lining. The details regarding plastics film lining have been covered in Chapter 3 on 'Applications'. There is a great potential for introduction of plastics film lining in the major and medium irrigation projects all over the country. Use of plastics film canal lining would offer several advantages some of which are: seepage losses would be almost totally prevented, likelihood of considerable cost saving due to reduction in section of brick or concrete lining,better strength recovery of masonry as well as concrete.

Minor Irrigation:

Upto the end of the Fourth Five Year Plan the total cropped area which benefitted from minor irrigation was assessed at 23.5 Mha. During the Fifth Five Year Plan (1974-79) against an increase of 5 Mha envisaged additional potential created during four years of the Plan (1974-78) was 3.8 Mha. By the end of 1977-78 the level achieved under minor irrigation coverage, therefore, was 27.3 Mha and during 1978-80 additional potential created is about 2.7 Mha. The physical achievements on some of the important items are as follows:-

	(in '000 Nos.)
Dug Wells	**7780**
Private tubewells	**2110**
Deep tubewells	**36**
Electrical Pump sets	**3650**

The target for the Sixth Five Year Plan (1980-85) has been proposed as under:-

Table-2 **(Mha)**

Year	Additional irrigation targets 1980-85		
	Surface water additional potential	Ground water additional potential	Total
1980-81	0.20	1.30	1.50
1981-82	0.20	1.35	1.55
1982-83	0.20	1.40	1.60
1983-84	0.20	1.45	1.65
1984-85	0.20	1.50	1.70
	1.00	7.00	8.00

The gross potential to be created during the Plan period is fixed at 11 Mha so that the additional potential, net of depreciation and siltation, may be 8.0 Mha; 1.0 Mha from surface water and 7.0 Mha from ground water. To achieve large scale development of ground water during the Sixth Plan the target for various items of the programmes is envisaged as under:

Dug wells	12 lacs
Private tubewels	12 lacs
Deep tubewells	15000
Electrical pump sets	25 lacs

An outlay of Rs. 11,810.30 crores has been envisaged in the public sector along with an institutional investment of the order of Rs. 1,700 crores.

In minor irrigation projects, considerable quantities of pipes and tubings are used in the pumping and conveyance of irrigation water. Plastics pipes made out of PVC and High Density Polyethylene (HDPE) can effectively replace the metallic pipe systems, adding durability, efficiency and economy to these projects. In many minor irrigation projects, plastics pipes have already been introduced successfully. Studies by the Institute of Co-operative Management, Ahmedabad have shown that the use of PVC pipes instead of conventional ones can generate saving of energy consumption to the extent of 35%. This benefit is very pertinent at present when cost of electricity and fossil fuels are increasing at a staggeringly fast rate.

The present system of tariff prevalent in the States is to charge a flat rate per tubewell. This system does not distinguish between a cultivator who adopts efficient pumping systems and another who does not. It has been suggested that as an incentive to reduce power consumption in tubewells the system of flat charge per tubewell should be changed to one based on actual metered consumption of electricity. However, the plastics pipes manufacturers must take up intensive training of engineering personnel on installation of plastics pipes in minor irrigation schemes so that failure of these pipes during installation and servicing due to faulty handling does not retard progressive penetration of these pipes in tubewell irrigation schemes.

Command Area Development:

Considerable investment has been made on major, medium and minor irrigation projects in order to create irrigation potential for increased agricultural production. The utilisation of the potential created has lagged behind for various reasons and for removing these deficiencies and in order to optimise the agricultural production during the Fifth Plan, a programme for integrated development of command area was launched and CAD Authorities were set up for identified projects. The coverage of CAD is proposed to be extended to more projects during the Sixth Plan. In spite of this, a great deal of ground still remains to be covered as the task is stupendous. Some of the measures to be adopted for effective utilisation of available irrigation potential are:

- Construction of field channels
- Development of main drainage system
- Lining of field channels/water courses
- Arrangements for timely and adequate supply of various inputs.

It has been recommended by the Planning Commission that water management should occupy a key role in the steps to be taken in the coming years. The objective of water management in irrigated agriculture is to provide suitable moisture and environment to the crops to obtain optimum yields with corresponding maximum economy. This technology would be location specific and would be governed by the nature and extent of water availability, soil and climatic conditions and the terrain of the area to be irrigated. Sprinkler and drip irrigation systems have to be used in areas where agro climatic conditions permit economic and efficient use of these devices.

A study conducted by Central Water and Power Commission (1967) revealed that 71% of the irrigation water is lost during its conveyance. Lining of canals would reduce these losses substantially and that would mean more irrigated area and better agricultural production.

Use of drip irrigation system which utilises a network of plastics pipes for conveyance of irrigation water from the source upto the plant root zone would result in very high water use efficiency, reduction in fertiliser consumption and increase in agricultural production. Use of these systems in small holdings would bring in high returns and render such units viable for operation.

Countries such as Israel have used drip system on a large scale and that has resulted in conversion of deserts into agricultural fields and today they are exporting fruits, vegetables and flowers to the European countries.

The agricultural applications of plastics have been tried in our country and many of these applications have proved to be technically and economically viable. However, efforts to popularise these applications must be intensified by resin manufacturers, the processing industry as well as, last but not the least, the Government so that the plastics materials are used for productive purpose all over the country. Deficient States like Maharashtra, Rajasthan and northern Gujarat can take advantage of plastics materials being produced in the country for water conservation and for improving agricultural productivity which would help in improving the quality of life in these localities. Similarly, in cold frontier regions, plastics materials can be used for plant protection and environmental control so that areas where nothing can grow today can be made self-sufficient in agricultural production.

Rapid strides have been made in many of the developed countries in the agricultural applications of plastics. The area under plastic mulching, greenhouses, tunnels and such other applications is rapidly expanding in these countries. Before we analyse the present status of agricultural applications of plastics in our country, an account of development of major plasticulture applications in some of these developed countries has been presented in the following Chapter.

CHAPTER 7

International Developments

In temperate climates as well as in arid desert areas, plastics have been deployed extensively for creating favourable agroclimatic conditions, conserve moisture and increase agricultural yield—both in quantity and quality. In this Chapter we have tried to furnish information on the international definition of plasticulture, history of plasticulture and status of some of the applications in selected countries all over the world.

International Experience

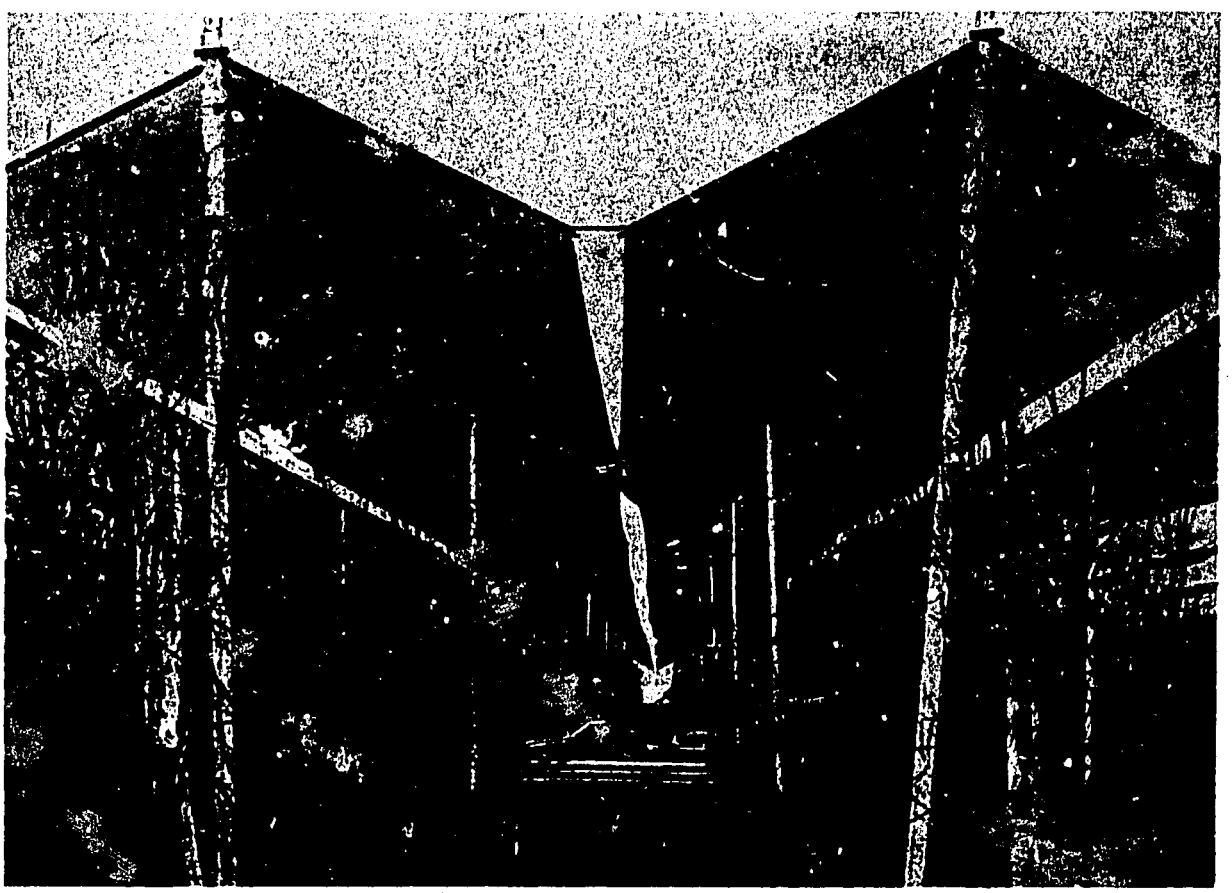
The first trials with plastics mulch for melons were carried out in France in April, 1961. Thirteen years later, in 1974, there were in France about 33,000 hectares of mulched crops which included melons, strawberries, asparagus, tomatoes and grape vines, to mention only the main crops. Around 3,000 mechanical film layers were used to do this job.

Mulching is however, only one of the many applications under 'Plasticulture'. The other applications under plasticulture which are being propagated the world over are:

a Semi-forcing and forcing (small and large tunnels, greenhouses)
b Protection of crops against weather and bird damage (wind breaks, shade nets and nets for protection against birds)
c Silo storage
d Fruit storage
e Irrigation
f Drainage
g Fumigation and soil improvement
h Water storage
i Pots and containers

The applications which also can be included under 'Plasticulture' are:

a Packaging for preservation of agricultural and horticultural products, both fresh and processed (fruit, milk, fruit juice, etc).
b Sacks and bags for packaging of fertilisers, pesticides and seeds.
c Packaging for collecting, handling and transportation.
d Agricultural buildings or the materials for their construction, etc.



Plastics orchard nets for protection against hail storms.

The tonnage of plastics used in some of the developed countries in 1976 for mulching, low tunnels, greenhouses, silage, protection of crops and equipment, water reservoirs, irrigation, drainage, nets, pots and containers is presented below:-

Country	Tonnage	Population in million	Per capita consumption: kg/inhabitant
Japan	233,700	112.77	2.07
USA	100,000	215.12	0.46
Italy	81,600	56.15	1.45
France	68,000	52.97	1.28
UK	47,600	55.93	0.85
Spain	29,000	35.97	0.80
Hungary	16,000	10.32	1.55
Sweden	10,000	8.00	1.25
Norway	5,600	4.00	1.40
Argentina	5,500	25.72	0.21
Portugal	1,170	9.45	0.12
Finland	600	4.71	0.12
India	7,000	615.00	0.011

The usage of plastics materials in different agricultural applications for some developed countries is discussed below:

Table-3

Mulching in Different Countries in 1976

	Area in ha	Tonnage (T)
Argentina	100	40
Belgium	1250	
Spain	18000	3000
Finland	300	110
France	35000	9000
Italy	7000	2500
Japan	204900	25200
Morocco	28	NA
Norway	1200	600
Portugal	360	117
West Germany	1100	NA
Czechoslovakia	286	424
UK	300	100
USA (pillage/mulching + fumigation)	NA	18000

Mulching of potato using plastics film for better growth and easy harvesting.

It has been observed that mulch has developed in countries:

a Where there are problems of water storage (Israel, West of the USA, South-East of France.)

b When it is necessary to slightly heat the soil in order to start growth (Japan, France, Spain, North and Central Italy)

c When problems of weeding, because of rainfall becomes significant (Japan, France, North and Central Italy, Louisiana in the USA.)

d Mulching being mechanised, the highly industrialised countries or those short of labour have adopted it by priority.

e All the countries having at the same time a plastics industry and an active agricultural policy.

On the contrary, where there is a risk of excess water in soil (UK), mulch is practically non-existent but drainage is highly developed as in the case of UK.

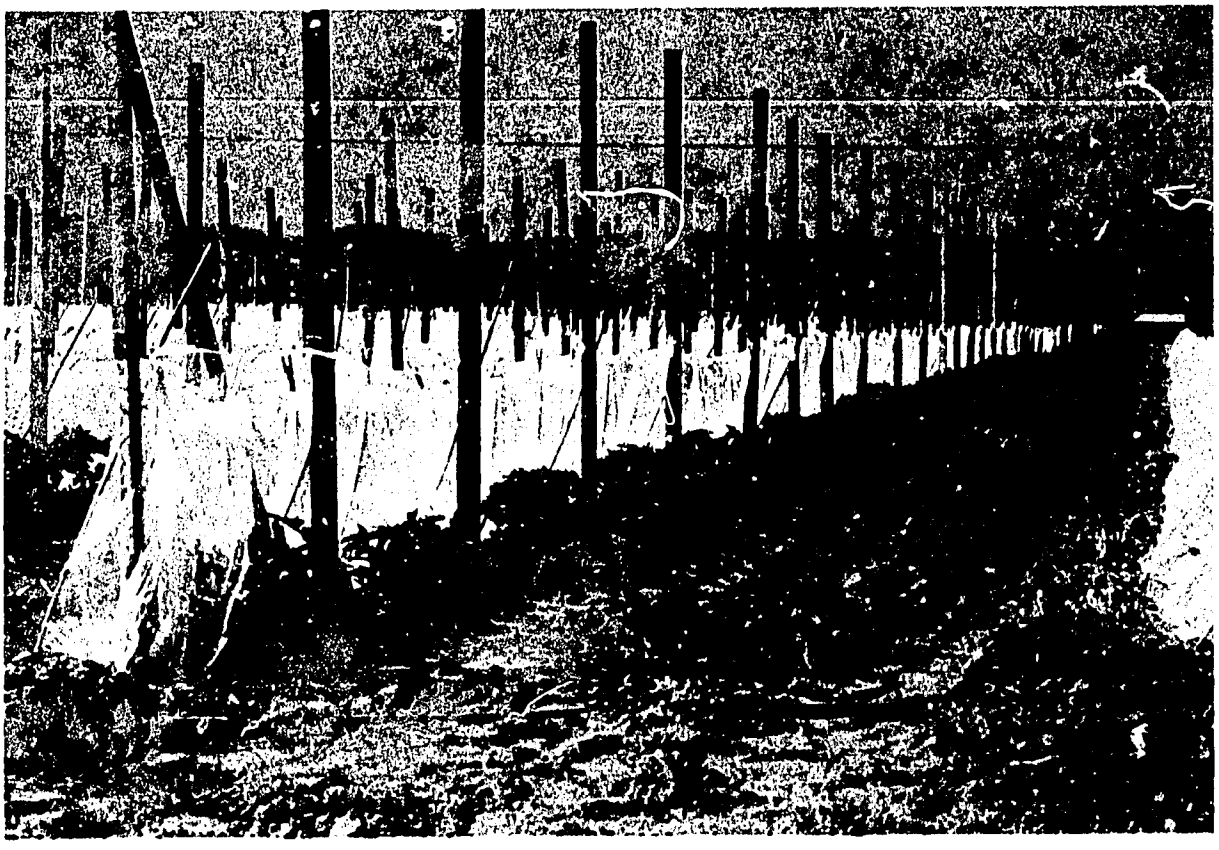
Table-4

Semi-Forcing (Low Tunnels) in Different Countries in 1976

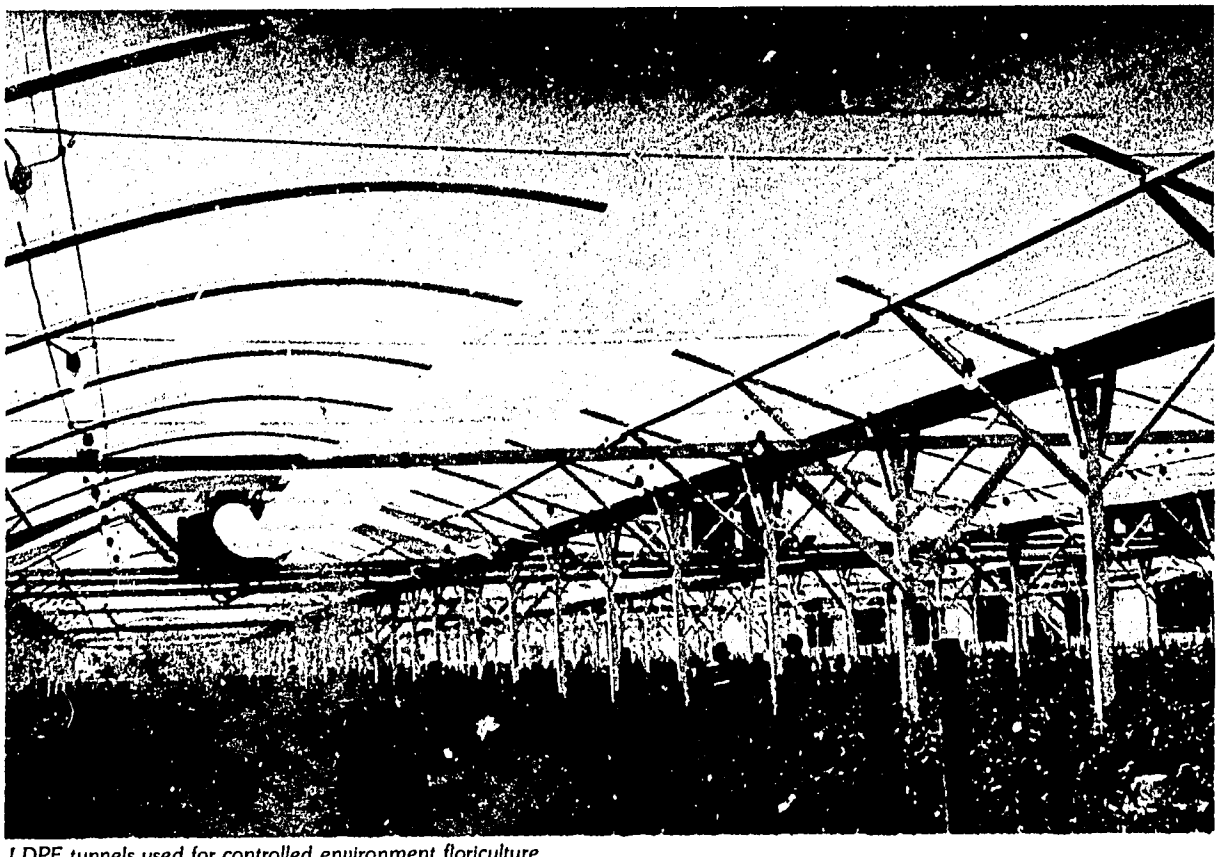
	ha	Tonnage (T)
Argentina	600	400
Belgium	550	NA
Spain	3500	1800
Finland	10	5
France	11000	7000
Hungary	500	1000
Italy	10000	8500
Japan	NA	27900
Norway	300	150
Portugal	50	30
West Germany	1135	NA
Czechoslovakia	195	233
UK	1000	700
USA		4000

As regards development of low tunnels the observations are:

- low tunnels are used in nearly all countries
- the countries in the mediterranean basin are the largest users of low tunnels
- low tunnels are little used in the countries where labour is expensive (USA)
- climatic conditions are not too favourable (UK)
- the climate allows the production in the open all the year in some place or other of early crops and these can be transported over the whole country (USA).



Protection of cucumber plants using LDPE film against cold wind.



LDPE tunnels used for controlled environment floriculture

Table-5 **Green-houses and plastics covered Structures in 1976**

	ha	Tonnage (T)
Argentina	500	1000
Belgium	235	N.A.
Spain	5800	10250
Finland	120	125
France	2300	5000
Hungary	1500	5000
Italy	17000	51000
Japan	16000	45800
Morocco	48	N.A.
Portugal	400	1000
Norway	22	60
West Germany	400	N.A.
Sweden	10	N.A.
Czechoslovakia	275	418
UK	900	1800
USA	3000-4000	10000

NA = Not available.

Green-houses and covered structures are being utilised in some of the middle-east countries where desalinised sea water is being used for irrigation purpose.

During 1963 to1973, the consumption of plastics in agricultural applications in 16 countries had increased by a factor of about 8 and this corresponds to a little more than 23% growth rate.

It is predicted that an average annual growth rate of 12 to 13% is not over optimistic which would work out to a total of 2,600,000 tonnes of plastics used in the agricultural sector the world over by 1983-84.

Israel and Japan are far ahead of others in their use of plastics in agriculture and horticulture.

The details of plasticulture development in some of the developing countries (China, Cyprus, Egypt, Jordan) are put up at Annexure-5 to 8.

Plastics crates used for packaging, transportation and display of fruits and vegetables.

International Committee on the Use of Plastics in Agriculture

France has taken the lead in plasticulture innovations and systematic development of this science for increasing agricultural productivity of that country. For propagation of the important plasticulture applications, a National Committee was formed in France which was the first of its kind in the world. By virtue of this lead provided by France, the other countries which have followed similar patterns and formed National Committees have conferred on the French National Committee the responsibility of providing the secretariat of the International Committee on the Use of Plastics in Agriculture (Comite International des Plastiques en Agriculture -CIPA).

The CIPA was formed in 1964 with the aim of helping the National Committees in the organisation of an International Symposium every two years and in a general way help maintain direct contact between all the research workers and plastics industry in all the countries.

So far, eight International symposia have been organised:

Year	Place	Number of countries participating
1964	Avignon (France)	13
1966	Pisa (Italy)	16
1968	Barcelona (Spain)	17
1970	Paris (France)	29
1972	Budapest (Hungary)	33
1974	Buenoz Aires (Argentina)	More than 40
1977	San Diego (USA)	NA
1980	Lisbon (Spain)	35

The next international symposium is proposed to be held in Mexico during 1983.

The International Committee also brings out a quarterly review captioned 'Plasticulture' which is published in French/English and recently Spanish also has been added. This bullettin helps maintain contact between all the National Committees as well as persons and organisations involved in plasticulture activities all over the world. The bulletin also contains statistics of plasticulture development which provides useful information to the respective countries in following their own course of development in the use of plastics in agriculture, horticulture and related areas.

The National Committees of different countries which are members of the CIPA are:

Argentina, Spain, France, Hungary, Italy, Japan, Portugal, UK, and USA.

Steps are being taken for membership of Indian National Committee of CIPA. Initially it has been decided that IPCL would become a member of CIPA and all the literatures and technical journals obtained by IPCL would be used by the National Committee for its reference and use.

The National Committees formed in all the developed countries operate on a permanent basis and their office bearers are changed, if necessary, from time to time. The permanence of the Committee offers long term involvement of the Committee in promoting plasticulture applications. Since the agricultural applications require intensive developmental efforts and also require change/alternation of strategy on the basis of feed back received from the end users as well as intermediate organisations, it is necessary that a body like the National Committee should be established on a long term basis for effective coordination and implementation. It is, therefore, proposed that the Indian National Committee should be given the status of a permanent body which would have its own secretariat and establishment for independent functioning. The Plastriculture Development Centres proposed later in the report could also be brought under the purview of the National Committee, so that it would have an executing/implementing machinery under its control for taking up developmental and extension work. The budgetary needs of the Committee could be provided by the Department of Petroleum or the public sector plastics industry and Oil Industry Development Board. The facilities provided for sound working of the National Committee would go a long way in fast development of Plasticulture applications in the country and in gearing up the industry as well as end users in putting this valuable raw material to productive purposes in the core sector of our economy.

The National Committee also should participate in the International Plasticulture Congress organised by CIPA from time to time.

Though our country lags far behind the developed countries in putting plastics into productive purposes in the agricultural sector, our contribution in the field of canal lining and outdoor warehousing (CAP) is significant. It is time that a systematic policy is evolved for inducing the cultivators in our country to go in for increased usage of plastics for increasing the quality and quantity of agricultural produce. Systematic adoption of these modern proven practices would help us produce agricultural products which can be export worthy and can bring in significant foreign exchange.

In the following chapter we have tried to present the status of all the agricultural applications of plastics which have been tried in the country and action areas have been identified so that these applications are expeditiously adopted on a commercial scale.

CHAPTER 8

Status of Plastic Applications in the Agricultural Sector in India

The status of plasticulture applications which have been tried in India either at experimental level or have been used commercially at field level have been discussed in this Chapter. An attempt has also been made to analyse the bottlenecks faced in the propagation of the applications and suggestions have been offered for faster adoption of these applications all over the country.

Pond/Reservoir Lining

The cycle of water begins with the rainfall and ends in evaporation and flow back to the sea. One must utilise the water to the maximum when it is on the land during the course of this cycle. This is of special significance to India where almost the entire annual precipitation is concentrated within some 3 to 4 months of the year. The reservoirs and ponds are a place to store the water to be used for various domestic, agricultural and industrial purposes over a long period of time.

In the areas of acute shortage of water, ponds and reservoirs some times form the only source of water for domestic, live-stock and agricultural use. However, a major portion of the water stored in these reservoirs is rendered useless by evaporation, seepage and percolation. These reservoirs are located in a variety of soil types which exhibit a wide range of seepage characteristics. The table below gives the seepage, which can occur in different types of soil:

Table-6

Type of soil	Water loss through seepage-Cusecs/ million Sq. Ft. of Wetted area
Heavy clay loam	4.00
Medium clay loam	6.50
Silty clay loam	9.50
Sandy loam	17.00
Loose sandy soil	20.00
Porous Gravelly soil	35.00

Reservoirs and ponds located in these soil types would exhibit drop in water depth as shown below:

Table-7

Type of soil	Drop in depth per day in cm
Heavy clay loam	10.36
Medium clay loam	16.84
Silty clay loam	24.61
Sandy loam	44.03
Loose sandy soil	51.80
Porous gravelly soil	90.65

For example, a tank having 4 metre depth of water located in a heavy clay loam soil area would totally get exhausted within 40 days and in case it is located in porous gravelly soil, in a matter of 5 days the tank would be empty. However, over a period of time the silt deposit helps in partially clogging the pores in the sides and beds of tank which helps in reducing the seepage losses. In water scarcity areas, the loss of water due to seepage means unending agony for the rural folk. Therefore, means must be found to minimise the seepage losses.

Bentonite clay as well as other clayey non-porous materials could be spread in the bed and sides of water tanks and reservoirs for preventing seepage losses. Though use of such materials helps in seepage prevention to some extent, the rural folks do not have a choice as other conventional materials such as brick lining and concrete lining are too expensive. Plastics film lining, when suitably used, can provide an answer to prevention of seepage losses. LDPE and PVC film linings have been successfully used in our country in the lining of small, medium as well as large size reservoirs.

LDPE and PVC film lining materials are both economical and easy to use. When properly handled, these film linings can have reasonably long and useful life. As per a report received from USSR, LDPE film lining lasts for more than 30 years during which initial investment is paid off several times over. There are several modes of lining which can be used with LDPE and PVC film, and depending upon the topographical conditions, suitable lining modes can be adopted. The sides as well as bed of the reservoirs/ponds could be lined with LDPE/PVC film. Depending on site conditions, the thickness of film to be used is determined. In our country, only 400 to 600 gauge LDPE film has been used for lining purpose. In certain cases where the pond is used for effluent storage, two layers of 400 gauge LDPE film have been deployed. As per specifications laid by American Society of Agricultural Engineers and reports received from USA and USSR, the film thickness ranges from 800 gauge to 1000 gauge. Use of higher gauge film is recommended in case of rough terrain and if safe handling of film cannot be assured.

Method of Lining Ponds with LDPE film

When the excavation of the pond is complete, the bed as well as sides of the pond have to be levelled and prepared for laying the film. Any rocks, large stones or other projections which might damage the film should be removed from the bed and sides of the excavated pond. The unevenness of the surface to be lined is to be removed either by cutting or filling up. It is important that the bed as well as sloping sides of the pond are well compacted. In case of ponds where soil removed from excavation has been used for preparing the embankments, the side slopes should be particularly well consolidated.

On very flinty or stony soils, around 25 to 50 mm of fine sand should be spread over the area on which LDPE film lining is to be laid.

The side slopes to be lined with LDPE film must be gentle enough to allow covering layer of sand, gravel or soil placed on top of it to remain in position (the slope depends on the angle of repose of the material used as cover). It is, therefore, recommendd that a wall slope of 3 or preferably 3.5 horizontal to 1 vertical is used.

The success of any pond or reservoir lining depends on the careful installation and joining of the polyethylene film. It has been observed that in windy conditions, laying of the film becomes difficult. It is, therefore, advisable to choose conditions as free of wind as possible.

At the beginning, the LDPE film is conventionally secured in the trench (Figure-1) at or just above the intended top water level of the pond. The LDPE film cound be kept in place by the use of plastics bags filled with sand or soil.

Adjacent lengths of the film are heat sealed. After completion, careful inspection should be made to see that nowhere the film is exposed. Such ponds should ideally be fenced to prevent farm animals from damaging the film. In termite infested regions, it is necessary to reduce the amount of organic materials in and around the edges of the pond so as to prevent damage to the lining material by termites.

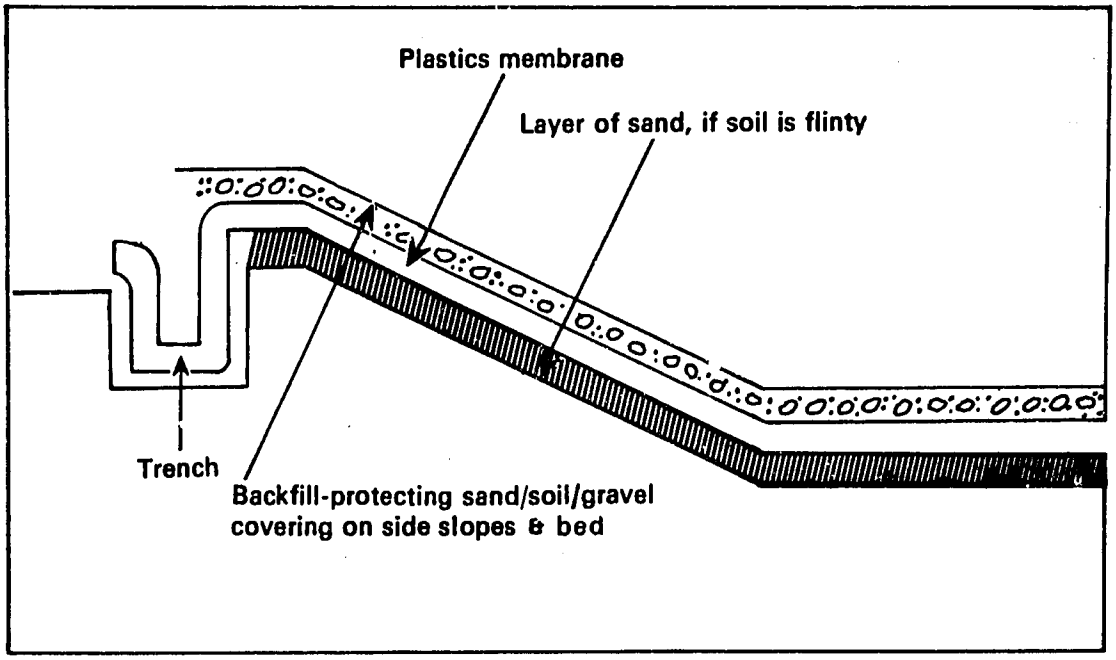


Fig. 1 Cross section of LDPE lined reservoir showing trench.

Pond lining with plastics film-pesticide/weedicide slurry treatment application as measure against pest and weed damage.

Weed growth can be eliminated by the timely application of suitable weedicide. It is also advisable to use suitable weedicides on the subgrade on which the film is to be laid. The selection of such weedicides has to be carefully done so that these do not have adverse effect on the stored water.

Lining of water harvesting ponds, village water tanks as well as irrigation water storage tanks could be taken up under the various schemes envisaged under the sixth plan, such as Drought Prone Area Programme, Integrated Rural Development Programme and Desert Development Programme.

Pond lining with plastics film: bed lining in operation.

The outlay under IRDP during the plan period 1980-85 will be Rs. 750 crores followed by DPAP under which Rs. 350 crores would be allotted for 557 blocks spread over 74 districts. The outlay for the Desert Development Programme will be Rs. 50 crores in the central sector with similar provision in the state plans. A large portion of these allocations are meant for storage and utilisation of water, and it is advisable to make use of the technology for the use of plastics, to achieve maximum results.

The plastics film lining should not be used as an exposed membrane lining, as these films deteriorate rapidly when exposed to sun light. Besides, mechanical damage would be more if these are exposed. Usually dry pitching or soil overlay would serve the purpose of protection of the film. However, the availability of suitable overlay in the locality where the tank is located should be studied so that the most economic method of lining could be adopted.

Recently, a 94 acre reservoir used for raw water storage has been successfully lined with 600 gauge (150 micron) thick LDPE film in Bhatinda (Punjab). The Public Health Engineering Department at Bikaner (Rajasthan) are also getting lined a large size reservoir with LDPE film. This reservoir would be used for storing water for supply to the Bikaner City.

Presented below is an extract from a technical report received from USSR on a large scale adoption of LDPE film for reservoir lining:

"Six basins and reservoirs of a capacity of 100 thousands up to 90 million m^3 and water pressure over the film cover from 5 to 20 m were covered by polymer films partially or completely in Armenia during the years 1962-1971 Most of the reservoirs were covered with a polyethylene film only in individual sections of the bottom where increased filtration of water or subsided soils are observed. Daily observations on the state of the film coverings shows that for the polymer film, laid on the rolled surface of the earth and filled by a soil of a thickness not less than 25 cm, no rodents, plants nor mechanical actions proved to be dangerous. At the present moment plans for the building of six basins (of a total capacity of more than one million m^3) with a film antifiltration covering at the bottom of dams of a total area of more than 25 hectares have been approved. The height of the dams is 14-16 m.

In October 1971 in the settlement of Bakten (Osh region, Kirgiz Soviet Socialist Republic) an All-Union School of advanced methods of working on the arrangement of anti-filtration screens of polyethylene films was started. This place was selected in view of the building here of a largest in the world of polyethylene film in the Tortgul reservoir with a water table of 657 hectares.

The participants of the school were selected and familiarised about this in the factory and at the place of construction with the whole complex of the technological processes on the arrangement of the polyethylene screen in the Tortgul reservoir. Reservoirs of a capacity of 90 million $m^3$are formed by two earth dams and spurs of the Turkestan range. The soils of the bottom and borders of its basin are characterised by a high permeability. Without the screen, the constant mean several year losses in filtration are of the order of 25.7 million m^3 of water per year (more than third of the useful volume) with the arrangement of a usual screen of 0.7 - 13 m thickness, and in the case of a film screen in face the losses arise only because of the filtration of water through the body of the dam, viz. 5.3 million m^3. The advisability of the film screen is thus evident.

The order of arrangement of the screen on the three geologically characteristic sections of the reservoir is as follows. In the central part of the depression of an area of 206 hectares folded by loams by without inclusions, a 40 cm thick soil layer is sliced off, the foundation surface is smoothed; it is smoothed off by motor driven rollers upto a density of 1.5 to 1.6 g/cm^3 (at a depth of 10-15 cm), and is covered by the film and filled up by the very same soil. In the second and third zones (area of 452 hectares) where the borders of the reservoir basin are mixed with rubble layers, the film is laid primarily on the 10 cm thick loamy layer. The treatment of the foundation by herbicides before the laying of the film is carried out only in the first zone where vegetation exists.

The thickness of the film (0.2 mm) depends on the working conditions, though according to calculations, it should not exceed 50 microns. The film is welded by impulse runners both under the plant and field conditions. In the plant, the film is welded width-wise with an area of not less than 0.5 hectares each (26 x 200 m) and with a weight of one ton and it is transported to the place of laying on a special platform by a tractor. Altogether, for shielding 657 hectares (making 10% allowance for overlapping, buttwelding and wavy laying), 1342 tons of stabilised film with a specific weight of 0.922 $g/cm^3$is required. The estimated cost of 1 m^2 of the surface of polyethylene anti-filtration mechanism is on an average 0.72 rouble for the three shielding zones."*

The reports received from other countries also have been encouraging. The development is Spain in the plastics lining for reservoirs and ponds is presented below:

Source: 1. "Dressing" of the Main Karshin Canal

2. Laying out of antiseepage shieldings prepared from films by Zimenko V. Subarv A.S. & M.L. Smushkevich

Hydrotechnology and Amelioration No. 7 1971 47-51

Spanish Development:

Because of the water requirements in the country, more and more reservoirs have been constructed each year. It is reported that polyethylene and butyl rubber are used to render these reservoirs seepage proof. The number of reservoirs and capacity of reservoirs lined with plastics sheets in Spain are given in the following table:

Table-8

Material used for lining	Number of reservoirs	Average capacity in cubic metres	Total capacity (Milion cubic metres)
Polyethylene	650	18,500	12.2
PVC	50	6,000	0.3

* Source: 1 "Dressing" of the Main Karshin Canal
2 Laying out of antiseepage shieldings prepared from films by Zimenko V. Subarv A.S. & M.L. Smushkevich
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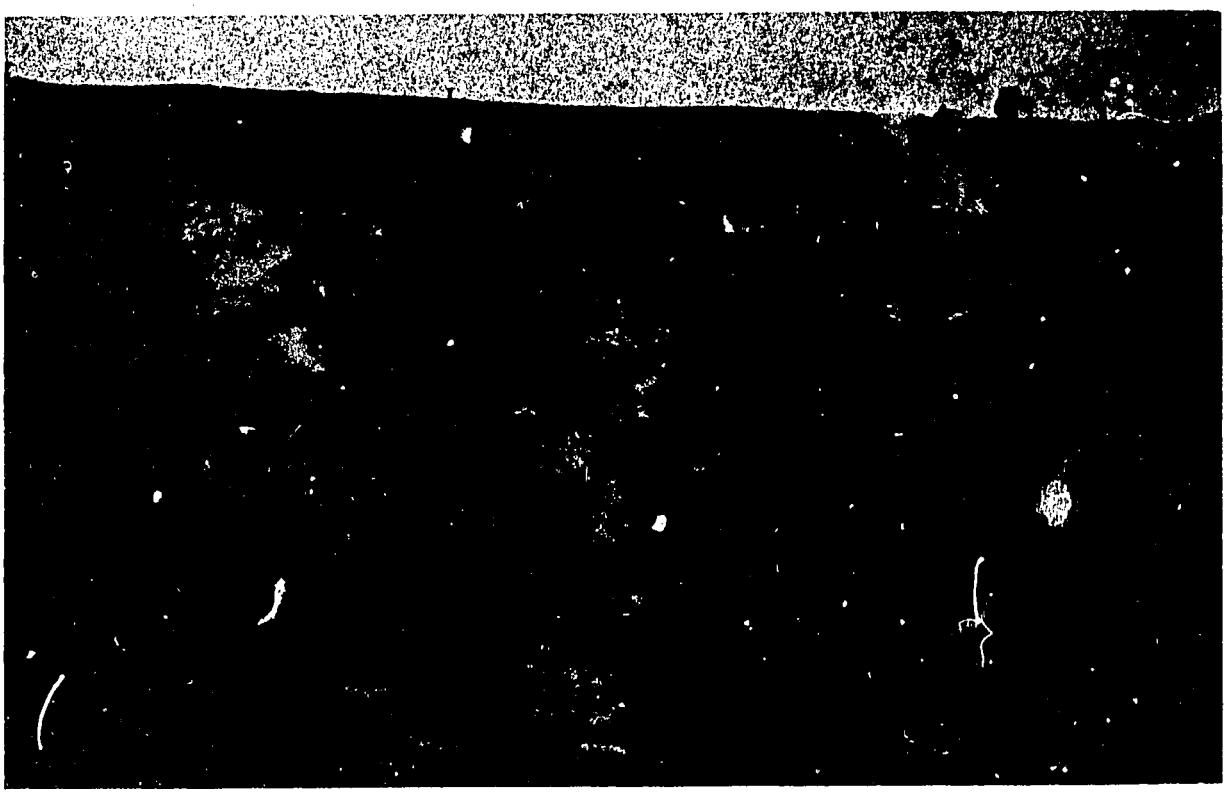
These figures indicate a probable capacity of the order of 15 million cubic metres for all the water reservoirs lined with plastics film.

Listed below are some of the major projects were LDPE film has been used for lining of reservoirs and ponds in our country.

Name of the Project	Purpose of Lining
1 Gujarat State Fertilisers Corporation, Baroda	Raw-water storage reservoir
2 Hindustan Salts Ltd., Kharagoda	Bittern storage reservoir
3 Madangiri Salt works, Karwar	Salt Crystalizer
4 Guru Nanak Dev Thermal Power Plant, Bhatinda, Punjab	Raw-water storage reservoir
5 Indian Farmers & Fertilizers Cooperative Ltd., Kallol	Lining of effluent lagoon
6 Gujarat State Fertilisers Corporation, Baroda	Chalk pond lining
7 EMEM, Baroda	Defence Tank Testing Pond lining
8 Union Carbide (I) Bhopal	Effluent pond lining
9 Central Arid Zone Research Instt. Jodhpur	Water harvesting pond lining
10 Punjab Agricultural University, Ludhiana	Water harvesting pond lining
11 Military Engineering Services, Sri Ganganagar	Water storage

There exists a vast potential for the use of LDPE film for lining of water harvesting ponds as well as catchment areas in our arid, semi-arid and desert areas.



Bed lining of fish pond using LDPE film - Ranchi, Bihar

Though the propagation of lining of ponds and reservoirs with plastics film has already gained considerable importance in the country, yet there are certain areas where developmental efforts are to be taken up in terms of technological improvement as well as extension efforts so that these applications can be rapidly propagated in the needy water scarcity areas of the country.

Technical Development Requirements:

A Development of suitable portable heat sealers for use at site for jointing LDPE films.

B Development of suitable adhesive tapes for jointing of film at site. Although a reputed manufacturer at Bombay has developed a pressure sensitive tape for jointing of LDPE film, the same is to be extensively tested for its effectiveness under submerged conditions before it can be recommended for use.

C Technical manuals for reservoir lining must be suitably developed by the resin manufacturers and wide width film manufacturers in various regional languages for the convenience of the village level bodies.

Side lining of fish pond with LDPE film overlaid with stone masonry - Ranchi, Bihar.

Extension Measures Required:

1 Efforts are required to propagate the use of LDPE for water harvesting ponds in drought prone areas in the country. As an example, the Rajasthan Govt. has shown interest in the lining of ponds in the drought prone areas of Churu Distt. with LDPE film. Immediate site demonstrations should be arranged so that the affected districts of Rajasthan can have the full benefit of LDPE film pond lining.

2 State level sub-committee should take up with State Public Health Departments to promote construction of water storage tanks in cities as well as villages. The State Governments must be asked to fix targets such as initial lining of at least one reservoir per village throughout the state especially in arid and semi-arid zones.

3 Resin manufacturers must produce documentary films and make them available to the village panchayats through extension deptt/public relation departments of the States.

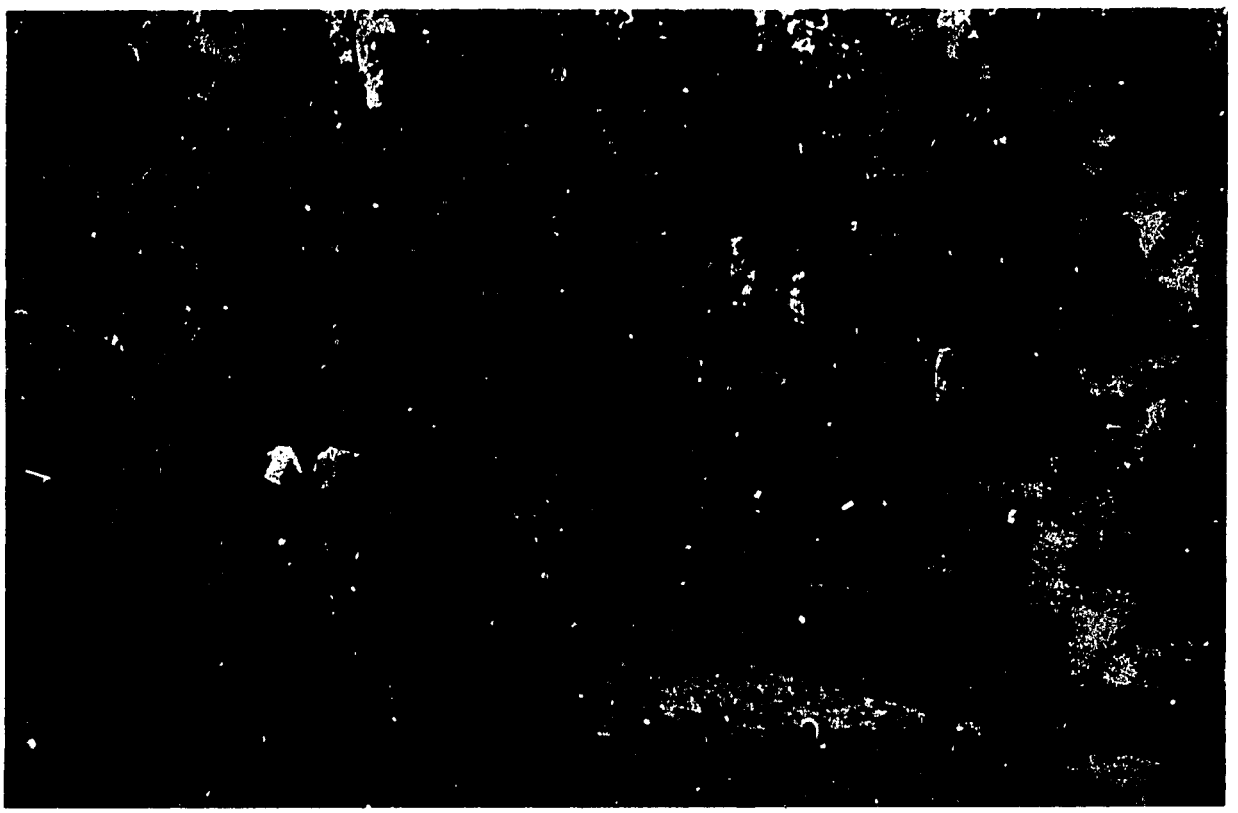
4 TV and radio network can also be used for exposure of the methods of reservoir lining to villagers through programmes based on agriculture.

Canal/Distributary Lining:

It is estimated that 40% of our net irrigated area is covered by canal irrigation. Canals/Distributaries and minors convey irrigation water over a variety of terrains finally to reach the agricultural fields through water courses and field channels. Ten years back there was 17,900 km length of major canals alone distributing water for irrigation purposes.

A study made by Central Water and Power Commission in 1967 reveals that in an unlined canal network, around 71% of the irrigation water is lost in transit from the reservoir to the fields. Of this loss, 15% is attributed to canals, 7% to distributaries, 22% to water course and 27% to field losses. The staggering loss occurs due to seepage and evaporation. Though research is being carried out for preventing evaporative losses, so far no practical and economical method has been developed which can prevent evaporation losses appreciably. However, seepage losses, which contribute to 75% of the total losses, could be effectively minimised by the use of an impervious medium between the porous soil and the water flowing in the system. Conventional lining materials such as clay, tiles and cement concrete have been used for prevention of seepage losses. Most of the conventional methods are either too expensive or not very effective.

Canal Lining work in progress in Kangsabati Project, West Bengal using LDPE film both in bed and sides overlaid with soil cover.



An urgent need to scientifically manage our available water resources cannot be over-emphasised, if we consider that a large portion of the water for irrigation harnessed at a very high cost through a vast network of reservoirs and canals is lost through seepage since most of the major canals, branches, distributaries, water courses and field channels are not provided with suitable lining to prevent seepage losses.

Plastics Film Lining:

Considerable research work is being carried out at various research institutions in India to find an effective and efficient and at the same time, inexpensive mode of lining irrigation system. Irrigation and Power Research Institution, Amritsar, has particularly conducted intensive research in this field and suitable lining techniques have been developed for lining of existing unlined canals and distributaries.

Both LDPE and PVC films are used for lining of water conveyance systems. These linings cannot be used as an exposed membrane and are required to be protected by a hard conventional overlay such as cement concrete, tiles, soil, etc. Some of the advantages of plastics film lining are:-

1 Inert to most of the inorganic acids and chemicals;
2 Highly impermeable to moisture;
3 Retains its physico - chemical properties over a long period of time;
4 Available in large widths and lengths;
5 Can be heat sealed to make impervious joints;
6 Available in desired thickness;
7 Elongation properties are highly favourable against damage due to settlement of underlayer or cracks in the overlayer.

Some methods of LDPE film lining which can be deployed in combination with conventional modes of lining for offering better seepage proof operation are described below:

i LDPE film in combination with Soil Cover

LDPE film can be deployed for lining of the bed as well as sides of water channels overlaid with soil cover. The various methods which can be adopted for this type of lining are shown in Figs 2 and 3. It is advisable that this mode of lining is confined to existing canals where the canal section is hydraulically stable. In this design of the lining work, consideration also must be given to the velocity of flow as it may adversely affect the soil cover. This is one of the cheapest methods of lining channels for seepage proof performance.

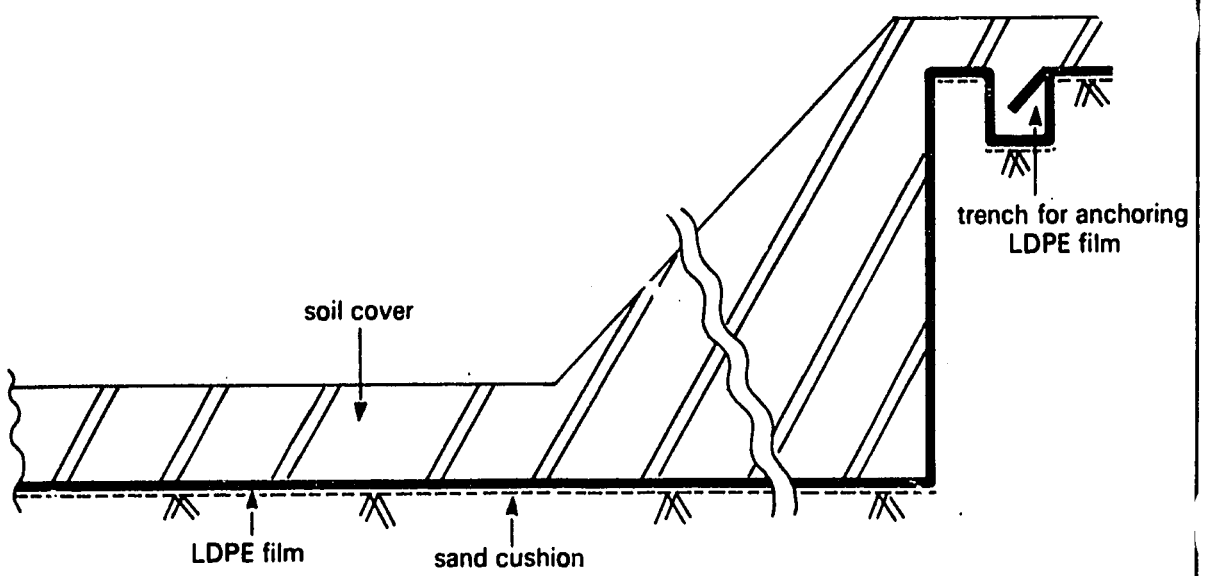


Fig. 2

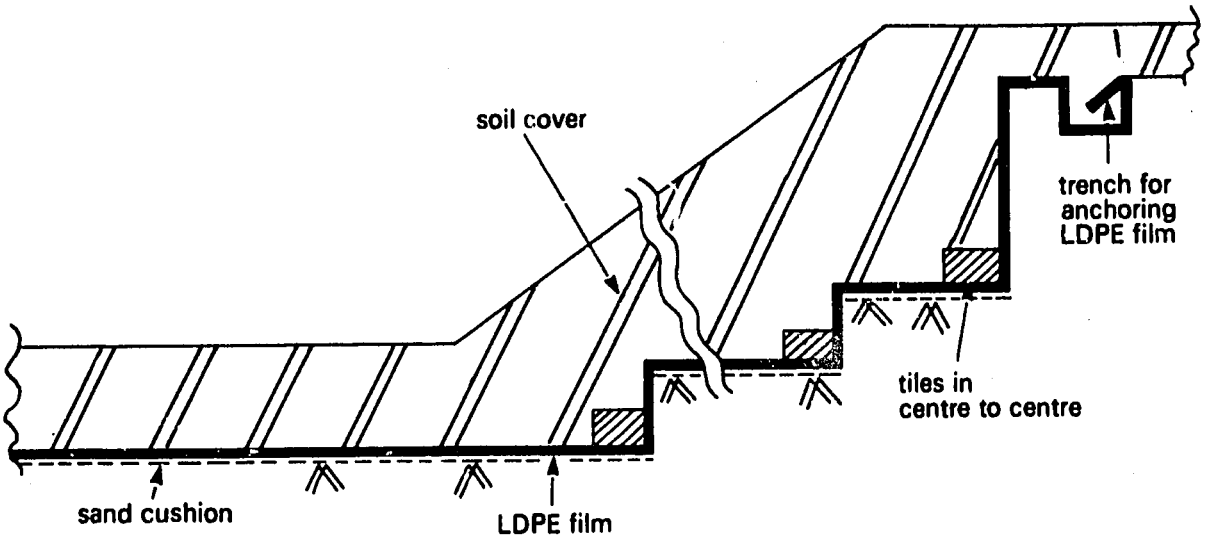


Fig. 3

ii LDPE film in combination with Single Tile Cover (Fig 4)

Lining of canals with LDPE film and single tile cover results in 100% seepage proof operation. As a result, water losses due to cracks which may develop in the single tile lining over a period of time are totally checked by the LDPE film underlay. Being highly elastic, LDPE film can easily take the shape of the single tile cover in case there is expansion or development of cracks on the single tile lining. In the Mahi Irrigation Canal Project, considerable cost saving has been achieved by replacing double tile lining by 400 gauge LDPE film lining overlaid with single tile cover.

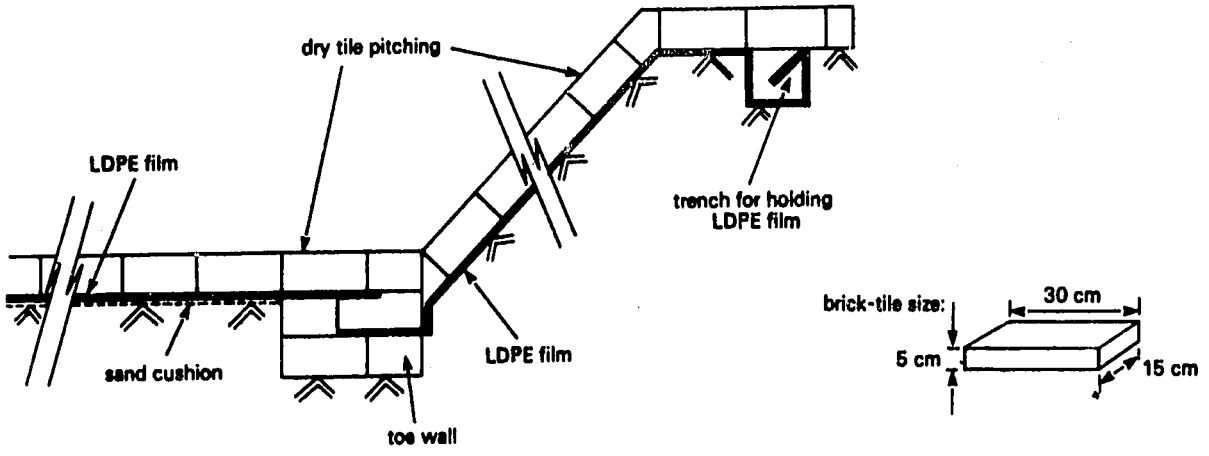


Fig. 4 LDPE film in combination with single tile cover

iii LDPE Film in combination with Double Tile Cover

LDPE film lining can also be deployed alongwith double tile lining to render the canal sections totally seepage proof. Though the cost can increase marginally over ordinary double tile lining, the benefits resulting due to prevention of seepage losses and consequent availability of more water for irrigating greater cropped area would more than offset the marginal cost increase. The method of using LDPE film in double tile combination lining is given in Fig 5.

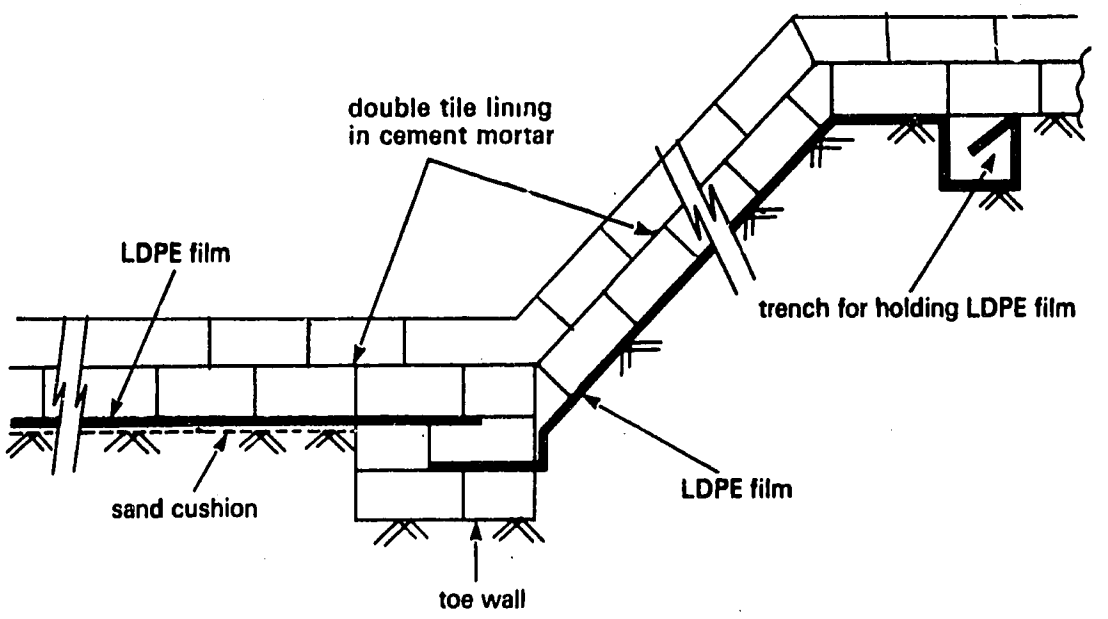


Fig. 5 LDPE film in combination with double tile cover

iv LDPE film in Combination with Cast-in-situ concrete lining:

LDPE film can be deployed for use as a underlayer in combination with cast-in-situ concrete lining and it offers the following advantages:

Use of LDPE film would result in better curing of the cast-in-situ concrete lining as the moisture from the cast-in-situ concrete, would be prevented from seepage into the subgrade thereby facilitating better curing. Over a period of time, the seepage losses which may occur due to development of cracks in the cast-in-situ concrete lining, would be taken care of by the LDPE film underlayer. The thickness of concrete lining also could be reduced thus achieving cost economics. (A report on the curing of concrete using LDPE film is presented at Annexure 10).

v LDPE film lining in combination with Precast Concrete Blocks:

The method of lining canals with LDPE film combination with pre-cast concrete blocks would be the same as that of LDPE film lining in combination with single tile cover and the advantages would also be similar.

Depending on the availability of material in the particular locality where lining work is being undertaken, suitable combination lining could be developed which would offer economy, durability and ease of operation.

In many of the advanced countries, including USA and USSR, LDPE as well as PVC films have been used in a large scale for the lining of canals. In fact, a joint study group comprising of engineers from USA and USSR has been formed for studying the efficacy of plastic films in canal construction. Reports are also available on the change in properties of these linings over a period of their use. Extracts from some of these reports are quoted below:

"It is quite evident that properties of PVC films deteriorate more intensively than those of PE films even with less thickness. It is evident by the deterioration curve that the intensity of the reduction of K_6 and K_E with an increase in the period of exploitation, is reduced. Apparently, the resistance of broken-down surface layer prevents further oxidation of polymer, this also shows a decrease in further destruction....

Taking into consideration the above stated expression we obtained guarantee life of film shieldings : for unstablisied PE of 0.06 mm thickness - not less than 28 years and for plasticised PVC of 0.16 mm thickness -- not less than 16 years. It is apparent that the life of shieldings prepared from stabilised PE will be somewhat more than that of films prepared from unstabilised PE of same thickness."1

"The structure of soil-film lining consists of one layer of 0.2 mm thick polyethylene stabilised film "A" of Soviet State Standard 10354-63 and a one metre thick protective layer of the soil. The use of film at Kulundinsky Artery Canal is based on the experiences gained earlier in its wide use during the design and construction of the biggest in Europe Main Kakhovsky Artery Canal in Ukrainian Soviet Socialist Republic. The experience has shown that soil-film shield is reliable and has relatively low construction cost under Ukrainian conditions. For example, during the period of 1971 to 1975, 2619069 sq.metres of soil-film shield consisting of 0.2 mm thick polyethylene film in two separate layers and a one metre protective soil layer was at Kakhoysky Artery Canal."2

"At present, the main Kakhov canal operates on a stretch of 118 km (planned length 130 km). The canal, excluding the section between pockets 20-220 was shielded by a soil-film covering, consisting of two layers of stabilised polyethylene film of a total thickness of 0.4 mm and of protective soil layer of 1 m. In the zone of wave actions a concrete - film lining was set up; reinforced in situ concrete of a thickness of 16 cm and of width upto 9.5 cm and layed on a polyethylene film. This covering has distributor R-2. The distributor R-5 is lined by an in situ concrete based on the technology of the company "Rakhko".

By comparing the obtained values (excluding the section R-2) with characteristics of film coverings, protected by in-situ concrete and precast reinforced concrete as per instruction V/O of "Soyuzvodpro kt" /1 page 32/ and the instructions of the National Committee of the USSR on irrigation and drainage /2, page 26/, we find that soil-film covering, constructed and operated in the main Kakhov canal, according to thier qualitative indices was not inferior to concrete - film coverings. The cost of 1 m^2 of soil-film covering achieved by the Ukrainian water organisation (Ukrvodstroi) was around one rouble, whereas the cost of 1 m^2 of concrete-film covering exceeds ten roubles."3

Source:

1. Study of the deterioration of polymer film shieldings of water reservoirs, by ALAVERDVAN R A

   Proceedings of the Coordination Conference on Hydraulic Engg. No. 144, "Energiya, Leningrad, 1977, 166-171. (Indian National Scientific Documentation Centre)

2. Experience in the construction and effectiveness of soil-film lining in start-up complex at Kulundinsky Artery canal, by KHDOSHOYANTS EE et al Exprее-Information, Series 5, No. 1, pp 3-11, Moscow 1979.

3. (Indian National Scientific Documentation Centre) Losses of water, efficiency of the soil-film covering and of the efficiency of the Main Kakhov Canal.

   Express-Information, Series 6, No. 5, Moscow 1980, 3-8.

"The effectiveness of film antipermeable device is explained by their low cost, high shielding capability and a possibility of considerable reduction in labour costs and the time required for their construction.

The main techno-economic benefits of the film shields happen to be the following:

1. a small thickness of the antipermeable elements and hence a low material consumption;
2. a high deformation capability of antipermeable structures which leads to undeniable benefits in cases when large and non-uniform deformations in structures are liable to arise;
3. a practically complete absence of the effect of the water nonpermeable element on the static working of the structure;
4. easiness of the carrying out of jobs due to a sharp reduction in the amount of transportation operations;
5. and the elimination of difficult and costly operations (compression of soil, laying and proceedings of concrete mortar etc.);
6. a replacement of operations limiting the time required for raising structures by such operations which require very little time for completion" 4

Pipelines and canals department of Soviet Water Structures in 1972 investigated portions of canal at Tatarbunar and North Crimea Irrigation systems in Turkmenia and Ukraina respectively. Useful properties of the shields and methods for improvement of their design elements were determined.

It is found that the main useful property shield happens to be the long life of film protected by layer of soil. For example, 0.2 mm thick stabilised polyethylene film laid in canal of tatarbunar irrigtion system after 8 years of operation was in a good state and there was no filtration from the canal. And 0.1 mm thick non-stabilised polyvinyl Chloride film at the canal of pumping station No. 4 of the Karakum system was in a satisfactory state. After 10 years of operation and no filtration of water from canal was observed. Shield made of 0.2 mm thick stabilised PE film at the canal which feeds water to the river Kurgab from Karakum canal is existing and satisfactorily working for 6 years.

The above examples and the investigations conducted by All-Union Scientific Research Instt. of Hydrotechnology and Amelioration and Ukrainian Scientific Research Instt. of Hydrotechnology and Amelioration permit us to conclude that the operational life duration of soil shield is not less than 25 to 30 years i.e. it is practically equal to operational life duration of concrete lining of the canals.

An important positive property of soil-film shield is its water-nonpermeability. The measurements of water losses due to filtration from canals with film shields operating for about eight years conducted by the All-Union Scientific Research Instt. of Hydrotechnlogy and Amelioration and the Tajik Scientific Rsch. Instt. of Soil Sciences have shown that water losses were practically equal to zero.

Investigations of shielded field portions of canals have shown that at the canals where one expects a growth of vegetation capable of damaging of the film, the soil in foundation under the film and the protective soil layer must be processed with wee killer herbicides.

The need for using herbicides is determined by the properties of soil and the depth of which the canal is filled.

Thus, for example, the film at the side slopes and zones of shallow water at the canal of pumping station No. 4 of Karakum system was damaged in some place by the roots of cane, hard grass, and tamarisk."5.

Besides USSR, plastics liners have been successfully used in the USA, Canada and several other countries in the lining of canals and reservoirs. Extracts from reports received from the USA on plastics film lining are given below:

"Next in order of use is polyethylene. Eighty miles of canals have been lined on the St. Mary and Milk River Development Project in Canada. Nearly one-quarter million square yards of polyethylene have been used for lining 7½ miles of canals in the vicinity of Delta, Utah."(*)

Source:

4 Effectiveness of the use of polymer films in water supplying construction and perspectives of its improvement

5 Film Shields in canals.
Express-Information, Series 5, No.6, pp-26-33
Moscow, 1975
(Indian National Scientific Documentation Centre)

(*) Flexible Membrane for Water Applications, Lauritzen CW Soil Scientist, Soil and Water Conservation Research Division, USDA, Utah.

"Over the past 20 years, the rapid development of synthetic polymers has made a host of new construction materials available. Through the Cooperation of industry, the Bureau of Reclamations has conducted extensive laboratory and field research on many of these synthetic materials, engineered specifically for use as waterproof membrane linings. This work has led to the development of plastic membrane linings for Canal Constructions.

The Bureau's earliest polyethylene (PE) plastic membrane installation was in 1953 on the Huntley Irrigation Project in Montana. A Polyvinyl Chloride (PVC) lining was first installed in 1957 on the Shoshone irrigation project in Wyoming. Since then, over 5,00,000 square yards of plastics canal lining has been placed on reclamation projects (*)

Developments in India

Use of plastics film lining in India started in 1959 in Doburji Distributary, Punjab. Since then LDPE film lining has been used both at field level and for conducting tests. The results reported so far on LDPE film lining in the country have been encouraging. Some of the lining work taken up in the country since 1959 is presented in the table below.

* US/USSR studies on polymers for Canal Construction, Timblin, LOJr.

Table-9

DETAILS OF CANALS LINED WITH BLACK LDPE FILM IN INDIA

Name of canal & year of lining	Discharge Rate (cusecs)	Type of Soil	Type of lining bed/sides	Remarks
1	2	3	4	5
1 Doburji-1959	79	—	PS/PS	Lining Intact.
2 Jethuwada Distributary-1961	19	—	PS/PS	Film has been found intact and free from damage caused by weed growth and water insects.
3 Hatmati Gujarat-1962	400	Sandy	PB/PB	Lining intact. Film inspected in 1971 and again in 1973 was found in good condition.
4 Resulpur Distributary, Ex-Kasur Branch Punjab-1963	36	Sandy	PS/PS	Experimental lining carried out by IPRI Amritsar.
5 Kasur Branch Lower-1963	784	—	PS/PS	—
6 3R Distributary Ex-Dantiwada L.B Canal Gujarat 1966	129	Sandy	PB/PB	Lining intact. Seepage trials conducted in 1968 & 1970-2.0 causes M.SQ. FT compared to unlined 2' .0 cusecs/M.SQ. FT
7 Tungabhadra L. Bank Canal, Karnataka-67	12	Clayey	PCC/PCT	Lining intact.An experimental lining to prevent sliding/sinking of lining in 'SLUSHY' soil.
8 Colony Minor, Ex. Dantiwada Canal Gujarat-1969	5	Sandy	PB/PB	Lining intact. An experimental lining to prevent sliding/sinking of lining in 'SLUSHY' soil.
			PS/PS	Lining still in operation. Experimental lining of impervious earth for banks carted from 50 miles.

Name of canal & year of lining	Discharge Rate (cusecs)	Type of Soil	Type of lining bed/sides	Remarks
1	2	3	4	5
9 Jullunder Distributory, 1972-73	217	—	PS	Lining is intact.
10 Lambhwel Distributary, Gujarat '69	15	Black	PS/PS	Lining intact. Seepage rate with lining-6.4 cusec compared to unlined 12 cusecs/M.SQ. FT
11 Haren Main Canal Gujarat, 1970	150	PCT/PCT	PS/PS	Experimental lining still intact.
12 Simarda S. Minor Gujarat, 1970	8	Black	PS/PS	Lining still intact seepage losses considerably reduced and breaches in the embankment minimised.
13 Distributory and Minor Mahi Canals Gujarat-1971-72	3-120	Black	PS/PS	Lining provided in embankment reaches (banking 0 to 71) to minimise seepage and prevent breaches.
14 Wansol S.M. Ex. Nadiad Branch Gujarat	5.7	Clayey	PS/PS	Experimental lining still intact.
15 Rania Distributary, Ex. Nadiad Br., Gujarat-1971	5.66	Loessic (Non-Cohesion)	PS/PS	Experimental lining still intact.
16 Nadiad Distributary, Ex. Mahi R.B. Canal, Gujarat '72	3500	Loessic to sandy loam	PB/DT (SW)	Total lining approved 20 kms. further lining on this distributary is awaitig approval.
17 Petlad distributary, Ex-Mahi R.B. Canal, Gujarat '73	2400	Loessic to sandy loam	PB/DT (SW)	Total lining approved 20 kms. further lining on this distributary is awaiting approval.
18 Sunder Sub-Branch Ex-Hansi Br. Haryana-1974	1944	Sandy	PS/DT	Lining completed in 1974.
19 Distributary, Ex-Chambal right Main Canal MP 1974	120	Sandy loam	PS/PS PB/PB	Experimental lining Experimental lining work completed in July 1974.
20 Amaravati Main Canal Tamil Nadu	480	Black Cotton	PCC/PCT	Experimental lining still in operation.
21 Ponnaniar Distributary, TN-1963	53	Black Cotton	PB(P)	Lining completed in '74 cupshaped channel
22 Paranibikulam Main Canal, TN-1974	108	Black Cotton	PCT/PCT	Experimental lining
23 Contour Canal Tamil Nadu-1974	1150	Black	PCT/PCT	Experimental lining
24 Azamgarh Canal UP 1975	400	Sandy	PS/PB	Experimental lining.
25 Kangsabati Canal Div. Jhargam Midnapore (WB)	31 1000	Laterite soil	PS	—
26 Thambaraparani Divn. Tirunelveli-21975-76	445 (Main 380 cusec Branch)	Laterite soil	PB	Film intact

Name of canal & year of lining	Discharge Rate (cusecs)	Type of Soil	Type of lining bed/sides	Remarks
1	2	3	4	5
27 Ponnaniar Reservoir Proj. Manaporal Sub-Divn. Tiruchirapalli Division				
i/Distributary No. 1 1973	30.96 cusecs	Black Cotton	PB	Back pressure problems otherwise OK.
28 ii/Branch distributary 1973	12.53 cusec	Black Cotton	PB	
29 iii/Sub-branch Distt. 1973	6.04 cusecs	Black Cotton	PB	
30 Palkhed Canal lining Divn. L.B. Canal 1981	820 cusecs	**Black Cotton**	PB	Experimental lining completed No seepage observed so far
31 Khadakwasala Canal Divn. Poona 1979	N.A	Rocks cut & porous	NA	Experimental lining
32 Phulewala Minar Canal lining Divn No.3, 1982	13.57 cusecs	—	—	LDPE film lining 1433 ft. long stretch.
33 Teona Distributary, 1981	300 cusecs	Sanday & LO MT	—	LDPE film lining 1000 ft. long stretch.
34 Nawada distributary canal lining Divn. 1, Patiala '81	83 cusecs	Clay & Sandy	—	LDPE film lining 1000 ft. long stretch.
35 Biroke Branch Canal Lining Divn. Patiala	—	—	—	LDPE film lining 1500 ft. long stretch.
Work yet to be done				
Salibura Minor Canal Lining Divn. No. 1, Moga	17	Clay & sandy	—	LDPE film lining to be done shortly.
Biroke Branch Canal lining div. Patiala		There is a plan to line 10,000 stretch of this branch with LDPE film shortly.		
36 Israna Dist. Haryana, 1981	171	Clay	—	1650 ft. experimental lining with LDPE film
37 Jundia Dist. Haryana, 1981	149	LOMI	—	1000 ft. experimental lining with LDPE film
38 Jaifeeder, Haryana, '81	700	—	—	4000 ft. experimental lining with LDPE film
39 Bhaini Bhairon minor, Haryana-1981	11	Sandy	—	15000 ft lining with LDPE film.
40 Sukhpura Minor	243	Sandy	—	7200 ft lining with LDPE film
41 Laharu feeder Haryana, 1981	1400	Sandy	—	3300 ft. lining with LDPE film.

KEY: PLB - LDPE film with single tile without mortar
PS - LDPE film with soil cover
PB - LDPE film with single tile with cement mortar
PB(P) LDPE film with single tile in mortar with pointing
PCT - LDPE film with concrete slabs in cement mortar
PCC - LDPE film with cement concrete in-situ
SB - Conventional single tile in cement mortar
DT (SW) - Conventional double tile sandwich-type lining

Gujarat

In Gujarat, LDPE film lining has been deployed in Mahi Canal Projects. Canals carrying 3,500 cusecs have been lined with LDPE film in this project.

Canal Bed lining in progress in MRBC Project, Anand, Gujarat using LDPE film overlaid with single tile and pointing.

The Mahi project authorities have opted for LDPE film combination lining because of the dual advantages of seepage prevention and cost saving as compared to double tile lining which was being used by the irrigation department earlier. Based on information provided by the Mahi irrigation authorities the cost comparison between LDPE film lining overlaid with single tile and soil cover and double tile sandwich lining is given below:

Table-10 **Comparative costs of various lining methods**

SL. No.	Method of Lining	Cost per sq. mtr. Cost of LDPE film reqd. Rs	Cost of earth work Rs	Total Rs
1	2	3	4	5
1	Double tile lining	—	—	24.00
2	Single tile lining	—	—	10.00
3	LDPE film lining with single title cover:			
	(a) 400 guage (100 microns) thick film	2.30	—	12.30
	(b) 1000 guage (250) microns) thick film	5.75	—	15.75
4	LDPE film lining with 60 cm soil cover:			
	(a) 400 guage (100 micron) thick film	2.30	2.40	4.70
	(b) 1000 guage (250 microns) thick film	5.75	2.40	8.15
5	LDPE film lining with 90 cm soil cover:			
	(a) 400 guage (100 microns) thick film	2.30	3.60	5.90
	(b) 1000 guage (250 microns) thick film	5.75	3.60	9.35

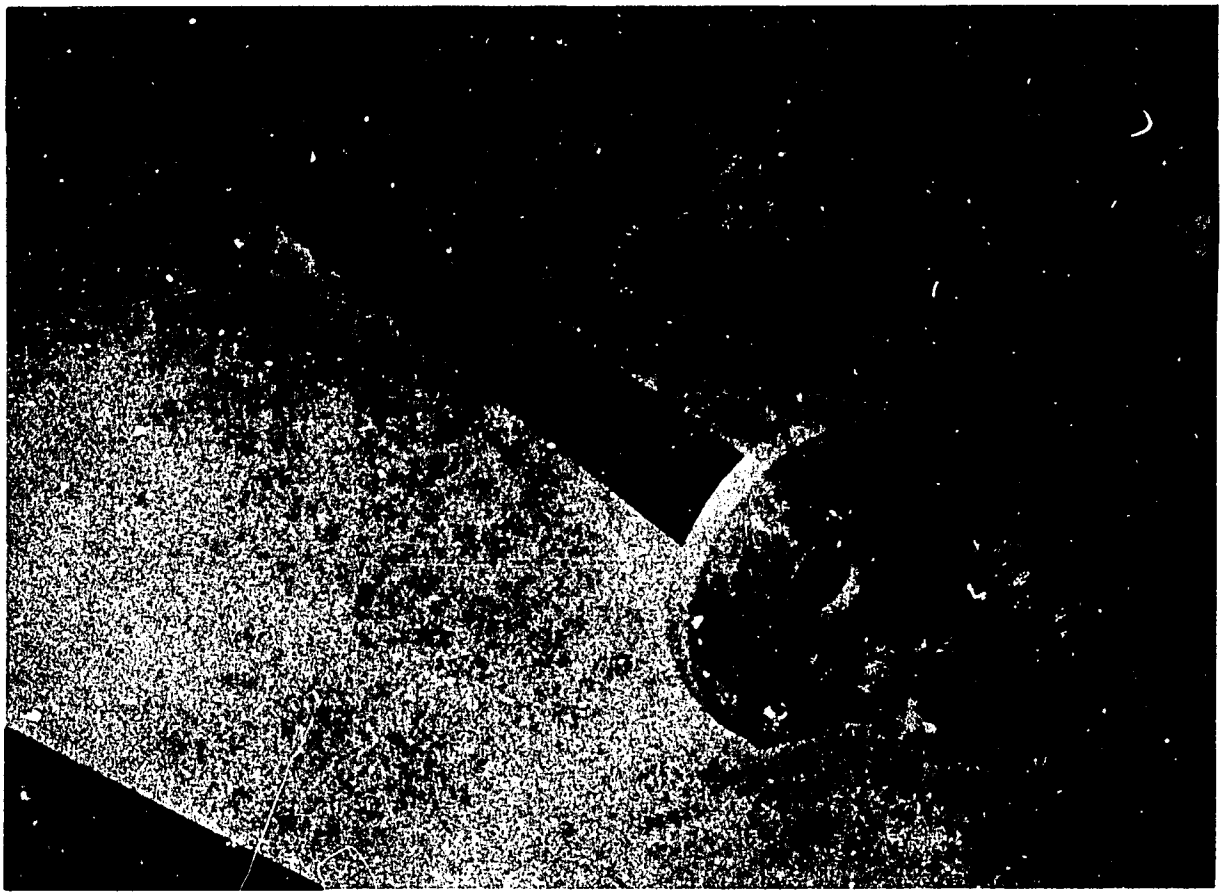
Earth work Rs 4.00 per cubic metre and LDPE film cost Rs 25/- per kg. only.

As could be seen from the above table, there can be 50 to 80 per cent cost saving by adopting LDPE film combination lining overlaid with single tile cover or soil cover. The brief specifications of the materials and works for sandwich type lining and single tile lining with LDPE film are presented at Annexure-13

The Gujarat Government has also accepted LDPE film lining for all their existing as well as future canal lining programmes in principle. A circular issued by Gujarat Govt. Irrigation department to all the World Bank aided projects in the state is placed at Annexure-11. IPCL has taken an extensive application development programme for popularising LDPE film for canal lining and as a result, many State Government Irrigation departments are showing active interest in taking up trial lining of canal stretches with LDPE film. The Narmada Projects authorities as well as Rajasthan Canal authorities are actively considering the deployment of this mode of lining in their canal system.

Punjab

Recently Punjab Irrigation Department has also initiated lining work with LDPE film in the project aided by the World Bank. Experimental lining work has been done in many channels. However, it will be of interest to note that recently Punjab Irrigation department has decided to line one distributary and four minors in each of the six construction circles all over Punjab. This will account for nearly 600 km of lining with LDPE film on experimental basis on the World Bank aided projects in Punjab.



Plastics one-way valve used for protection of canal lining against back pressure.

Haryana

In Haryana, the concept of lining of canals with LDPE film was introduced for the first time when Sunder Sub-Branch near Panipat was lined way back in 1974. Presently, Haryana Irrigation department is engaged in the programme of modernisation of existing canals and distributaries, with the World Bank aid. In their programme of modernistion of canals and distributaries, they have included lining with LDPE film. Due to concept promotional efforts undertaken by IPCL and the film suppliers in the recent past, Haryana Government have recently decided to line initially 6.4 km of Jawahar Lal Nehru feeder canal. It is estimated that this canal will require about 150 MT of LDPE film for lining application.

The National Committee meetings held with the State Government officials of Karnataka, Tamil Nadu, Andhra Pradesh, Punjab, Haryana, and Maharashtra have met with particular success in convincing the State Government Irrigation departments regarding the efficacy of LDPE film lining. Details of recent tenders floated by Irrigation department of Madhya Pradesh and Gujarat are at Annexure-12.

LDPE film canal lining should be given top priority in the extension programme because of the following reasons:

a LDPE film has been successfully used in the country for more than two decades. We had got technical know-how for LDPE film lining in a wide range of terrains and soil conditions. In a recent UNIDO Conference at Alexandria, it was opined by an international audience that LDPE film lining has been used for maximum advantage in India and engineers in Egypt are planning to visit India for observing LDPE film canal lining.

b Sufficient international data is also available indicating the long life of this mode of lining and its benefits in terms of seepage prevention.

c Use of LDPE film under cast-in-situ concrete lining has the possibility of increasing the strength of the concrete lining itself because of better curing achieved. This may result in reduction of concrete section thickness which would reduce cement consumption.
In case of LDPE film lining overlaid with single tile cover instead of double tile lining there is straight saving in cement as well as bricks.

d The Government of India has granted permission to several firms for the production of wide width LDPE film in the country. As a result, several firms have put up modern processing units which are capable of producing heavy duty LDPE film in very wide width suitable for the lining of canals with minimum of joints. This ensures free availability of LDPE film for lining applications.

LDPE resin manufacturers, such as Indian Petrochemicls Corporation Limited and Union Carbide (India) Limited have done considerable work in the propagation of this application all over the country. IPCL has produced documentary films and audiovisuals for exhibition to irrigation authorities. They have also published a detailed technical manual on the lining of canals and reservoirs which, it is understood, has received world wide acclaim. IPCL has also supplied substantial quantities of LDPE and heavy duty LDPE film free of cost to interested irrigation departments for trial purposes. To offer a complete package to the irrigation authorities a self adhesive tape has been developed which could be used at site for jointing LDPE film.

We understand that several state government irrigation departments opting for LDPE film lining have faced difficulty in specifying standards for LDPE film procurement. The selection of lining material depends upon parameters such as, economy, stability, durability, hydraulic efficiency, rugosity, minimum seepage and maintenance cost. Some of the relevant Indian Standards which could be considered are:

IS 5690 - 1969 Guide for laying combination lining for existing unlined canals.

This recommends 150 micron (min) thickness and 3 metre minimum width LDPE film for a combination lining for lining of stable reaches of existing unlined canals, of bed width greater than 2.5 metre, during their closure periods. This method is considered suitable in area where sub-oil water level is lower than the bed level of the canal and/or where the sub-soil is self-draining. It also recommends antiweed treatment of the sub-grade before lining.

The IS 9698 - 1980 Code of practice for lining of canals with LDPE film lays down the standard practice for lining of small canals with a discharge of upto 10 cumecs (355 cusecs) with 100 micron minimum thickness and minimum 5 m width LDPE film, with a protective cover.

The IS 2508 - 1977 (Revised) deals with LDPE film specifications and is under further revision for revising the impact strength specifications.

In the meantime, the draft recommendations are being communicated to the interested irrigation departments so that they can float tenders on the basis of the recommended specifications till the ISI standards are finalised. The American Society of Agricultural Engineers also have got certain standards for plastics membrane lining which is put up at Annexure-14

Though LDPE film canal and distributary lining is highly developed in our country, it is necessary that modifiction and developments are immediately taken up for quick propagation of the application in all the States. Following are the Committee's recommendations for promotion of this application by the resin manufacturers, state level committees, Government departments and other related agencies:

a ISI should finalise the standards for LDPE film used for canal lining;
b The resin manufacturers as well as leading film processors should develop suitable portable heat sealers and adhesive tapes for joining of LDPE film at site'
c Deputation of irrigation engineers to canal sites where LDPE film lining has been undertaken or is in progress, should be considered by the State Irrigation Departments;
d The State Irrigation Departments should appoint committees consisting of 3 or 4 chief engineers for evaluating LDPE film lining to be used in various irrigation projects, and lay down procedures for its usage.

Watercourse Lining:

In canal irrigation as well as irrigation through tubewells or ponds the irrigation water reaches the plant in its final lap through watercourses or field channels. These channels are generally small earthen channels running along the borders of fields. The bed width is as small as 30 cm with similar depth of water flowing in the channels. In case of tubewells, sometimes these channels are lined with brick and mortar. As indicated earlier, the loss due to seepage and evaporation which can occur in the watercourses/field channels can be staggeringly high.

In canal irrigation system, the irrigation departments maintain the canals, distributaries, minors and sub-minors. The water courses fall under the purview of the cultivator. The irrigation tariff system being based on area irrigated, the cultivator find hardly any need to conserve water during its conveyance. Recently, in some States, even the field channels are being tackled by the irrigtion authorities under their Command Area Development Programme.

The West Bengal CADA has shown considerable interest in lining of watercourses with LDPE film and watercourse lining has been taken up in West Bengal in the following projects:

i Pilot Projects of CADA, Kangsabati.
ii Pilot Project CADA, Mayurakshi.
iii Comprehensive, Area Development Corp.
- Baidyapur Project
- West Dinajpur
- Bainchi

iv Vishwa Bharati, Bolepur

The reports from these projects so far have been satisfactory. The CADA of Rajasthan as well as several other states are also showing interest in plastics film lining. The Andhra Pradesh Agriculture University, Hyderabad, as well as Mahatma Phule Krishi Vidyapeeth, Pune, are taking up intensive research programmes for evaluating LDPE film water course lining with suitable overlays. Use of LDPE film in conjunction with brick tile lining or, in some cases soil cover, would result in definite prevention of seepage losses.

It has been reported that in case there is heavy penetration of weeds, the weed stems plug the hole which again resists leakage through the punctured spots by itself. In case of brick lining, there are possibilities of cracks developing in the brick lining which may result in loss of water due to leakage. The use of LDPE film along with brick tiles would prevent such losses eventhough cracks may develop in the brick lining.

Following are the recommendations of the National Committee for further development on the lining of water courses with LDPE film and extension measures to be adopted for propagating this application in the rural areas:

a Field level data on durability of the LDPE film used in water course lining and cost benefit analysis - to be generated by agricultural universities as well as CADA authorities.
b The LDPE resin manufacturers as well as heavy duty film processors should bring out easy-to-follow do it yourself literatures which should be printed in regional languages for its propagation at grass root level.
c Documentary films and audiovisuals should be prepared by resin manufacturers/processors describing method of lining water courses with

LDPE film which can be exhibited by the Stateowned extension agencies and also could be included in the Doordarshan (TV) programme for farmers.

d The Agro Industries Corporations should patronise reliable processors from whom LDPE heavy duty film can be obtained by them for marketing through the agro service centre network, so that LDPE film suitable for water course lining is made available to the cultivator at his doorstep. The resin manufacturers should help the agro industries corporations in the selection of such processors so that quality material is made available to the agro industries corporations for distribution through the agro service network.

Lay-flat Tubings

Irrigation water from tubewells and pumps is conveyed to the point of use through earthern channels. Appreciable amount of water is wasted due to seepage through the channel's bed and sides. This also creates high concentration of moisture in the side of the channels which after long use leads to increased salinity of the soil. The conveyance efficiency of these channels could be improved by the use of suitable lining which can effectively check the seepage loss. Conventionally, bricks, tiles and concrete are used for lining the channels. All these methods have certain disadvantages:

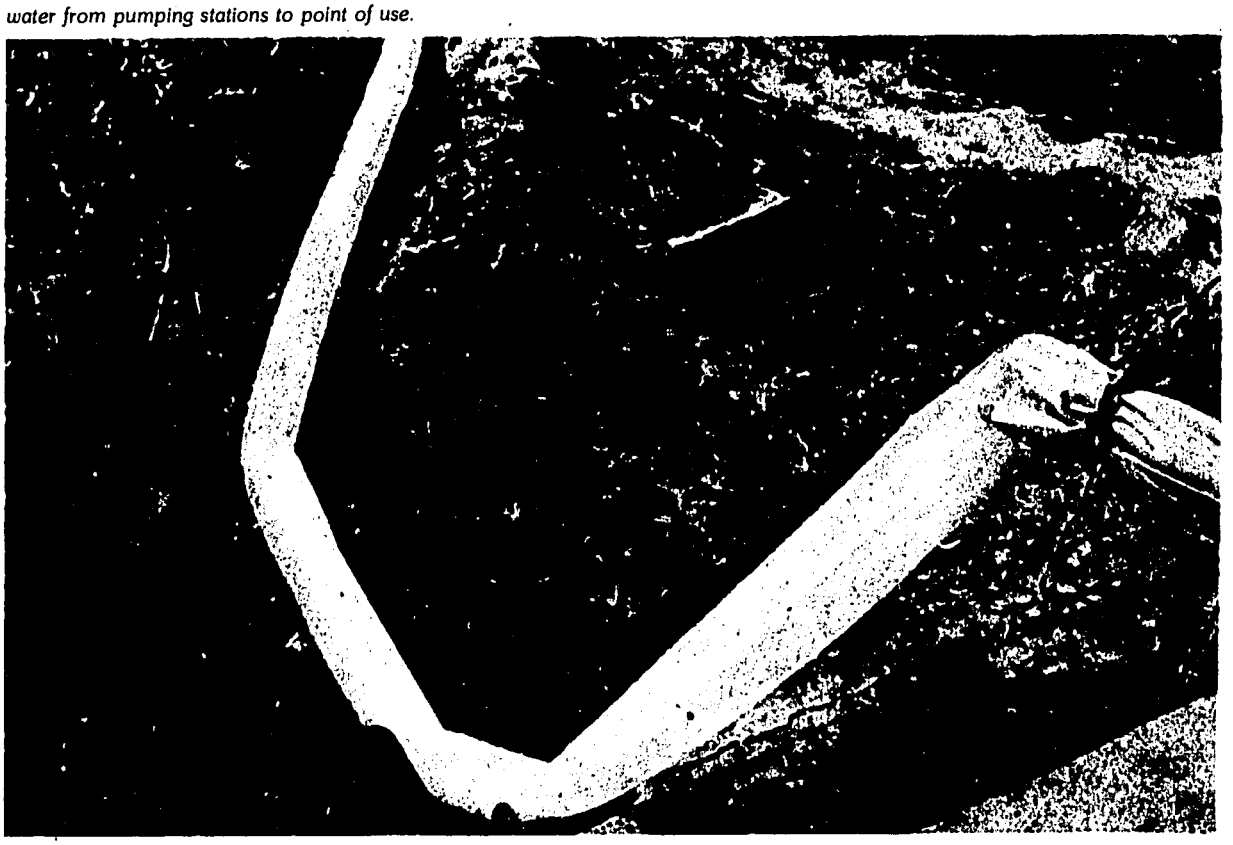
(a) Appreciable amount of land is wasted for conveyance of water as the area occupied by these channels cannot be beneficially utilised.

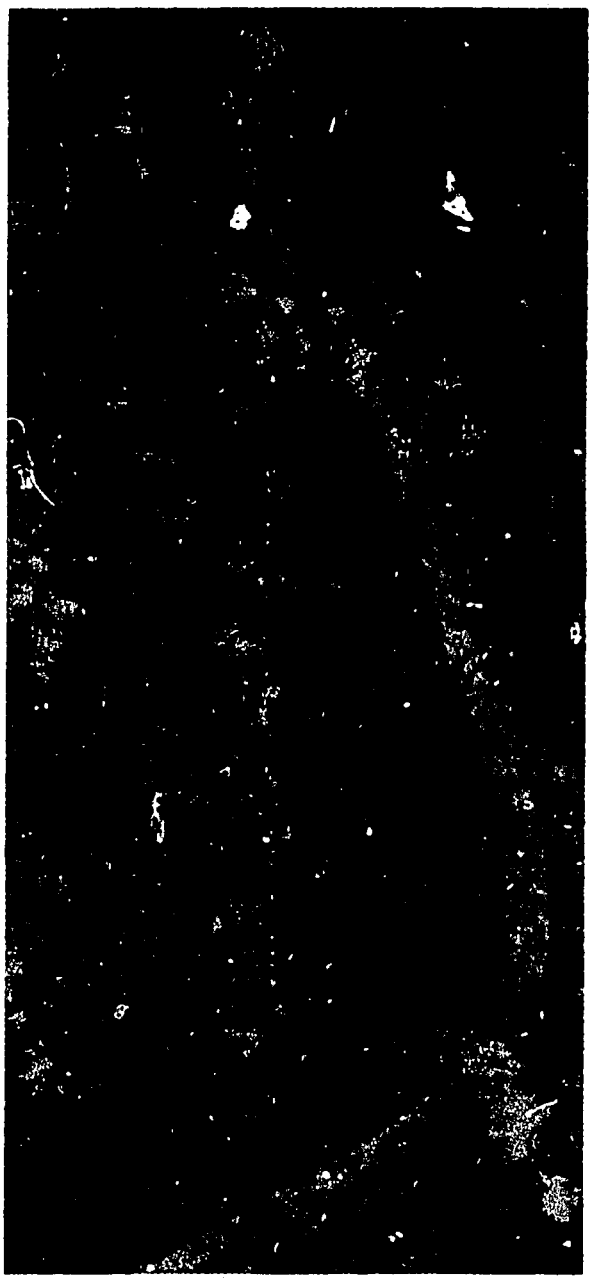
(b) The cost of most of the conventional linings is quite high and is some times beyond the reach of small farmers.

(c) In saline soils, the conventional linings deteriorate very fast, thus rendering the lining uneconomical.

Most of the above difficulties are overcome by the use of Low Density Polyethylene lay flat tubing, which is popularly known as Krishi Hose. This is a thick gauge, usually 2000 gauge (500 microns) and above, collapsible PVC/LDPE tubing. The tubing can be black in colour (for ultra-violet protection) or natural. Being collapsible, it can be rolled very easily and therefore offers good operating flexibility. The hose can be shifted from one location to another in the farm thereby eliminating wastage of land. Evaporation as well as seepage are completely prevented by use of Krishi Hose.

PVC lay-flat tubings popularly known as "Krishi Hose" used for conveyance of irrigation water from pumping stations to point of use.





Consumption of Plastics in Lay-flat Tubings In India

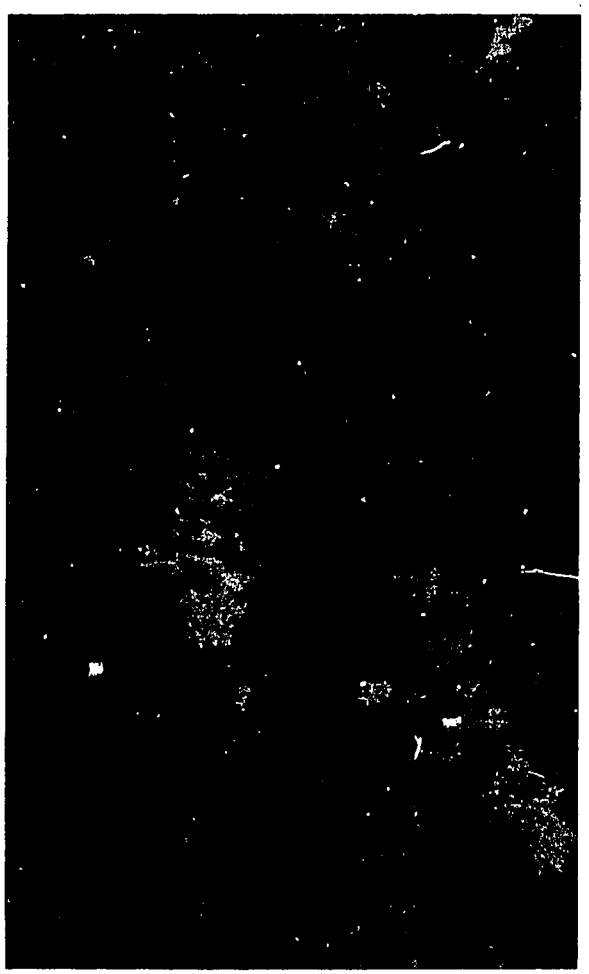
Krishi Hose in India is reported to be mainly produced from reprocessed PVC and LDPE materials because reprocessed material is available at a comparatively cheaper price all over the country. The farmer has a tendency to procure the cheapest Krishi Hose as he expects the life of Krishi Hose to be one or two seasons.

In the absence of data regarding cost economics of Krishi Hose made of virgin LDPE and PVC, no definite recommendations could be formulated. In view of the above the following measures may be taken:

(a) State Agro Industries Corporations may be persuaded to start marketing of quality Krishi Hose in the respective States.
(b) Data on durability of reprocessed Krishi Hose versus Krishi Hose manufactured out of virgin raw material may be generated by PVC and LDPE resin manufacturers.
(c) The agricultural universities should take up experimental field level trials using reprocessed vis-a-vis virgin Krishi Hose to determine the life under actual field conditions. On this basis, cost benefits analysis should be taken up for finalising the recommendations in this sector.

Potable and Farm Water Distribution

Pipe systems for irrigation purpose use a variety of conventional piping materials, such as, galvanised iron, cast iron, asbestos cement, reinforced cement concrete and plastics like HDPE and PVC. Plastics pipes are increasingly replacing the conventional pipes because of many advantages these offer over other piping systems.



Reinforced PVC hoses used in water pump inlet & outlet.

Some of the significant advantages of plastics pipes are:

i Light weight and easy to handle;
ii Ease of installation;
iii Higher flow characteristics;
iv Corrosion and incrustation-resistant;
v Low power requirement during water transmission;
vi Length for length, plastics pipes are lower in cost in comparison with conventional pipes of equal dimensions and pressure ratings.

Other advantages are the suitability of plastics pipes for surface piping over uneven terrains due to their flexibility and availability all over the country. However, in large diametres (beyond 200 mm) these pipes are more expensive.

In our country, plastics pipes are mostly used in areas where adequate irrigation facility is not available.

The table below presents current prices of various pipe materials and it can be seen that plastics pipe are lower in cost upto 100 mm diameter compared to cast iron, reinforced cement concrete and asbestos cement.

Table-11

Current prices of piping materials (Rs/metre)

Size in mm	Pressure class (kg/cm²)	PVC	HDPE	Asbestos cement	Cast iron	Galvanised	Reinforced cement concrete
50	6	5.23	—	—	—	14.16	—
110	6	21.24	—	31.74	38.56	57.27	25.50
250	6	143.25	—	125.12	116.91	—	59.30
32	10	—	10.50	—	—	13.12	—
63	6	8.24	29.50	—	—	32.00	—
315	2.5	—	217.00	81.80	—	—	46.50

The other characteristics of PVC pipes compared with GI, CI and asbestos cement are summarised in the following table:

Table-12

Parameter	Galvanised iron pipe (GI)	Cast Iron (CI) pipes	Asbestos cement (AC) pressure pipes	Rigid PVC pipes	Economic advantages of PVC pipes
Weight	Heavy	Heavy	Lighter than CI but heavier than PVC	Light, pipes weight ½ of CI 1/6 of GI and ⅓ of AC	Saving in handling & transportation costs.
Availability in lengths	5-6 metres	3-4 metres	3-4 metres	5-6 metres	Fewest joints
Coefficient of flow (C) value	100 for new pipe decreases over a period of use	100 for new pipes. 40 to 50 after 5 to 10 years	140	150	Less frictional loss. Saving in pumping cost

Reference Source: PVC pipe development organisation.

PVC/HDPE Pipes in Tubewells:

PVC and HDPE pipes have been used for tubewells. They are used as strainer as well as casing pipes. Plastics pipes are suitable for small and shallow or moderately deep tubewells. These have not been used beyond 150 metre depth. The GERI Baroda has installed a tubewell with PVC pipe to a depth of about 100 metres which has given satisfactory performance for the last 8-10 years.

PVC strainer used in tubewells.

PVC pipes used in tubewells have the following advantages:

i **Corrosion resistance**

The steel tubes currently in use last upto 5 years depending on the quality of water as the screens corrode slowly and after some time the tubewell tends to fail. PVC pipes are absolutely corrosion free and if installed properly, can last for 30 to 50 years even in very aggressive soils. Tubewells in highly aggressive water conditions using steel pipes are known to have failed within a period as short as six months.

ii **Flow characteristics and Energy Savings**

PVC pipes have better flow characteristics as compared to steel pipes due to their inherent smoothness and high value. The resistance to flow of water is much lower as compared to steel pipes resulting in energy saving of 20 to 25% or in other words, for the same power consumption of pump, the yield of tube well can be increased by 20 to 25%.

iii **Economics**

PVC pipes are economical as compared to steel pipes. In highly aggressive water conditions these can replace stainless steel which is prohibitively costly. PVC pipes turn out to be economical on account of their longer life as the screens do not have to be replaced as in the case of steel, or the tubewell has to be abandoned on account of corrosion of metal screen.

In the states of Punjab, Uttar Pradesh and Tamil Nadu, PVC pipes are being used in tubewells.

PVC pipes can be used both in hand pumps as well as in deep wells. In the case of hand pumps, 3.75 cm or 3.15 cm size, 9 to 18 metre length pipes are used. In tubewells 30 to 45 metre length pipes are used.

It is estimated that around 0.5 MT of PVC pipes would be required for each tubewells and 0.25 MT for hand pumps on an average. Thus, the potential for this application is tremendous.

The consumption of PVC pipes in most of the developed countries is enormous. The utilisation of such pipes in some of the developed countries during 1978 and 1979 is presented below:

in MT

Year	USA & Canada	West Europe	Australia	Japan	India
1978	954000	875000	59800	439800	17500
1979	1200000	978000	75000	498734	20000

The consumption of PVC pipes in India during 1980 and 1981 has been reported to be 29,000 MT and 36,000 MT respectively. There is no doubt that more and more PVC pipes and other plastics pipes must be used in our country to meet the increased pipe requirement in the agriculture and public health sectors.

Recommendations

i Failure of PVC pipes during installation as well as subsequent servicing have been reported which goes to show the lack of know-how regarding installation of such pipes. It would be necessary that the PVC resin manufacturers as well as pipe manufacturers impart sufficient training to the irrigation department authorities so that such failures are prevented.

ii PVC pipes used for irrigation purposes can be taken up by the Agro Industries Corporations for marketing and servicing through the agro service centres in their respective States.

iii The use of PVC/HDPE pipes in tubewells results in appreciable energy saving could be used for pumping more water and thereby more area can be irrigated. The minor irrigation department should evolve a tariff system which would offer incentive to the cultivators for using plastics pipes in their tubewell irrigation system.

Drip Irrigation

The increased understanding of the soil plant relationship has given rise to the concept that the best use of available water resources and optimum plant performance may be realised through preventing moisture stress rather than through relieving moisture stress by maintaining ideal soil moisture conditions in the plants root zone.

The conventional modes of irrigation, such as furrow irrigation, border irrigation, basin irrigation, corrugation irrigation, etc. cannot efficiently control the water application rate, thus giving rise to over irrigation, under-irrigation, build-up of salinity, water logging, etc. Over and above these, appreciable amount of useful irrigation water is lost due to percolation of the applied water beyond the root zone of the plants. The drip or trickle system of irrigation has got over many of the problems faced by conventional modes of irrigation. This irrigation concept was developed in the last decade in Israel and is becoming more and more popular in the USA as well as in many other countries in Europe, Middle East, South Africa, and Australia.

The Israeli Blass method places non-corrosive plastic tubes on the ground next to the base of the plants. No soil levelling is required. Tubes which can be permanent installations, continuously drip water-fertiliser mix to the plant roots. About every 5 acres is a control head unit with water tap and filter, water meter and fertiliser tank. A unit requires about 2½ gallons per hour and system takes 1 to 2.3 atmospheres of pressure.

This is essentially an old glass house system applied to field conditions and in some way it is comparable to the careful old Chinese system of often applying trickles of water from a watering can. Its mechanized and automated version developed for field conditions have been installed in the coastal central rolling country of Israel. Grapes, tomatoes and oranges were grown with it; elsewhere still on an experimental basis, trickle irrigation was also applied to melons, cotton, sorghum, flowers and various types of vegetables.

The drip irrigation system consists of plastics pipes and tubings, inline filters, fertilizers injectors and emitters which let out water in drops near the plant root zone. The lateral tubings which run along the plants are commonly one centimeter in diametre and made of LDPE. Schematic diagram of a drip irrigation system is shown in Fig. 6.

Several types of drippers have been developed. One type of dripper consists of a 10 centimeter long cyclinder suspended from the tubing. Within this cylinder water follows a spiral in the process of which pressure is so completely dissipated that water drips from its end at a steady rate. These drippers discharge at 2 to 4 litres per hour, but drippers for other rates of discharge are available.

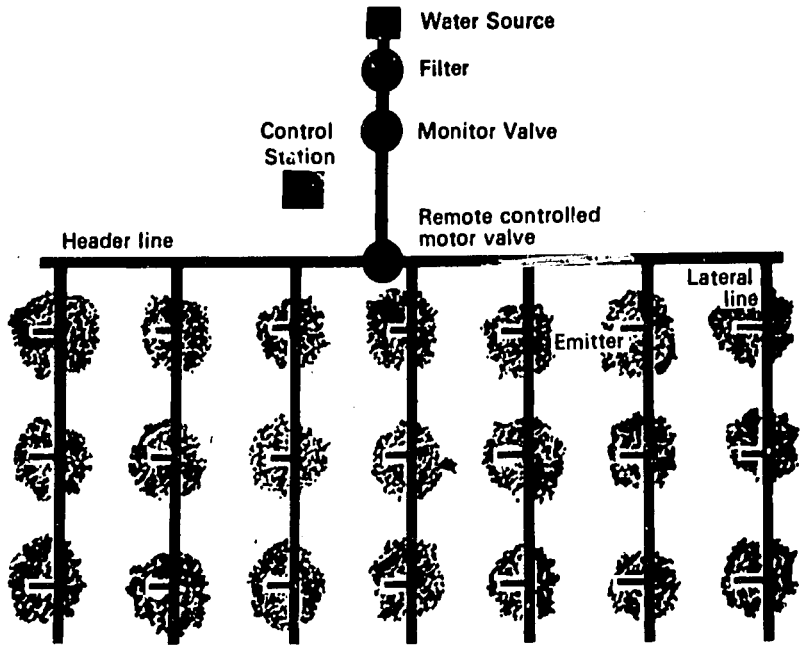
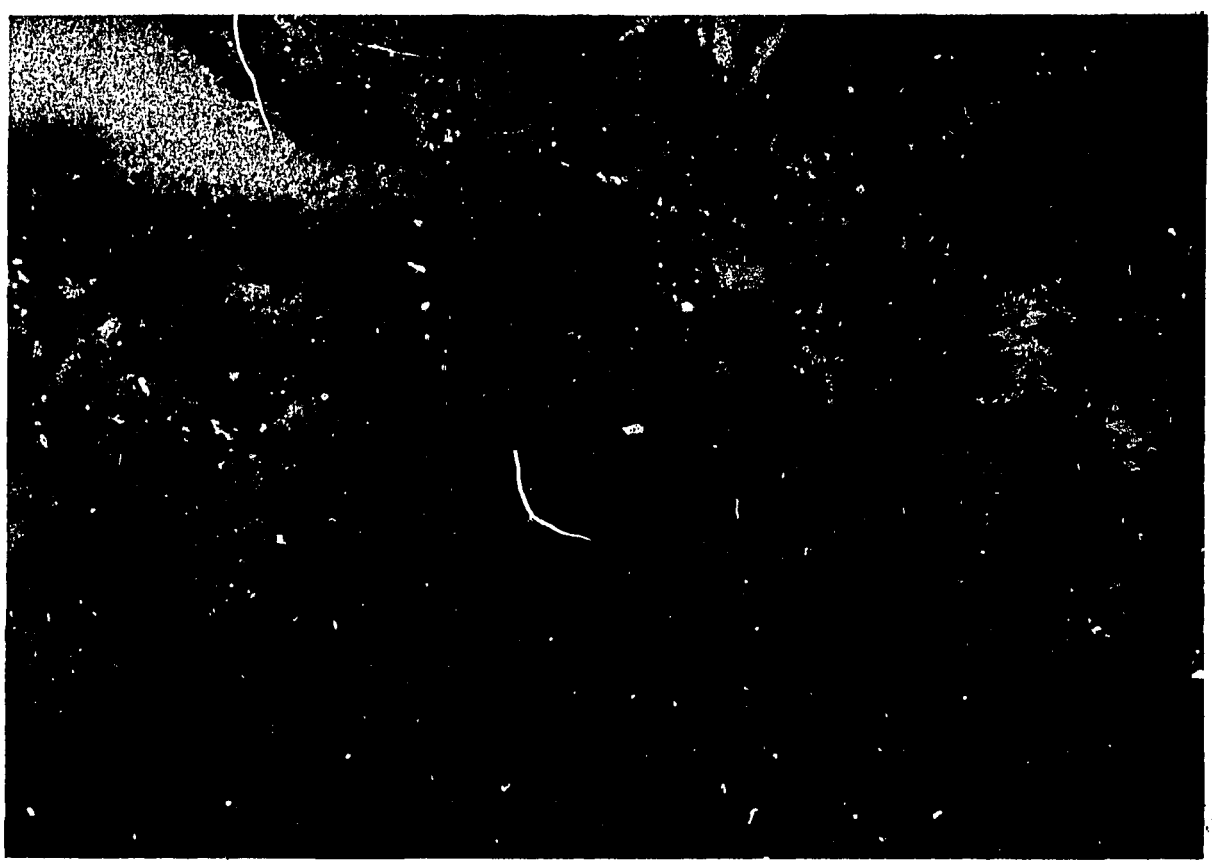


Fig. 6 Drip Irrigation System



Microtubes used in drip/trickle irrigation system.

Agricultural implications of Trickle Irrigation

The field application of this method is so new that it is not yet possible to assess its full potential and implications on the basis of detailed investigations. However, from data in the available literature, from discussions in Israel and from experimental work elsewhere, trickle irrigation has the following agricultural implications:

Crop Spacing

Trickle irrigation applied to the base of a plant wets a truncated ellipse of soil just below the plant. As a consequence, the root system becomes bunched in the same way it becomes bunched when plants are grown in pots. All water and nutrients are thus derived from a relatively small body of soil. This could thus change our concept of row and plant spacing in as far as this is permissible from an energy balance point of view, as discussed below:

In conventional irrigated agriculture, water is applied between rows through furrows, basins or sprinklers and roots from adjacent rows overlap in their search for moisture and nutrients. Assuming no rain, a conventional inter-row space is left unused with trickle irrigation. As incoming solar energy is fixed for a given area, that reaching the inter-row space heats the soil and the air which reaches the plant is used to evaporate or transpire water moisture. When using trickle irrigation, a marked difference in temperature and humidity exists between the inter-row space and the row space. Unless the hot interrow air is advected (blown out by wind) it will convect to the rows of plants and effectively increase the quantity of energy for transpiration. Thus, transpiration from a row crop should be higher when the soil in the inter-row space is dry than when it is wet.

If growth is directly related to transpiration, superior results from trickle irrigation could thus be explained from increased transpiration. If however, transpiration is a passive process, unrelated to growth (and this is still not certain), then the energy entering the inter-row space could be better used, at least in some cases, by bringing the plants closer together. In that case, trickle irrigation could be instrumental in utilisation of available energy for growth.

Fruit and Grain Ripening

The essence of trickle irrigation is that it constantly keeps soil moisture at a very high level (without interfering with aeration), some where between saturation and field capacity. Such a high moisture content of the soil is likely to adversely affect fruit and grain quality, but this should be further experimentally confirmed.

Using Soil Solely for Plant Anchorage

In conventional irrigation systems there is a substantial waste of water through its uncontrolled movement below and beyond the root zone and because of this waste, work on the magnitude of transpiration from various cropped surfaces has remained of quite academic value. With trickle irrigation this work becomes suddenly important in that it should be possible to apply water to a confined soil area underneath the plant at a rate that matches the loss of water from the leaf surfaces. A water fertiliser mix applied to a confined root zone could benefit our concept of soil fertility and fertilisation in that it would be possible to plan more or less for a replacement of nutrient elements that are removed by a crop.

Reduction in Sub-surface Drainage Problems

Whether irrigated agriculture is desirable or not has long been debated. The question has arisen from the inability of man to apply water at the rate at which it is used by the plant. Over irrigation has been unavoidable and it has resulted in the rise of the water table, water logging and salinisation of irrigated lands. The accuracy with which trickle irrigation can be designed and applied should eliminate the debate to a very large extent.

Using Saline Water and Saline Soils

The experimental results have demonstrated that it is possible to irrigate through trickle irrigation with water of considerable salinity. The outstanding yields that have been obtained in the Negev are explainable from (1) the high soil moisture content, yet adequate aeration, that is maintained under trickle irrigation, and (2) the leaching of salts from the induced, small root zone.

By keeping soil moisture content high, root hairs, which can normally develop 5 to 7 atmosphere tensions, have to cope only with the osmotic value of the soil water arising out of the salt concentration in it. For water with 3000 part per million (p.p.m.) that is water that is 3 times more salty than water of maximum salinity usable with normal irrigation, the osmotic value represents only about 1 atmosphere. The high soil moisture content almost eliminates the force with which water is held in the soil by surface tension which may equal several atmospheres.

The continuous water supply by trickle irrigation is critical. It has been shown in earlier experimental work that as the soil moisture content is lowered due to water absorption by the plant, salt accumulates in the neighbourhood of water absorbing roots and osmotic values in the soil water of 5 to 7 atmospheres at these critical sites are rapidly reached.

Clearance of silt under trickle irrigation in the small root zone just below the plant is by salt being bodily pushed out by an advancing front of wetted soil. It has been demonstrated on several occasions that salt accumulates just beyond the wetted boundary. This observation has far-reaching consequences in that it may alter our concept of treatment of saline soils.

Assuming that soil can be leached free of salt by transmitting water through it, which usually can be done when the lime content of the soil is adequate, leaching is conventionally achieved by means of leaching basins to which as much 1 metre depth of water is applied. The water that is transmitted through the soil profile is then removed with its salt charge throuhg a man-made deep drainage system.

The high cost of basin formation that of water under saline conditions, that of providing under drainage, and above all the organisation required for all these operations has been the cause of numerous costly failures of agriculture on saline or salinizing soils. Now there ae prospects that all these costly operations and failures can be eliminated by using trickle irrigation with spot leaching rather than area leaching. This conclusion is so far-reaching in its application that careful further experimental work is needed to verify it.

Several research institutes including Indian Agricultural Research Institute, New Delhi, Central Arid|Zone Research Institute, Jodhpur and Tamil Nadu Agricultural University, Coimbatore have taken up trials on drip irrigation system and the results so far have been encouraging. The table below gives the results obtained at TAU, Coimbatore, on the use of drip irrigation system with several vegetable crops:

Table-13

WATER USED AND YIELD IN DRIP AND CONTROL PLOTS FOR VEGETABLE CROPS

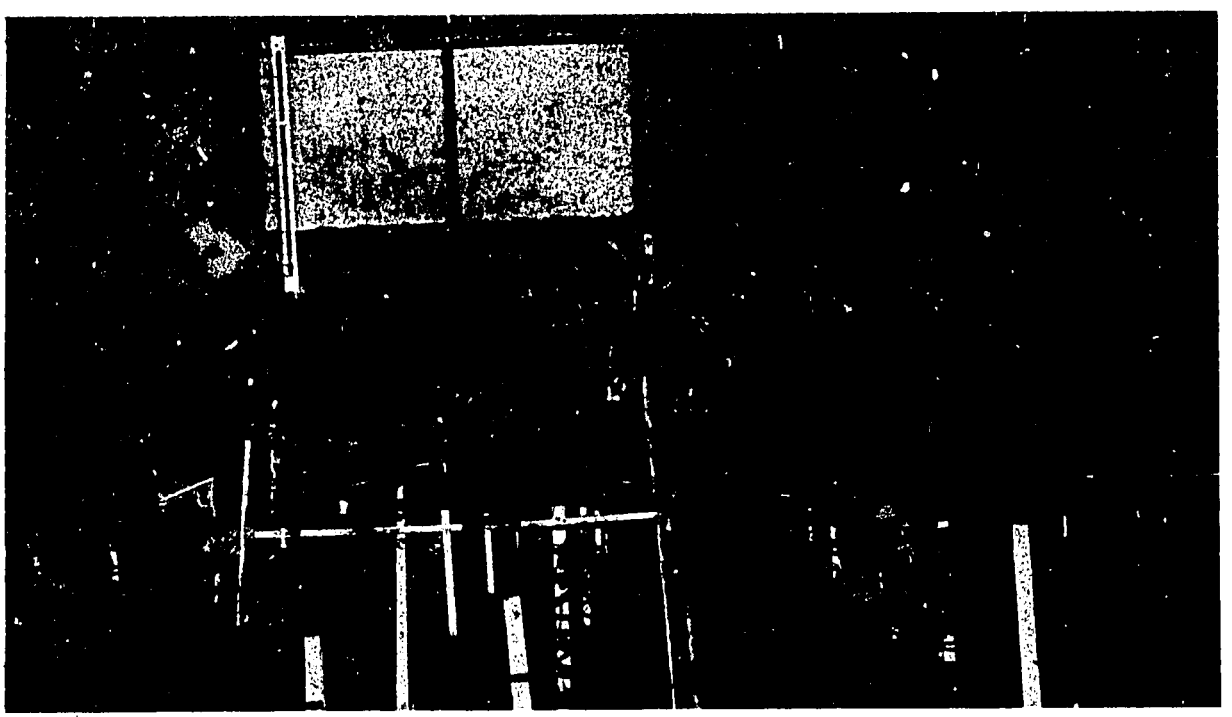
Sr. No.	Crop	Water used in cm		Yield in kg/Hcs		Rain fall
		Drip	Control	Drip	Control	
1	Tomato	10.76	49.20	8872	6186	21.18
2	Bhindi	10.00	40.50	11000	10200	3.00
3	Brinjal	24.47	69.18	12300	13400	17.10
4	Chillies	41.77	109.71	6080	4233	20.75
5	Beetroot	17.73	85.76	6887	6571	—
6	Radish	10.81	46.41	4186	4045	—
7	Sweet Potato	25.20	63.14	5888	4244	12.10
8	Cotton	15.20	70.60	3255	2604	15.00
9	Sugarcane	92.10	136.00	11296	7591	67.00
10	Papaya	75.38	228.50	23.48/plant	13.88/plant	61.65
11	Banana	58.00	243.00	15.31/plant	16.95/plant	34.00

Source: Tamil Nadu Agricultural University, Coimbatore.

Although somewhat crude methods were adopted in the design and manufacture of plastic pipes and nozzles for the preparation of the drip/trickle system which were used at these research institutes, the improvement in yield was significant.

Orchard irrigation using drip system.

Drip irrigation can be used in row crops and orchards. Without levelling, this system can be laid on undulating lands as the plastics pipes are flexible and can take to the contour of the land.



Drip system with low head over head tank - Tamilnadu

There are a few manufacturers who are developing drip system for use in Indian conditions. It has been observed that the efforts made by these organisations in promoting the drip irrigation systems manufactured by them have not met the particular success. This is because of the high cost of plastic raw materials in our country and excessively high processing charges paid by these organisations in view of limited requirement. At Annexure-IX the cost details of drip system for various orchard crops have been presented. These details were obtained from a drip irrigation manufacturer in the South.

There are several drip systems operating successfully in the country. The table below gives the details of some of such drip systems operating in the various parts of the country.

Table-14

Farm location	Area (Acre)	Crops
Vandaloor Farm, Madras	2½	Banana/Coconut
Kasturi Rangan Farm, Bangalore	18	Rose & Coconut
Parampahi Estate, Hassan	13	Coconut/Sapota/Coffee
Jaidevi Farm, Kadun	7	Coconut
Breaks India Ltd., Nancot Distt.	54	Coconut
Pondichery Botanical Garden	0.75	Roses
TAU, Coimbatore	2	Roses
Mandya Research Station, Mandya	—	Plantation crop
Chettipalayam Village, TN	10	Orchard crops
TAU, Coimbatore	1	Mango nursery
Indag Research Centre, Madras	2	Cotton
Saguvadi Village, Gujarat	2	Groundnut
Gadadasamy Village, Gujarat	1.6	Groundnut
Fariyadka Village, Gujarat	1.3	Groundnut
Sumarasher Village, Gujarat	1.6	Groundnut
Mandvi Village, Kutch, Gujarat	6	Kubabul forestry

The Gujarat Irrigation Deptt. has recently floated a tender for establishment of a 500 Ha. of drip system in the State. The success of this installation is going to play a major role in further propagation of this system in Gujarat as well as in other States. There is a definite need for further development of this system for making it more economic and adaptable to our agriculturists. Though there are only a few drip irrigation systems in use today in our country, the demand for this system is bound to grow. Our demand for irrigation water is growing rapidly and drip irrigation could be one of the answers to increasing its water use efficiency.

Drip Irrigated capsicum - Jodhpur, Rajasthan.

Following are the recommendations of the National Committee for promoting this application in the rural areas:

a The agricultural universities in all the states should test drip system made available by the existing manufacturers and prepare technical feasibility report in relation to the crops etc.

b The resin manufacturers should take up developmental programmes for producing suitable grades of resins which can be used for the production of pipes, tubings, and emitters used in the system.

c Resin manufacturers also should study the compatibility of the drip irrigation components at field level so that leakages, cracking, etc. do no occur, thus rendering the system ineffective.

d The resin manufacturers as well as major processors should invest on developing total drip systems which would be economical, efficient and easy to operate.

e Banks should finance the establishment of drip systems by progressive/competent cultivators.

Drainage:

In certain areas where the water table is high at particular periods of the year, there is always a danger of land becoming water-logged and eventually becoming salt-effected as the water continuously evaporates from the soil. To overcome these difficulties, the land can be drained so as to keep the water table at a lower level and thus preventing the "Salt build up" problem.

Land drainage is traditionally undertaken by using clay-tiles or concrete porous drains. In clay-tile systems, it is necessary to excavate long trenches which have to be accurately sloped so that the drained water can flow by gravity. Not only does this call for special expertise, but it takes considerable time to dig the large number of trenches that are needed to drain a given area.

Slotted and corrugated PVC pipes offer an ideal system for land drainage. The pipes, being corrugated, can readily be coiled and thus long lengths can be laid with a few joints. However, if needed, machines could be imported which will lay the drain, by a mole-plough technique.

PVC/HDPE pipes have characterstics best suited for land drainage purpose. The advantages of plastics drainage pipes over conventional pipes are:

i **Light Weight:**
The lightness of the plastics material is probably one of the main advantages over the traditional clayware or concrete product. On an average this weight ratio is equivalent to 40:1.
The importance of this fact is realised when related to transport, site handling and, in terms of damage to soil structures.

ii **Transport:**
50/60,000 feet of pipe can be carried on one lorry-load and a man may easily lift and handle a 500 feet coil. Transport costs are, therefore, minimal and the expensive use of labour for unloading is drastically reduced.

iii **Handling:**
'On-site' handling is considerably reduced. An efficient drainage contractor is easily able to save the labour of at least three men and a tractor/trailer unit.

iv **Damage to soil structure:**

Apart from the physical and mechanical problems of moving loads of heavy clay or concrete pipes over wet land, the problems created in relation to soil structure can be devastating.

Most farmers recognise the effect of soil compaction on their crops (and indirectly upon their incomes), but the use of light-weight plastics pipes can avoid this problem.

With plastics pipe onlythe actual drain-laying machine need cross the land, thus eliminating most of the risk of soil damage by compaction and panning.

In softer soils particularly, the longer or continuous lengths of plastics pipes are speedily installed and the straighter drainage lines are not so easily affected by ground movement, thus proving a longer functional life in the more difficult ground conditions.

The risk of blockage from sliting up is reduced by controlling the entry of solids whilst also allowing a maximum water entry into the pipe.

This control is achieved by maintaining a perforation size of between 0.6 mm and 1.7 mm. Different specifying authorities exercise varying tolerance bands but most are within the stated limits. The new British Standards Specification for plastics pipe for use as light duty subsoil drains (B.S. 4962-1973) specifies a maximum perforation width of 1.25 mm.

The British Standard also covers perforation distribution: ". . . at least one perforation in every 50 mm length of tube and at least one perforation per 120° segment in every 150 mm length of pipe". This uniform distribution clearly provides the most efficient formulation for maximum water intake.

B.S. 4962 also requires that plastics pipe has adequate resistance to degradation and shall not suffer any loss of properties from the effects of soil water.

Plastics pipes are immune to corrosion from aggresive soil conditions and are suitable for subsoil drainage in any soil type.

Mulching

Mulching is a term used to describe a "Covering of the soil". In this practice the cultivated land is covered with suitable materials such as dry lear, straw, saw dust, ash, etc., which helps in preventing moisture loss through evaporation from the soil, reduce weed growth and insulate the soil from low night temperatures of the environment. In many of the developed countries plastics film, such as LDPE film has rapidly replaced the conventional mulching because of its effectiveness and commerce.

Mulching of strawberry using LDPE film - Himachal Pradesh.

Plasticscovers, which are available in colours ranging from black to clear, cause marked changes in the temperature and moisture conditions of the covered soil, particularly in the surface portion of the profile. They also affect the amount of light reaching the soil surface. When fully understood, this new technique for altering the soil climate can be used to advantage by the grower of practically all crops. In this method, around 30% to 60% of the cultivated area is covered with a thin polyethylene film (30-150 microns). The crop or plant grows through the pores made in the LDPE films. The use of LDPE film mulch offers the following advantages:

Very limited experiments have been conducted in our country using LDPE and PVC mulch. However, on the basis of information gathered from the experience of other countries as well as data generated within the country, the effects of LDPE mulch are:

1 **Soil Temperature:**
Under transparent film, the temperature of the soil rises by several degree during the day. This can vary between 2 and 10°C according to the season and the soil and also according to the level of sunshine and the moisture content. At night, the difference with the bare ground is less (2 to 4°C), which appears as if the energy accumulated during the day is only partially retained. It is in effect the true greenhouse effect to which we will refer later in relation to tunnels and protective structures. Under black film the temperature of the soil during the day is practically hardly any higher than in the bare ground and in certain cases, it is even slightly lower. But, on the other hand, during the night, the temperature is always higher by 0.5 - 4°C than for the uncovered ground.
Under white film, the temperature is always lower than the uncovered ground. Since the energy exchange is very poor, this film is used either in regions with a high level of sunshine where it is required to reduce the energy and lower the soil temperature, or in regions of low luminosity where one wishes to increase the amount of reflected light on the lower and middle leaves. It has been observed that transparent film stores up in the soil more energy than does black film but that the soil under the former tends to lose this more easily during the night than under a black film.

2 **Moisture content of the soil:**
It has been observed that under both black and transparent films, the moisture content in the soil is generally, higher than for bare ground except immediately after rain. The plastics mulch play a regulating role in respect to rain and irrigation. There is, in general, less water initially penetrating soil but it is evident after a certain period that the degree of moisture remains higher under the films than in the atmosphere. The soil under black film absorbs water more easily than under transparent film but after a certain time, the levels are very close.

3 **Soil Structure:**
Plastics mulch maintains the structure of the soil in the state in which it was originally laid. Only in case of heavy soil this may not be applicable. This property of plastics mulch has the following advantages:-
- It allows lateral infiltration of water from rain or from watering and this is essential because mulch accumulates rain water on the non-mulched area and this moisture is likely to be lost by evaporation if it is retained in this area.
- It allows gaseous exchanges in the soil. Thus the carbon dioxide produced by the roots and the micro organisms, instead of accumulating to a level which is toxic for them both, comes to the surface under the film and can escape through the holes or slits made in the film.

4 **Effects of weeds:**
Black film has a complete herbicidal effect, smoke grey acts only partially in this way and transparent film has little or no effect. If one is looking for a build up of energy in the soil, and this is not always the case either because of a tropical or sub-tropical climate, then transparent non-coloured film can very well be used with or without previous treatment with herbicides.

5 **Contribution from Carbon Dioxide:**
It has been concluded that mulching in the open increases the level of carbon dioxide by 32 to 100%. Mulching in greenhouse increases the carbon dioxide level by a factor of about 3. Smoke grey and black film increases the carbon dioxide more than transparent mulch film.
The considerable difference in yield obtained with mulch is because of the mulch maintaining the carbon dioxide supply to the plants.

6 **Root System:**
Mulching creates conditions favourable for the plant to explore immediately a greater surface area in the soil under mulch than in the bare ground, while at the same time, does not have any detrimental effect on development of deep roots. In one study, it was observed that vines grown under mulch had roots 150% more in weight compared to unmulched control plants.

Though very limited work has been done in our country, the results obtained from these trials have been reported to be encouraging. The reason for limited trials could be that the mulching experiments have not been taken up in areas where it is most likely to succeed and get propagated.

The forward areas are the most favourable regions which present agro-climatic conditions where plastics mulch would help in plant growth.

Recommendations:

i Complete information of mulching trials taken up in the country should be collected by ICAR.

ii Mulching trials should be initiated in different agroclimatic zones by ICAR in collaboration with agriculture universities and agriculture and horticulture departments.

iii Mulching with different crops may be tried in other agroclimatic conditions so that definite recommendations could be made to cultivators interested in using plastics mulch in these areas.

Nursery Bags

Plastics bags made of LDPE are extensively used in the growing of nursery. All the State forest departments use these nursery bags for growing seedlings for use under their afforestation programmes. The forest department of Gujarat has put up its own LDPE film manufacturing plants to meet their captive requirement of LDPE bags for nursery purpose. Other State Government forest departments are also evaluating the possibility of establishing such plants for manufacture of LDPE bags to be used under their afforestation programmes.

Nursery bags made of plastics have many advantages:

(a) These bags are extremely light, flexible and unbreakable thus rendering these easy to transport.

(b) The bags can be kept in very close contact with each other thus using minimum space. This also facilities easy watering and supervision.

(c) Use of plastics nursery bags results in minimum water use as well as fertiliser saving.

(d) The bags are easy to open and thus transplantation becomes easier.

Besides afforestation and flower nursery, these bags are used in the tea gardens for raising tea nursery over a considerably long period of time. There is a possibility of using these bags for growing nursery of hybrid crops where loss of germination could result in substantial loss of production to the cultivator. As an example, in hybrid cotton 25% of cotton plant population can be grown in nursery bags and rest can be drilled in the field. In case there is germination failure in the field the plants grown in nursery bags can be transplanted to the field thus maintaining optimum plant density for maximum production.

Recommendations:

i Use of nursery bags for growing hybrid crops for countering germination failures could be propagated through the agriculture department extension machinery in selected pockets for popularising this application.

ii The Agro Industries Corporations can take up the marketing of nursery bags through their extensive network of agro service centres. This would ensure the availability of these bags at the grass root level.

iii Technical literatures and audiovisuals could be prepared on the various methods of nursery growing highlighting the aspects of saving of time and money and to get best out of these bags.

iv The effect of different colour of nursery bag on plant vigour could be studied by IARI in collaboration with resin manufacturers so that a technical bulletin on plastics nursery bags could be prepared for reference purpose and for propagation in the potential areas.

Air layering using plastics film.

Soil Fumigation:

Soil sterilisation can be carried out by covering the soil with a plastics film and releasing a suitable fumigant in the space entrapped between the soil and the plastics film. Introduction of this system in the infested soils in many parts of our country could be studied and field trials should be carried out to deinfest the soil using this method.

Plastic Flower-Pots

Owing to a better knowledge of the properties and considerable fall in the prices of plastic flower pots, their use is bound to increase in the years to come.

Plastic flower pots can be made of polystyrene, polyethylene, PP, PVC, or other materials. The advantages of non-porous clay pots are:

1 Empty pots can be stacked in large quantities, are easily transportable and require a little storage space.

2 They are light in weight, unbreakable in ordinary use, easy to disinfect and to clean and are supplied in many variations with regard to shape and colour.

3 As the walls are not porous, the loss of water by evaporation is much lower, consequently the plants require less water. This is of importance for ornamental plants on the window sills of centrally heated offices, hospitals, houses, etc.

4 The root penetration of the ball of soil is better. Moisture as well as soluble nutritional salts are evenly distributed throughout the ball of soil, so that the roots do not grow in one direction or cling to the wall. The ball of soil is easily removed from the pot and the plants can be repotted at each stage without difficulty. The good penetration of the roots in the ball of soil will enable the plant to adapt itself more readily to drought.

5 The temperature of the soil in a plastic pot is higher than that in a clay pot under the same conditions. As the clay pot loses much more water by evaporation (about 3 times more), more heat is dissipated from the ball of soil.
During the day, the temperature of the soil in translucent pots rises considerably owing to the radiation energy of the sun. This difference in temperature might be an advantage for plants grown in winter or in early spring.

6 Growing experiments have shown that the growth in plastic pots can be excellent and often better than in clay pots. This is probably due to the uniform-moisture content of the ball of soil and to the higher temperature.

A disadvantage of the plastic pot, which should be mentioned, is the danger of excessive watering. If the soil is too wet the roots of the plants receive too little oxygen, they suffocate and the plant languishes and dies. It is important that the potting soil should have a good structure in order to get the optimal water/air ratio.

A drain hole is essential. Plants cultivated in pots vary from marsh plants to desert plants and have various requirements on the humidity and the structure of the ball of soil. Polyethylene bags are used for raising tomato and cucumber plants and with this system it has proved that the plants are less potbound than by raising in clay pots. These pots are also used for propagating young coffee plants.

Low Tunnels, Greenhouses and other Controlled Environmental Techniques

Environment provides severe restraint on conventional agricultural production in many areas of our country. Green house food production offers a means for moving forward greater degree of environmental control. The extent can vary from mere protection from rain to complete environmental control. Major factors influenced are light, temperature, atmospheric composition and the roof environment. Green house food production provides the present ultimate in intensive agriculture when the three major factors of production - land, labour and capital are taken into consideration.

Food crops have been intensively produced in green houses for hundreds of years and commercially for the last 100 years in some countries. The degree of environmental adjustment in green houses at first was quite limited. With the introduction and improvement of effective heating systems, green houses are being increasingly used.

Low tunnels made of steel wire hoops and LDPE film cladding used for controlled environment agriculture.

There are a few organisations which are working on low tunnels and green houses for growing tender nursery and high value crops. For example, Tropical Pine Research Centre, Dehradun, is working on the low tunnesl for growth of tender pine seedlings which are imported from countries like Mexico, etc. Low tunnels can be constructed with hoops made of 8 gauge galvanised wire, preferentially high tensile wire. These hoops are covered by LDPE film, preferably UV stablished, and tied at the sides with a thread in order to protect it from flying away with wind. Appropriate Eco-Technology

Development Group is another organisation which is engaged in experimentation on green houses in the upper Bhagirathi Valley (Gangotri Zone) of the Garwal Himalayas. They are trying to evaluate the weatherability performance and standardisation of specifications of LDPE film for the entire range of green houses. In Himalayas the forests are being denuded day by day due to tree felling, solid erosion and land slides, etc. The result is that some of the rare Himalayan species are also becoming extinct. The Appropriate Eco-Technology Development Group is also doing research in the regeneration of rare species by developing controlled environment chambers in which the temperature and humidity are controlled in such a way as to offer the right weather conditions for the growth of plants.

Plastics tunnels and green houses for controlled environment agriculture.

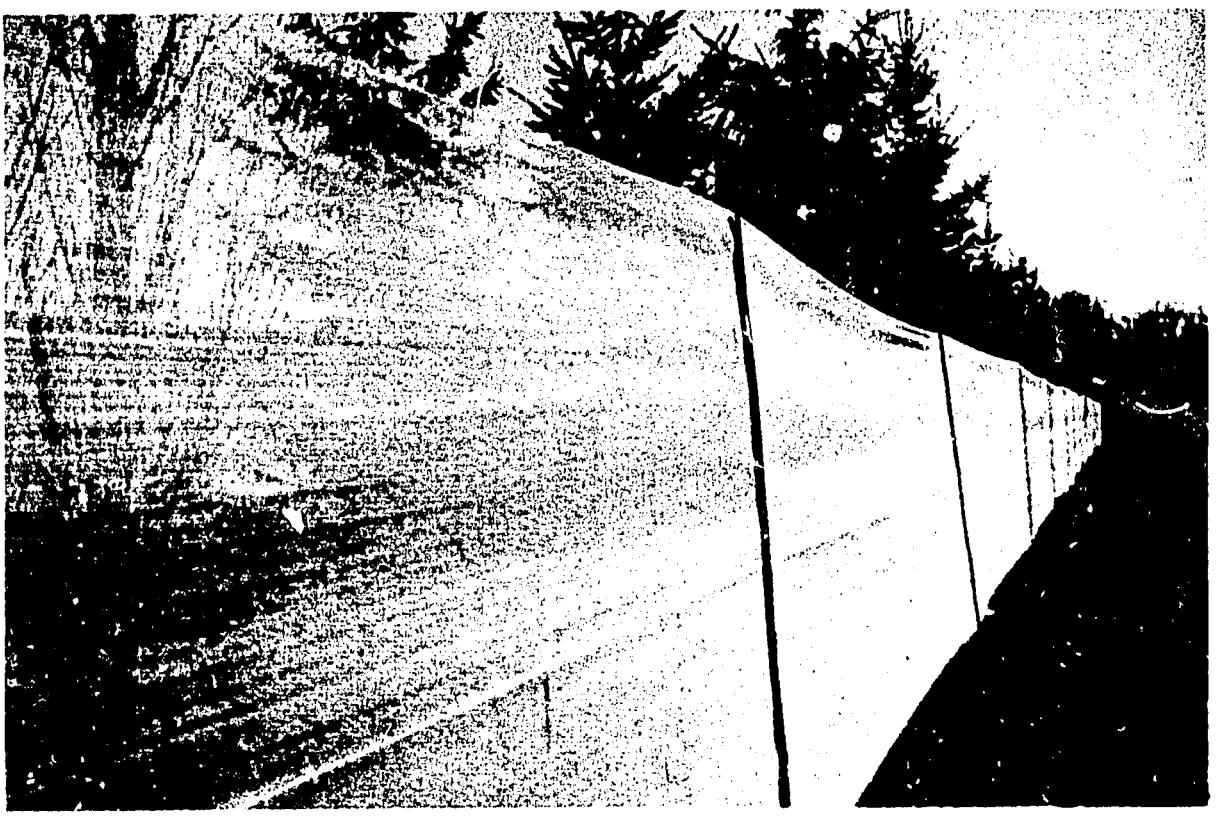
In future, these experiments may reveal most meaningful and educative data which can be further propagated by the National Committee in other parts of the country. Agriculture Research Unit at Almora which is under Ministry of Defence has also been engaged in growth of some of the high value crops like mushroom and other vegetables under low tunnels/sheds at high altitudes in Himalayas. It has been found that there is early growth of these vegetables under LDPE covers.

Low tunnels and nursery bags used for tea nursery raising, Coonoor, Tamilnadu.

Green houses have also been tried out by many commercial horticulturists, Universities and Government horticultural farms. The resin manufacturers should organise seminars in order to further propagate the concept of green houses and other controlled environmental techniques in hilly areas for the growth of high value crops, tea/coffee plantations and some of the rare species of Himalayan origin in order to bring it to commercial exploitation level.

Plastics nets used as wind breakers for protection of plants against high wind as well as cold wind.

Plastics nets used as wind breakers for protection of plants against high wind as well as cold wind.

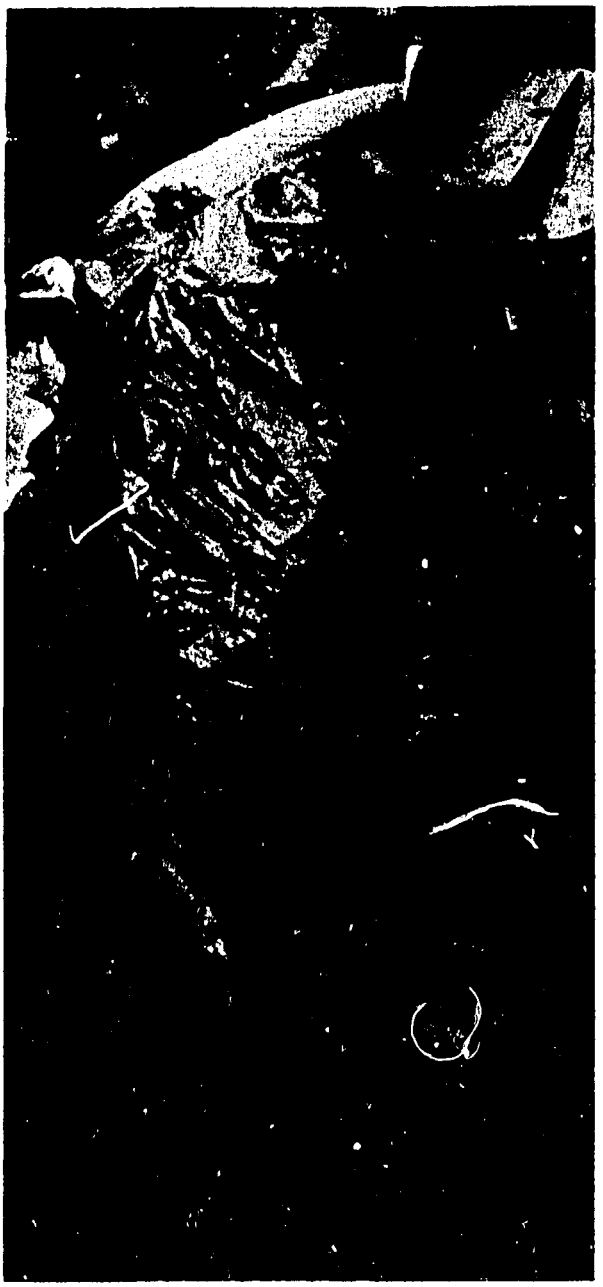


Bird Protection Nets

Many of the orchard crops as well as hybrid seed farms get affected because of bird damage to the standing crops. The use of bird scarers has not proved very effective because of the birds getting used to their presence after constant use. Light weight plastics nets made of nylon, PP, HDPE or LDPE can be used for covering grape vines as well as other high value orchard crops for preventing bird damage. Even in the arid areas, date palm can be protected from birds by the use of plastics nets.

Both knotted as well as integrally extruded nets could be used as orchard protection nets. Integrally extruded nets would be less costly as compared to knotted nets and there are some entrepreneurs trying to manufacture integrally extruded nets in the country. More information on cost benefits of this application has to be gathered before the recommendations and plan of action could be formulated.

LDPE sleeves used as banana bunch cover.



Coloured LDPE banana bunch cover.

Cover Bags for Plant Protection

In some areas of Punjab early tomato is grown inside LDPE clear film bags. The transplanted dwarf variety tomato seedlings are covered with LDPE film bags supported by stick stuck around the nursery seedlings. These bags protect the tomato crop during cold winter nights and eliminate the possibility of frost damage. It has been reported that by use of cover bags, the yield is increased by around 37% and the plants start bearing mature fruits earlier, thus fetching good market price.

LDPE plant covers used for protecting early tomato against frost damage - Ludhiana, Punjab.

Sleeves for Mango Tree

Mealy bug causes extensive damage to mango crop. The Pant Nagar Agricultural University has come up with a new innovation. They wrap the main trunk of the mango tree with a LDPE sleeve which is too slippery for mealy bug to climb on. Thus, the mango crop is protected from the attack of mealy bug.

Indian Agricultural Research Institute (IARI) should look into this application and prepare regional language brochures which can be circulated to orchard owners in the mango growing belts of Maharashtra, Andhra Pradesh, Tamil Nadu and other states.

Coconut Plant Protection

Plastics sleeves are being used to cover the trunk of coconut trees to act as a slippery agent. The use of the plastics sleeve prevents the Rhinocerous Beetles from climbing the coconut trees. The use of these sleeves also prevents rats from climbing the trees and damaging the coconut bunches. The film sleeve is used at the lower bottom portion of the tree trunk.

Further study on this application should be taken up so that measures for its propagation in coconut growing regions could be identified.

Portable Sprayers

Plastics parts are used in the manufacture of most of the components of portable sprayers. The use of plastics parts results in saving in weight, replacement of scarce metals as well as corrosion-free operation.

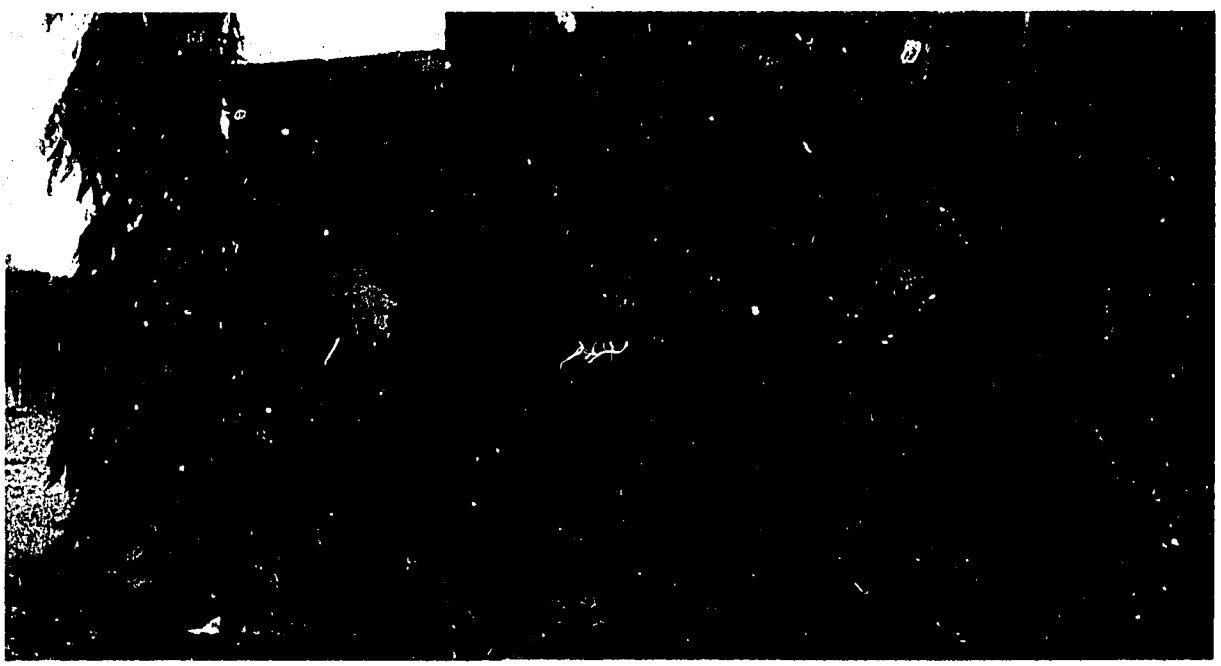
Light weight portable sprayers are to be propagated in some of the States, where metallic heavy weight sprayers are still being used.

Rain Guards for Protection of Rubber Latex Grooves

In rubber plantations, latex is collected in containers kept below the spiral grooves cut in the trunk of the rubber tree. The collection is carried throughout the day and collected latex is removed in the evening. In order to protect the latex grooves from rain, dust, and other foreign particles floating in the air, the grooves should be covered. LDPE/HDPE films have been used extensively for covering the latex groove as it has the necessary rigidity and flexibility.

Pusa Bin

In India, unscientific storage, rodents, insects and micro-organisms account for more than 10% loss of total food grains produced, a quantity good enough to feed at least 50 million people. Estimates indicate that the magnitude of wastage of food grains is as much as the quantities imported to meet the shortage in the country.



Pusa Bin incorporating LDPE film sandwiched between brick walls for on-the-farm food grain storage.

Food grain storage continues to be an important problem from the time man learnt to grow crops. Millions of tonnes of food grains are either damaged or lost for want of knowledge of scientific methods of storage. The loss is not only in terms of the quantity, but also in deterioration in quality of the food grains stored. The qualitative deterioration is attributed to chemcial changes in protein, carbohydrate, amino-acids, fatty acids, and vitamins which affect the nutritive value of the grains. When damp, several biological agents like fungi, bacteria, insects and mites attack the grain and accelerate deteriorative changes.

These losses are appreciable in a country like India where 70% of the food grains produced are retained with the primary producers at village level where facilities for scientific storage are yet to be developed.

Storage of food grains at producer's level is mostly traditional, using locally available materials. The cultivators are generally using bulk storage in different types of indigenous storage structures such as underground cellar, mud bin, straw bin, thekkas, etc.

The existing storage structures in rural India are not ideal from the scientific storage point of view, with the result that substantial losses occur during storage of grains. Improvement in storage practice can be brought about either by replacing the existing structures by new ones involving huge expenditure and organisational set up or by incorporating simple features in the existing structures, which farmers themselves can make use of.

With the increased realisation of the importance of storage, intensive developmental work has been undertaken for developing scientific storage methods. Many of the storage techniques developed are expensive, require scarce raw materials for construction and are, to some extent, sophisticated. Indian rural population, which constitutes more than 70% of the total population, being what it is, it is necessary to develop storage methods which could be made locally with local resources, and the cost must be within the farmer's reach.

With this objective in view, the Entomology Division of the Indian Agricultural Research Insititue, New Delhi, has, after considerable research, developed a storage method which meets most of the safe storage conditions effectively and, at the same time, the structure is much cheaper to construct compared to other scientific storage methods, which have been developed in India. These storage structures are popularly known as PUSA type bins or cubicles.

Fig. 7

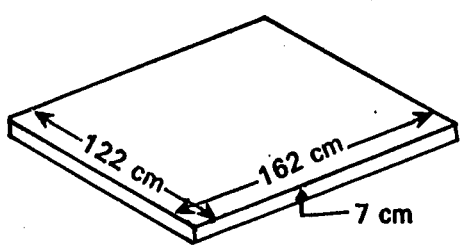


Fig. 8

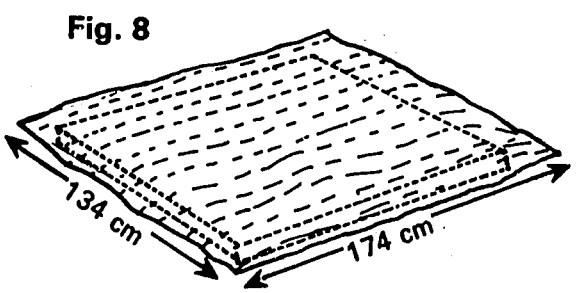
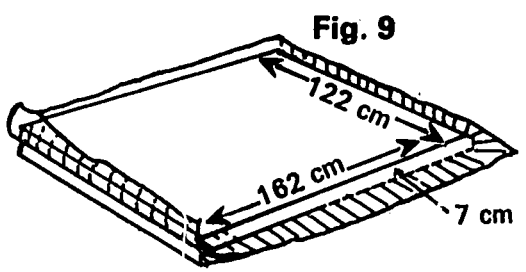


Fig. 9



The table below shows the cost comparison of steel concrete and PUSA bin (2000 kg. capacity):

Table-15 **COST COMPARISON OF GRAIN STORAGE BINS**

Basis : Capacity-2 MT ; size : 140 cms × 100 cms × 160 cms

Cost break-up	PE film based bin with internal walls built of unburnt bricks & outer walls built of burnt bricks upto a height of 45 cm and the rest by unburnt bricks		Concrete bin with a wall thickness of 15 cm and a man-hole cover of cast iron.		Mild Steel bin with a wall thickness of 5 mm and a man-hole cover of cast-iron.	
	Qty	**Cost (Rs)**	**Qty**	**Cost (Rs)**	**Qty**	**Cost (Rs)**
1 Material cost:						
a PE film (700 guage & 180 cm width)	8.5 mtr	62.00	—	—	—	—
b Bricks:						
Unburnt	1150	65.00	—	—	—	—
Burnt	100	23.50	—	--	—	—
c Wood	—	15.00	—	—	—	—
d Mud	—	Negligible	—	—	—	—
e Steel	—	—	110 kgs	495.00	425 mm	1700/-
f Concrete	—	—	1.58m³	605.00	—	—
2 Cost for man-hole and exit pipe	—	20.00	—	30.00	—	130/-
3 Fabrication cost	—	Negligible	—	65.00	—	550/-
4 Total cost	—	185.00	—	1295.00	—	2380/-

As could be observed, the cost of PUSA bin is many times cheaper than concrete and steel bins. Further, all the raw material required for the construction of the Pusa Bin could be obtained locally expecting the LDPE film which could be easily fabricated at site or could be fabricated in a town and easily transported to the village because of its flexibility and light weight.

Method of Construction

Select a hard floor for construction of the bin as prevention against rodents. A platform of 162 cm × 122 cm × 70 cm thick is made with unburnt bricks on the hard floor. In case the floor is not hard, the platform should be made of burnt bricks (Figure 7). Next, a black LDPE film, 700 gauge (175 micron) thick having 174 cm × 134 cm dimensions, is spread over the platform so that it extends 6 cm on all the four sides of the platform (Figure 8). Prepare with unburnt bricks another platform of the dimensions 162 cm × 122 cm × 7 cm with unburnt bricks, the inside walls are raised upto the height of 160 cm and internal areas of 140 cm × 100 cm (Figures 9 and 10). Plaster the inside of the structure with mud.

A wooden frame with the shape of inverted "P" with an additional pole at a distance of 45 cm from the end of the structure prepared earlier is placed at the top of the inner wall for supporting the roof. An additional pole, 162 cm × 4 × 4 cm, is placed at 25 cm distance from the other side of the structure to give further support thereto (Fig. 11).

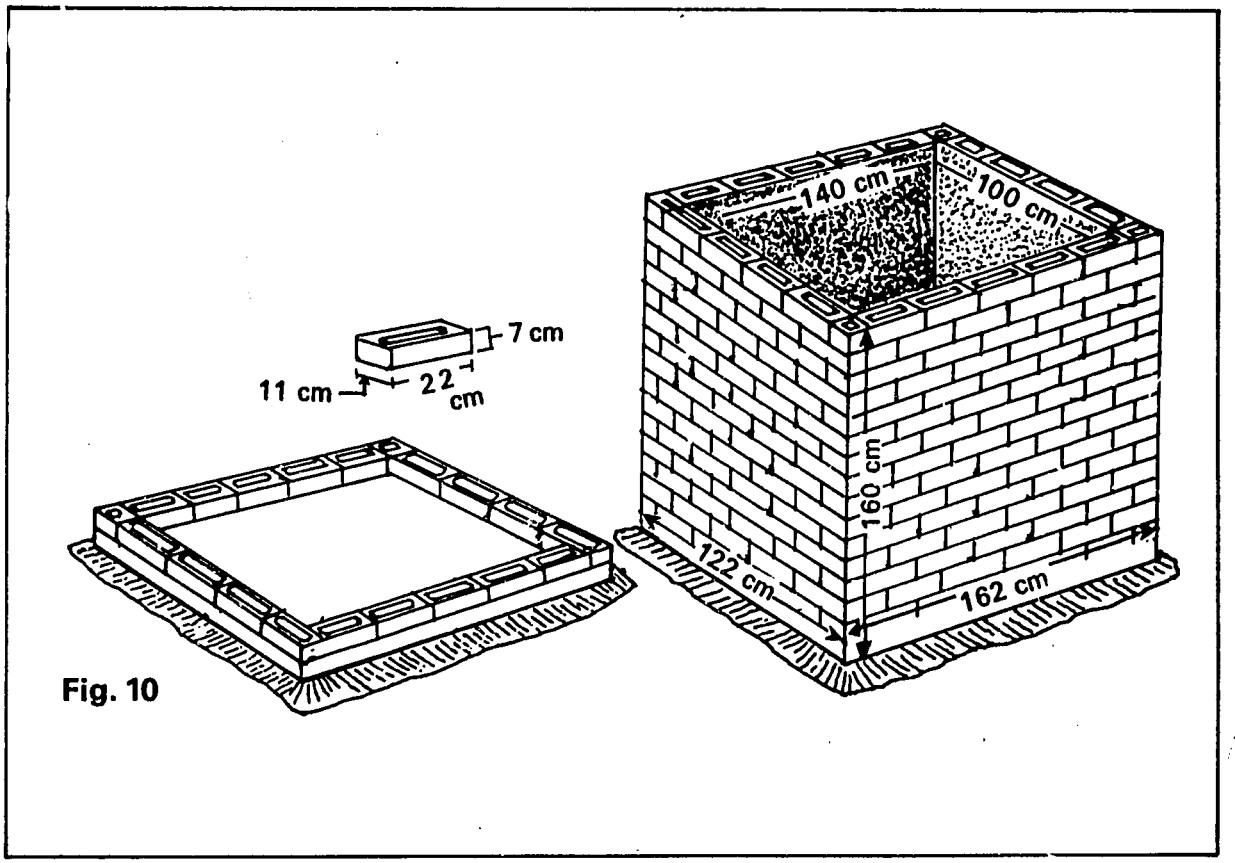


Fig. 10

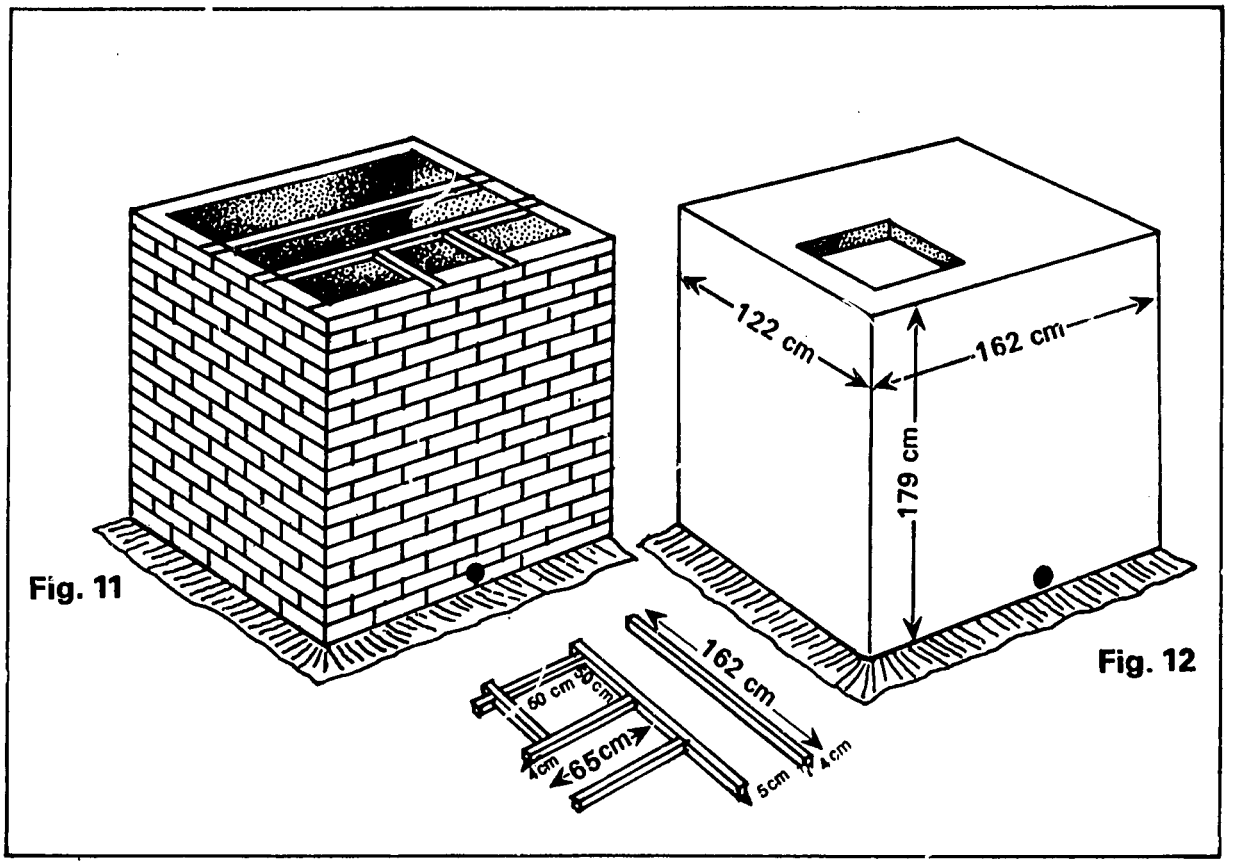
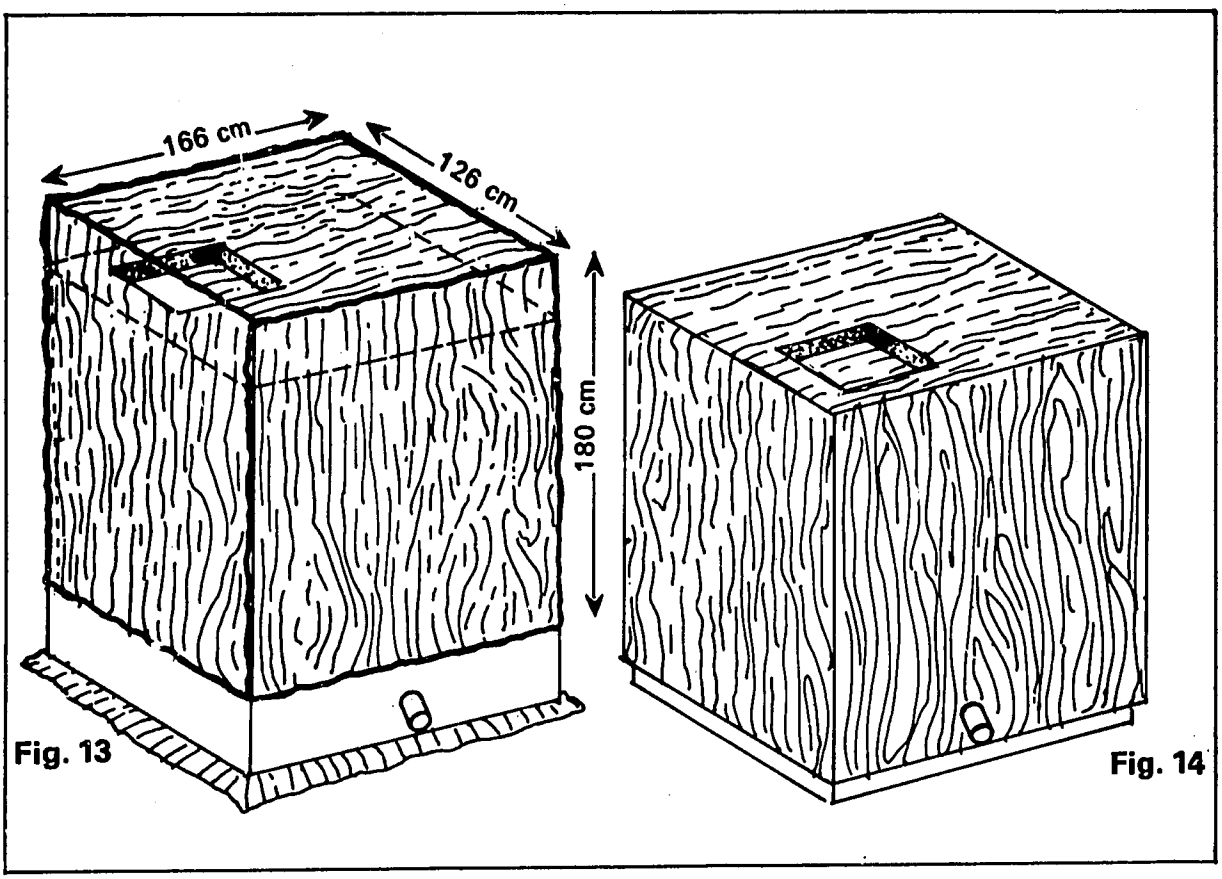
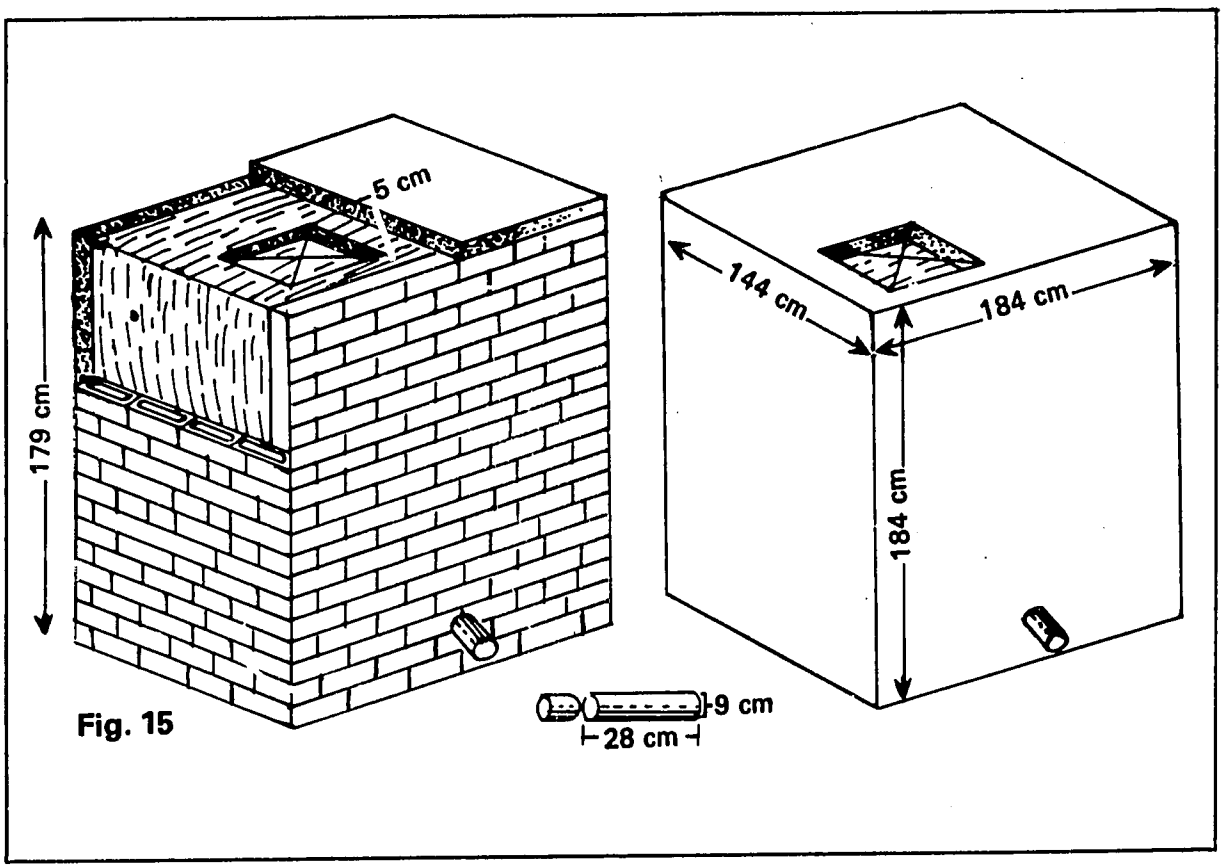


Fig. 11

Fig. 12


166 cm
126 cm
180 cm
Fig. 13
Fig. 14


5 cm
179 cm
144 cm
184 cm
184 cm
9 cm
28 cm
Fig. 15

A small hole of 9 cm diameter is cut in the middle front inside of the bin near the floor in the first layer of the inner wall to accomodate the exit pipe (Fig. 12). A mud slab 5 cm thick is prepared and placed over the raised inner wall to serve as the roof except the area of the man-hole (50 cm × 50 cm) in one corner (this is the square area of the frame). The structure is next plastered with mud on top as well as four sides and allowed to dry well.

An LDPE film cover (black LDPE film 700 gauge thick) of 166 × 126 × 180 cm high made (by heat sealing) in the form of a mosquito net, is placed over the dried structure (Fig. 13). At this stage a pouch made out of galvanised iron sheet or a plastic pipe of 9 cm dimension with a cap is fitted in the hole made in the middle front side of the bin for removal of grain. The LDPE cover is pulled to the lower most level so as to meet the LDPE film placed earlier on the platform. The extremeties of the LDPE cover and the film laid on the platform are heat-sealed. A small hole is cut in the LDPE cover to accommodate the exit pouch and the pouch is pulled out through this hole (Fig. 14). A little soft wax is applied around the pouch touching the LDPE film to make the portion completely air tight.

The LDPE film covering the 50 cm × 50 cm man-hole area is next cut diagonally (Fig. 15). Next, the outer wall of the structure is erected to a height of 179 cm using burnt bricks for the first 45 cm and unburnt bricks for the rest of the portion. Alternatively, a band of metal plate may be provided around the structure to a height of 45 cm to render the structure rodent proof. Place a mud slab, 5 cm thick, on the top leaving out one portion of the man-hole. The structure is plastered on top as well as four sides and allowed to dry before use. After the structure is filled with grain, the diagonal cut on the LDPE film covering the man-hole is sealed with adhesive tapes and the man-hole is plugged with mud.

For efficient performance, it is essential that the bin is completely dried before use and the moisture content in the grain is lowered to less than 8% before the same is placed inside the bin for storage. For efficient performance, it is also necessary that the bin is completely filled with grain so that the free space inside the bin is kept to the minimum. The bin could be made of various capacities and sizes. The raw material requirements for various capacity Pusa Bins are given below:

Table- 16 **RAW MATERIAL REQUIREMENT FOR PUSA BINS OF VARIOUS CAPACITIES**

Sl No	Capacity MT	Qty. of material regd.			Internal Dimensions		
		Length	Breadth	Height	LDPE film 700 g N²	Unburnt Bricks No.	Burnt Bricks
1	0.5	61	61	136	8.1	800	80
2	1.0	84	84	140	11.7	900	95
3	2.0	140	100	160	15.3	1150	100
3	4.0	172	152	160	20.88	1650	210

Besides, LDPE film and bricks, wooden frame and wooden pole of approximate size as described earlier for the construction of a 2 MT capacity Pusa bin could be used for construction of the bin. An exit pipe of 9 cm diameter made of galvanised iron sheet or plastic pipe with an air tight cap is to be used as the outlet manifold. Existing storage cubicles made of mud could also be lined with LDPE film to obtain safe storage conditions.

What Pusa Bin offers:

1 It is a damp proof structure.

2 It limits permeability of gases.

3 The thermal conductivity is very low.

How It Helps In Safe Storage of Grains:

Damage to stored grain occur from four sources; namely, insects, mites, micro-organisms and rodents. The safety of stored grain from the first three largely depends on:-

1 the moisture content of the grain;
2 the availability of oxygen to the stored grain;
3 development of temperature gradient within the stored grain.

The above factors have been effectively taken care of in the construction of the Pusa Bins.

LDPE film being an excellent moisture barrier prevents exchange of moisture between the stored grain and the outside atmosphere thus maintaining almost the same moisture content of the grain through out the storage period. Particular care must be taken to store grain having safe moisture content. The metabolic water released due to insect and/or grain respiration inside the storage space is insignificant if the exchange of moisture with outside atmosphere is taken care of.

The consumption of oxygen by the insects for respiration is as much as 130,000 times more than the amount used by grain on weight for weight basis. If the infested grain is sealed and stored inside the Pusa Bin, the consumption of oxygen by the insects and micro-organisms is very fast and this leads to rapid depletion of oxygen content inside the bin.

As each insects species requires a minimum percentage of oxygen in the atmosphere for survival, it ceases to exist once the oxygen content drops below the minimum. This is precisely what happens inside the Pusa Bin. Thus, the insects are eliminated much before the oxygen present inside the bin is totally exhausted and an aerobic respiration of the grains or the micro-organisms is expected to start.

The LDPE film being differentially permeable to oxygen and carbondioxide, it allows sufficient level of oxygen inside the bin to facilitate metabolisms of the stored grains. It further goes to show that it is enough if the storage structure is sufficiently air tight so as to bring down the oxygen content of the enclosed air to a desired level.

Due to variable temperature conditions inside the bin, there are such developments as (1) heat spots within the stored grain and (2) temperature gradient inside the grains bulk.

Heat spots are caused by the excessive heat produced by either insect multiplication or by microbial infection in some localised pockets of the stored grain. Insect respiration produces both water and heat. As the grain is comparatively a non-condutor, heat does not dissipate effectively which results in an increase in temperature and moisture inside the stored grain, leading to greater multiplication first of insects and later of micro-organisms. Some time these heat spots develop even without insect infestation if the moisture content of the grain is high enough for microbial activity. Temperature gradient develops as a result of unequal heating in the different portions of the stored grain because of the respiratory activity of the grain, insect infestation, microbial infestation, etc. The gradient is generally from the middle of the bin, where the temperature rises, to the periphery, where it may be low.

All these factors lead to the caking or even charring of the grain. It is, therefore, advisable to make the wall of the storage structure from a material with poor heat conductivity and Pusa Bin, being made of two layers of mud walls, offers this feature.

The moisture content of the grain, the development of temperature gradient within the stored grain are ideally taken care of in the construction of the Pusa Bin.

The polyethylene film is very good as a moisture barrier and its gas permeability is low enough to prevent insect and microbial multiplications. Thus, the Pusa Bin combines in itself the three major requirements of safe storage. It is moisture proof, it is sufficiently air tight and its walls have poor thermal conductivity.

Recommendations

Pusa Bin should be included under save grain campaign recommendation. The Agro-Industries Corporations should take up marketing of the LDPE film required for construction of Pusa Bin through the network of agro-service centres. Regional language versions of the Pusa Bin 'do-it-yourself mannual' should be prepared for distribution to the progressive cultivators so that awareness is created at grass-root level regarding use of scientific storgae methods for preservation of seeds and grains.

Outdoor Foodgrain Storage Covers

The green revolution in India, which revolutionised agricultural production and led to bumper harvests of wheat in the main wheat producing States of Pujab, Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh in the years 1968-69 and 1971-72, created in its wake the problem of storing large quantities of food grains marketed within a short span of six to eight weeks. During the rabi crash programmes for construction of godowns, mopping up all available ware-housing space with the Central and State Ware-housing Corporations and hiring of all types of accommodation were resorted to. Private parties also constructed storage accommodation on guarantee and custom basis. All these efforts could not cope with the phenomenal increase in food production which rose from 52 million tonnes in 1951-52 to 108 million tonnes in 1970-71. The Food Corporation of India, according to a Planning Commission directive, was supposed to provide a buffer stock of 7 million tonnes by the end of Fourth Five Year Plan ending 1973-74. The Corporation, however, had to build a buffer stock of 7 million tonnes by the middle of 1971 itself. Faced with such a challenge, some quick storage methods had to be devised and the result is what has now come to be popularly called Cover and Plinth (CAP) storage.

CAP storage is an improvised arrangement for storing food grains in the open, generally on plinths which are damp and rat proof, over which are laid wooden dunnage of crates and the grain bags stacked to standard size as in conventional storage. Each stack of grain was, in the initial stages, covered with either polyethylene covers or with tarpaulins to protect the grain from the vagaries of weather. Now the grain stacks are covered only by LDPE covers of 1000 gauge thickness.

It has been inferred from observations of stacks laid Uttar Pradesh, Punjab, Haryana, Rajasthan, Delhi, Maharashtra and Gujarat way back in 1972 that the stocks stored in open storage were practically free from deterioration for a period of one year and they were, at any rate, better than the stocks stored in hired godowns. From the experience gained till then, it was noted that food grains like wheat, gram, maize, paddy and jawar were suited for CAP storage. It was also inferred that CAP storage is the most economical of all the storage methods adopted by the FCI for bagged grains.

Till recently FCI was procuring around 60,000 CAP covers annually for storage of food grains in the open. The State Marketing Federation which are engaged in the procurement and trading of food grains, are also adopting this mode of storage for temporary storage of food grains in the open.

Development Efforts Required

Following are the recommendations of the National Committee for propagating plastics covers for outdoor storage of foodgrains:

i The CAP covers should be modified to reduce over-heating during the summer months. Resin manufacturers, in collaboration with FCI, should take up this exercise.

ii It has been reported tha reprocessed material is being mixed in the extrusion of film used for CAP covers. This is leading to early failure of the covers. The resin manufacturers along with reputed film processors should undertake a contract for supply of CAP covers of first quality so that this application is increasingly adopted by other food grain trading agencies.

iii The Agro-Industries Corporations should evaluate the possibility of marketing CAP cover-like storage structures to individual cultivators through the wide net work of agro service centres.

Fumigation of Stored Foodgrains

Food grains during storage develop insects and micro-organisms which can deteriorate the quality of the stored products and lead to heavy losses. The infested grain could be treated with suitable chemical agents so that these insects get killed and thus cannot multiply at a later stage. This facilitates longer storage life for the stored food grains. The chemical agents are generally toxic and should not be allowed to come in contact with human population. It is, therefore, necessary that the food grains to be fumigated are enclosed inside an impermeable cover for intensive fumigant action. For fumigation, a special type of plastics cover produced from LDPE is used. After the food grain is subjected to the fumigant action for sometime, the plastics cover is removed and the stocks are aerated to remove traces of toxic gas which may affect the workers working in the vicinity of the fumigation stacks.

Improved Bamboo Basket for Safe Storage

In the eastern regions, wheat cultivation is being taken up on a large scale. Because of high humidity, storage of wheat seeds has been posing a problem ever since wheat cultivation was taken up in these regions. The Assam Government had approached ICAR for assistance, and the Indian Agricultural Research Institute took up a project for developing a suitable storage method. Several modes of storage were tried and it was found that kerosene tins and polyethylene bags could store the grains at very low moisture content and germination of 88 to 96 percent.

Thus, a choice of polyethylene film (0.175mm/700 gauge) as a moisture proof material and basket prepared from bamboo strips as in vogue locally were made to fabricate a small structure with storage capacity of 70 kg. A pair of round baskets with flat bottom were painted with coaltar and plastered all round with mud and cow-dung (3:1) paste. The baskets were sun dried. A polyethylene cover of 195 cm diameter and 98 cm depth, having shape of the basket, was prepared by heat sealing. A basket with slightly smaller dimensions was inserted inside the polyethylene cover and then this polyethylene covered basket was gently inserted inside the second basket, leaving only 50 cm of open end of polyethylene uncovered. Wheat seed with 8 percent moisture content and 95 percent germination, was filled upto basket level and the open end of polyethylene was tied with a rope. The lid of the bakset was placed in position to cover the polyethylene. The structure was kept at 45 cm above the ground on a rectangular bamboo/wooden frame to prevent rodent damage. The seed samples were analysed after 6 months of storage. The seeds remained unaffected with regard to their moisture content and viability. These structures could be made readily available for safe storage of wheat seed in the coastal wheat growing regions.

This method of storage which can be easily fabricated by local artisans should be examined by Save Grain Campaign authorities and, if found suitable, it should be included in their recommendations.

Underground Storage Silos for Loose Grain

In many of the eastern and southern states in our country, food grains are stored in underground pits. These pits are usually lined with paddy straw at the bottom, sides and the top.

It is essential for the site of an underground grain storage silo to be on land that is well drained naturally. Pits are best strategically situated so that they are as close as practicable to harvesting and/or feeding out areas. They should not be placed adjacent to one another as moisture collected in an emptied pit could move laterally through the silo and spoil other pits. The pit needs to be in a resonably clear area so that grain can be handled quickly and easily by machinery as soon as the pit is opened.

The best soil types for storage pits are the hard-setting deep soils; for example, mulga, box, box-mulga, leopard-wood, in fact any solid which forms a water-shedding crust. Most red soils are ideal. Successful pit have been put down in heavy clay soils which crack extensively, but these can be troublesome with water, air and weevils entering the cracks after a dry spell. Weevils have been known to cause damage when the cracks are open, but with rain and subsequent closing of the cracks, the weevils were killed. This is, of course, through the lack of air.

The exclusion of air to the extent that insects cannot live in the grain is the big advantage of underground as against any other form of grain storage. Because of this, there is no need to treat grain with insecticide even if the grain is to be stored for several years. In conventional storage, it may have to be treated several times.

Localities where the water-table can rise to within a few feet of the surface are unsatisfactory as underground storage pits. Any movement of moisture into the grain will result in wastage. Lining of underground storage pits with LDPE film would pay for itself in terms of prevention of storage losses and improved quality of the stored grain, which can bring better market prices. The most suitable size for a pit will depend on the particular situation, for example, the number of stock to be fed and the above ground facilities.

A common size of pit is 9 metre long 3 metre wide and 1.8 metre deep. This size holds around 400 to 450 bags. The disadvantage in having a pit too large is that a pit has to be emptied as soon as practicable after it is opened. The reason for this is that, shoud rain fall on a pit that has been opened, a high percentage of the grain will be spoilt. The shape of the pit is important in practice. The sides should slope to the bottom to minimise caving in and consequent contamination of the grain by soil.

At least one end should have a steep batter. This makes it easier to empty. The steep batter is often achieved by laying logs of iron sheeting across the end. The bottom of slope at the other

end is probably best left fairly gentle-about 3:1 or 4:1 should be satisfactory. This allows simple entry and removal of equipment from the pit if equipment has to go into the pit during emptying. The pits should not be filled to more than a few inches above the ground level. If possible, the side of the pit should be smooth and flat so that no air pockets remain.

The Save Grain Campaign authorities should examine this mode of storage and initiate trials on some of the coastal villages in Andhra Pradesh and Tamil Nadu. The processibility of pac y stored in underground storage pits also should be studied.

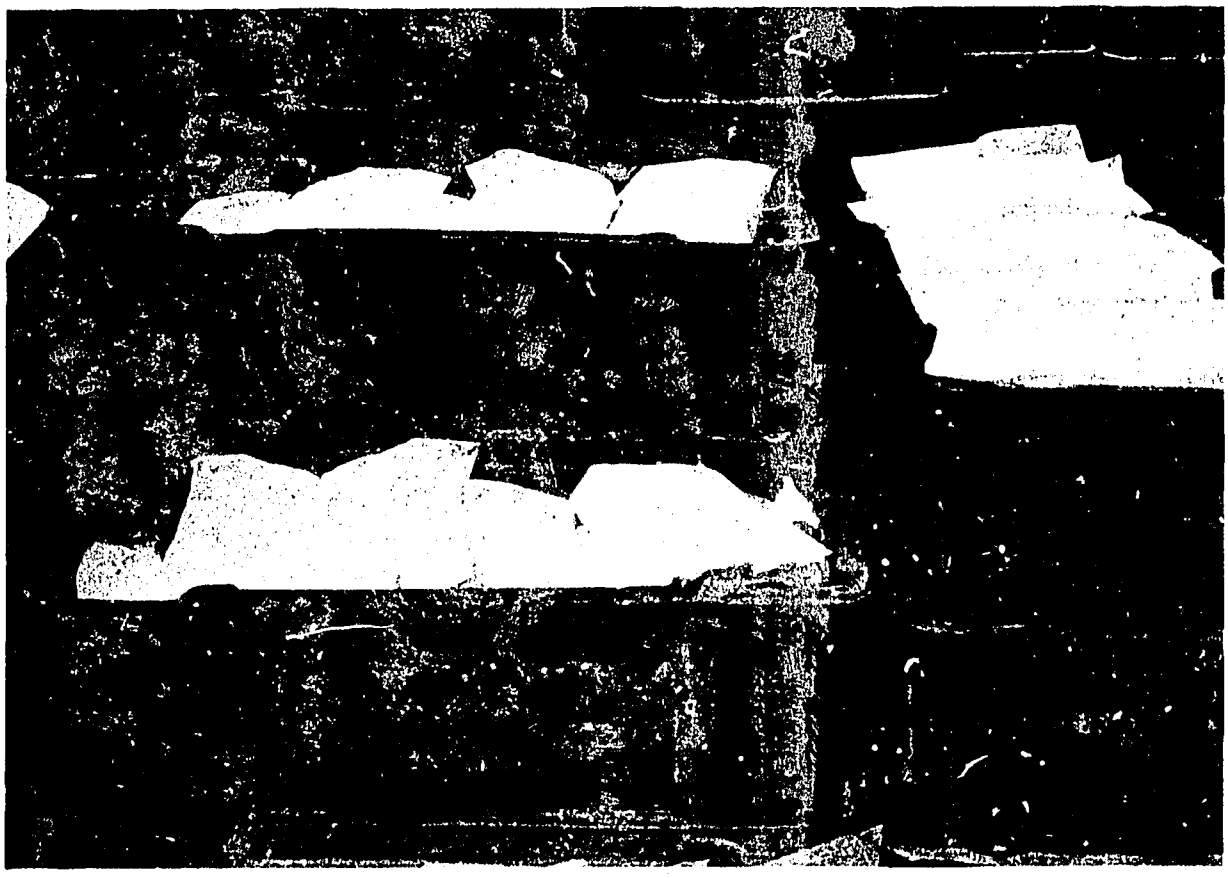
Fruit Storage

It has been observed that because of differential permeability of LDPE to carbon dioxide and oxygen, it is possible to create a natural storage atmosphere. The right condition for conservation of certain fruits, such as apples and pears, is in an atmosphere of 5 to 7% of carbon dioxide and 2.3-3% of oxygen. This process is valid for small lots, upto a tonne, but under certain conditions it is necessary to use more permeable membranes such as silicones.

Plastic Bags for Agricultural Produce Packaging

Plastics woven sacks as well as knitted bags can be used in the storage and transportation of agricultural and horticultural produce. These bags can be reused many times. Storage in LDPE film lined bags reduces shrivelling of the fruits to an appreciable extent. The farmers in Gujarat transport vegetable to Bombay City in LDPE film lined jute sacks.

There is a vast scope for plastics packaging in the vegetable and fruits for export market. One case in point is bananas. The quality of the harvested banana could be preserved if LDPE bags are used over the banana bunches and transporting them in paper cartons.



Milk packed in LDPE sachets being transported in HDPE crates.

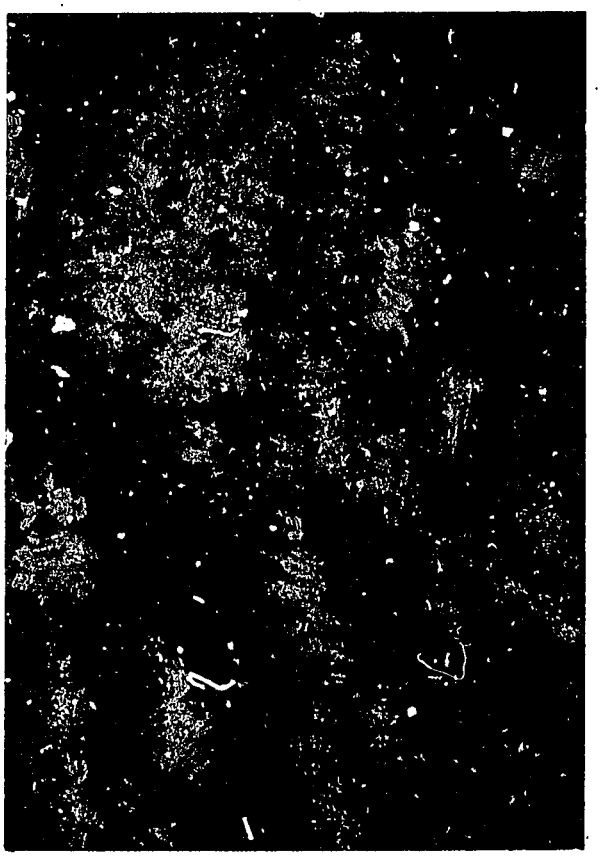
Plastics Trays/Crates

Collapsible plastics trays/crates, could be developed in the country for transportation of fruits such as apples etc., over long distances. Being collapsible these trays could be returned to the place of origin with minimal cost. Currently, apples produced in Himachal Pradesh and Kashmir are being packed in wooden boxes for transporting to the various city centres all over the country. It is estimated that about 1 million trees are cut every year for this purpose, leading to massive deforestation and associated ecological imbalance such as silting of dams, floods in river valleys and heavy erosion and gully formation. Collapsible plastics trays can replace the wooden crates with a little more initial investment.

Because of the returnable nature of the plastic trays, the initial investment could be recovered and it may prove more economical over a period of time.

Recommendations:

The PP resin manufacturers should undertake detailed cost estimates for the manufacture of PP crates in the country. Detailed techno-economic feasibility report on use of such crates for fruit packaging should be prepared for consideration.

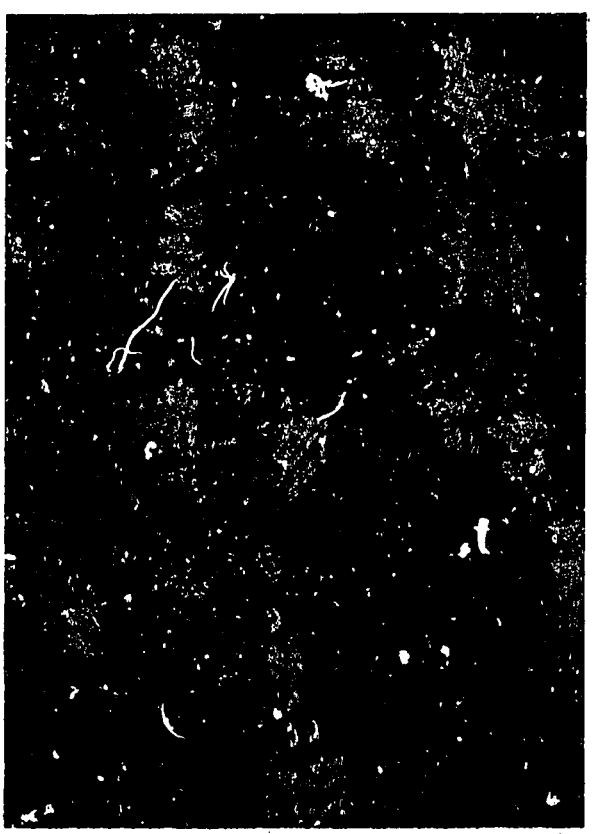


Apple packaging using thermo formed plastics sheets.

Land Reclamation

In sandy and porous soils water retention for plant usage poses a formidable problem. Since usually such areas also face scarcity of water, it becomes a necessity that suitable methods are devised for increasing the water retention capacity of the soil. Growing of Paddy in sandy soils is a test case where the soil must be made to have a water barrier at certain depth of the soil so that adequate moisture is available for optimal plant growth.

It has been reported that in some coastal areas of Tamil Nadu farmers even go to the extent of laying a concrete bed under the soil so as to prevent water percolation in sandy soils for growing wet land paddy. Use of plastics film such as LDPE heavy duty film can simplify this to a very great extent. The Irrigation and Power Research Institute, Amritsar has taken up limited trials of lining of sandy soils with LDPE film for growing wet land paddy and their findings are encouraging.



Reports also have been received from Taiwan as well as USA regarding the effectiveness of plastics sub-soil barriers. In Israel, plastics films barriers laid under the desert sand combined with modern drip irrigation system has resulted in very high water use efficiency and increased agricultural production. The technique has been modified and developed so as to prevent excess salt accumulation on the upper surface of the plastics film which may result in damage to the root stock.

Thorough study should be taken up to understand the use of plastics film barrier on a large scale in areas where less water holding capacity of the soil poses a threat to normal cultivation practices. Further research should be initiated in Rajasthan, Punjab and Gujarat (northern) regions for determining the techno-economic feasibility of this application.

Gobar Gas Plant and Holder: Plastics Piping System for Distribution of Gas from Community Plants.

Gobar gas from large community plants is distributed through pipe network. Trials have been conducted using PVC pipes for gobar gas distribution. Pipes used for gas distribution are normally in the small size (upto 50 mm dia). Both PVC and HDPE pipes would be considerably cheaper than steel pipes.

Gas Holders

Gas holders have been developed using rigid PVC and HDPE. These gas hoders provide an advantage of low maintenance cost as they do not get corroded. The requirement of PVC or HDPE for construction of gas holders for a small family size gobar gas plant (3 cubic metre) is about 36 kg. The cost of a rigid PVC gas holder for 3 cubic meter gobar gas plant would be in the region of Rs. 3000/- to Rs. 3400/- per holder. The cost of a normal metal gobar gas holder for the same size gobar gas plant would be in the region of about Rs. 3000/- per holder. In other words, rigid PVC holders would be comparable with metal holders.

It has been reported that experiments have been carried out with flexible PVC nylon laminate to develop a flexible gas holder in place of the rigid metal holder. If such flexible holders are not damaged due to the external mechanical abuse it would be considerably cheaper than the metal holder.

It is, however, necessary that further field trials are undertaken to assess the service life of such flexible holders based on PVC Nylon laminate.

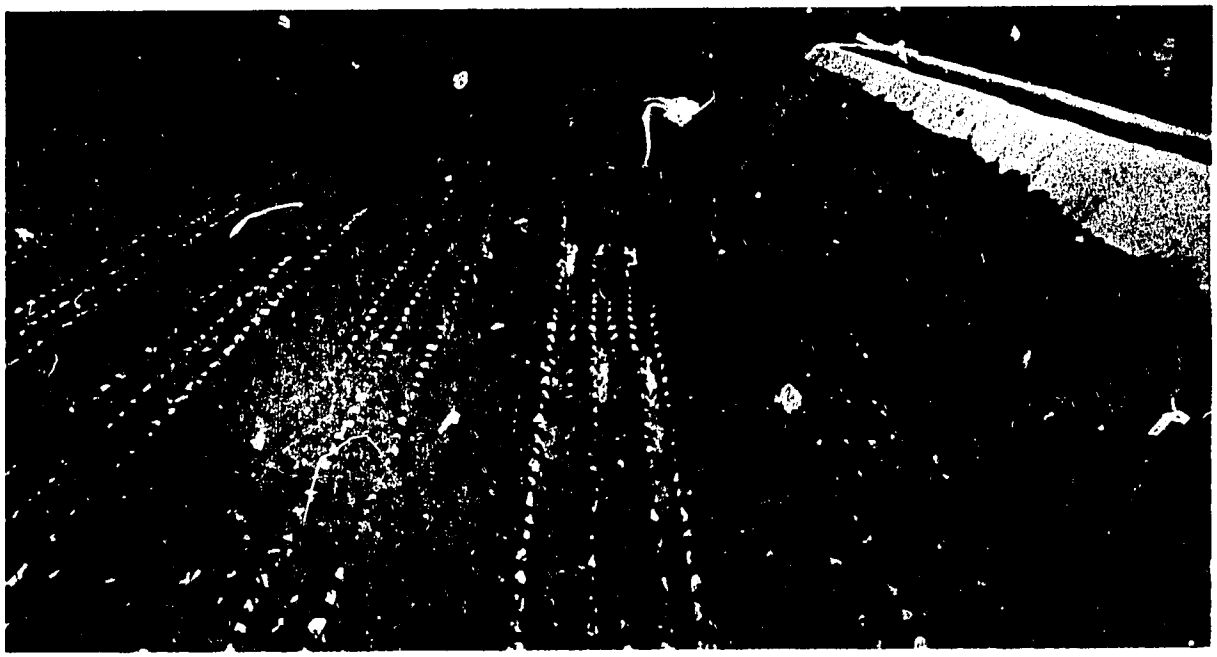
Lining of Slurry pits

Trials are being undertaken using PVC/LDPE film lining of slurry pits. Gas holders for such plants are also prepared from PVC sheets covered with timber. It has been reported that the cost of such plants is 30% cheaper compared to normal gas plants.

Nutrient Film Technique (NFT)

The Nutrient Film Technique (NFT) is a method of growing crops in a thin film of water containing plant nutrients. This technique was developed by Dr. Allen Cooper in the U.K. and is used today in several countries for growing vegetables and flowers in greenhouse. National Organic Chemicals Industries Ltd. (NOCIL) has modified the technique under Indian conditions of farming.

Essentially, the NFT refers to water management. It involves "encouraging" plants to send their root into gullies lined with plastics films. These gullies hold water and plant nutrients. A capillary matting in the form of a narrow strip of sack cloth (about 2" wide and 4" long) is used for attracting the roots towards the gully. One end of the capillary matting is dipped in the nutrient solution in the gully. The plant is placed in capillary matting and held there with a thin layer of soil. The roots are guided by the wet capillary matting into the gully. Here the roots are able to draw all the nutrients and water required by the plant for healthy growth, from the gully.



Different stages of NFT planting.

The NFT system consists of one tank (capacity 4000 to 6000 litres of water) and several plastic gullies root on the soil at right angles to the tank (Fig. 16).

The tank is made out of soil compacted and overlaid with a plastics film. It is erected to stand a couple of feet above the level of the gullies. The gullies themselves are small furrows about 8.5 cm deep, dug in to levelled land and lined with plastics film (Fig. 17). From the water source (well, river or canal) water is pumped into the tank. A small plastics tube is used to siphon water from the tank into the gullies. Standard fertiliser grades mixed in a balanced proportion to provide all the nutrients, including micro-nutrients, required by plants are added to the tank.

A capillary matting made of narrow strip of sack cloth (about 7 cm wide and 10 cm long) is used for attracting and guiding the roots towards the gully. One end of this capillary matting is dipped into the nutrient solution in the gully (Fig. 18). The plant is placed on the capillary matting, and held secure with a thin layer of soil (Fig. 19).

A small barrier of plastic film is placed below the capillary matting to prevent water getting into the soil via the capillary matting. The roots follow the wet capillary matting into the gully. Once in the gully, the roots are able to draw all the nutrients and water required by the plant for healthy growth.

Some of the roots go into the soil as shown in the illustration (Fig. 20) and this helps anchor the plant. As plant draw water from the gullies, it is replenished from the tank.

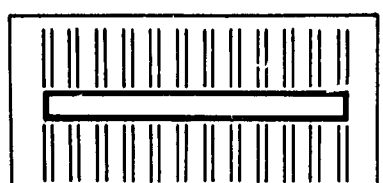


Fig. 16

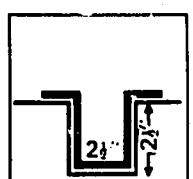


Fig. 17

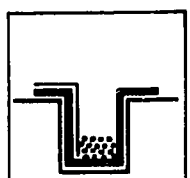


Fig. 18

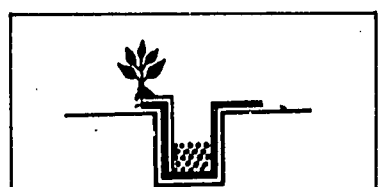


Fig. 19

Fig. 20

Chilly/Sugarcane/Sorghum under NFT system.

Advantages of NFT

i NFT maximises efficient use of water and nutrients, the two scarce inputs in our country. It has been reported that excellent plant yields have been obtained with one-fourth the quantity of water normally used in conventional methods or irrigation.

ii All the nutrients added are made directly available to plants. In normal agriculture part of the fertiliser added is either physically leached away from the root zone or gets chemically fixed in the soil and thus becomes unavailable to the plant roots. There is no such problem with NFT, since the nurtients are all in the gully and are readily available to the roots.

iii Since the plants get all the water and nutrients, full growth is achieved. It is, therefore, possible to get very high yields.

iv In NFT, soil fertility is immaterial. So it is possible to get good yields even from poor soil, since all the nutrient is provided to plants through the gullies and soil is used merely to anchor the plants.

v It is possible to add 'systemic' pesticides (i.e. pesticides which are absorbed by plants and translocated throughout the plant 'systems') to the water in the tank. This eliminates the need to spray insecticides. It is also possible to get good results with a fraction of the normal dosage, because whatever is added is efficiently absorbed by the plants through the gullies.

vi Although a major portion of the work has been carried out with hybrid napier grass, it is possible to use NFT to grow a wide variety of crops such as vegetables. Initial experiments with sugarcane have proved encouraging.

Economics of NFT

The cost economics of NFT on growing of napier grass as reported by NOCIL are given below: One NFT unit covering 550 sq. metres consists of a liner for a tank (of approximately 6000 litre capacity) and 88 gullies (each 10 metres). The cost of one such unit is about Rs.1750/-.

The other items required are:

Sack cloth	: Rs 210
Hose	: Rs 75
Cost of Hybrid Napier Grass sets	: Rs 200

Fertilisers are supplied in two packs - macro - nutrients in one pack and micro-nutrients in another pack. The macro-nutrients are added @ 1.5 kgs. per 1000 litres of water, and the micro-nutrients @ 55 gms per 1000 litres of water. Water consumption is roughly 1100 litres per day and on this basis, the cost of fertilisers works out to approximately Rs1,800 per annum.

On a yearly basis the costs work out as follows:

Cost of plastics	Rs 875 (1750 ÷ 2 years life)
Hose, sack cloth and sets	Rs 97 (485 ÷ 5 years)
Cost of fertilisers	Rs 1800
Labour (½ man-day throughout the year)	Rs 900 (180 man-days @ Rs.5 per day)
	Rs 3672 rounded to Rs 3700/-

The yield: Each line of hybrid napier grass is expected to yield 14 kgs per cutting. There are 176 lines and approximately 12 cuttings per year.

Therefore, a 550 sq. metres plot can be expected to yield approximately 30 tonnes of fodder per annum. The cost of production, therefore, works out to Rs 124 per tonne, as against which the value of the fodder is about Rs 150 per tonne.

The sites where NFT has been used in our country on trial basis as well as on commercial scale are given below:

A. Demonstration

1 Chitrakoot, Madhya Pradesh :15 acres - 60 families
2 Mafatlal Engineering Kalwa, Maharashtra: 3.5 acres
3 Mr. Garewal's farm Gurgaon, Haryana
4 University of Agricultural Research, Hebai, Karnataka
5 CIPET, Madras
6 Shalibory Fodder Research Instt, Midnapore, W.B.
7 Tilonia, Rajasthan
8 Indore, MP
9 NOCIL Plant, Thane

Total area 20 acres.

(Crops grown: Napier grass, Brinjal, Tomato, Capsicum, Chillies, Soyabean, Cotton).

B. Commercial

Total No. of units sold	: 32
Installed	: 9-10
Area	: 1.5 acres

Hybrid Napier Installation on a farmer's field at Chitrakoot, Madhya Pradesh.

NFT is a modern hydroponics technique using plastics film and can be adopted on a large scale in the desert and acute water scarcity areas. This technique also can be most suitable in greenhouse cultivation where controlled environment agriculture alongwith modern water management techniques could be used to yield high water use efficiency and increased agricultural production.

The NFT technique should be examined by ICAR so that suitable operation research programmes could be taken up to establish the usefulness of this application for inclusion in the package of practices.

Silage:

Animal husbandary has been an integral part of Indian farming for centuries as it provides motive power for farm operation, milk and milk products for family use and commercial scale. Farm animals also provide natural manure for soil and fuel for domestic consumption. Importance of animal husbandary, therefore, could not over-emphasised. The White Revolution has now brought to the doorstep of the farmer new breeds of animals and improved nutrient feeding patterns which is resulting in very high rate of milk production. In the table below are given the various types of cattle feeds available, total digestible nutrient (TDN) value expressed on dry basis and period during which these feeds are available in a typical annual cycle:

Table-17

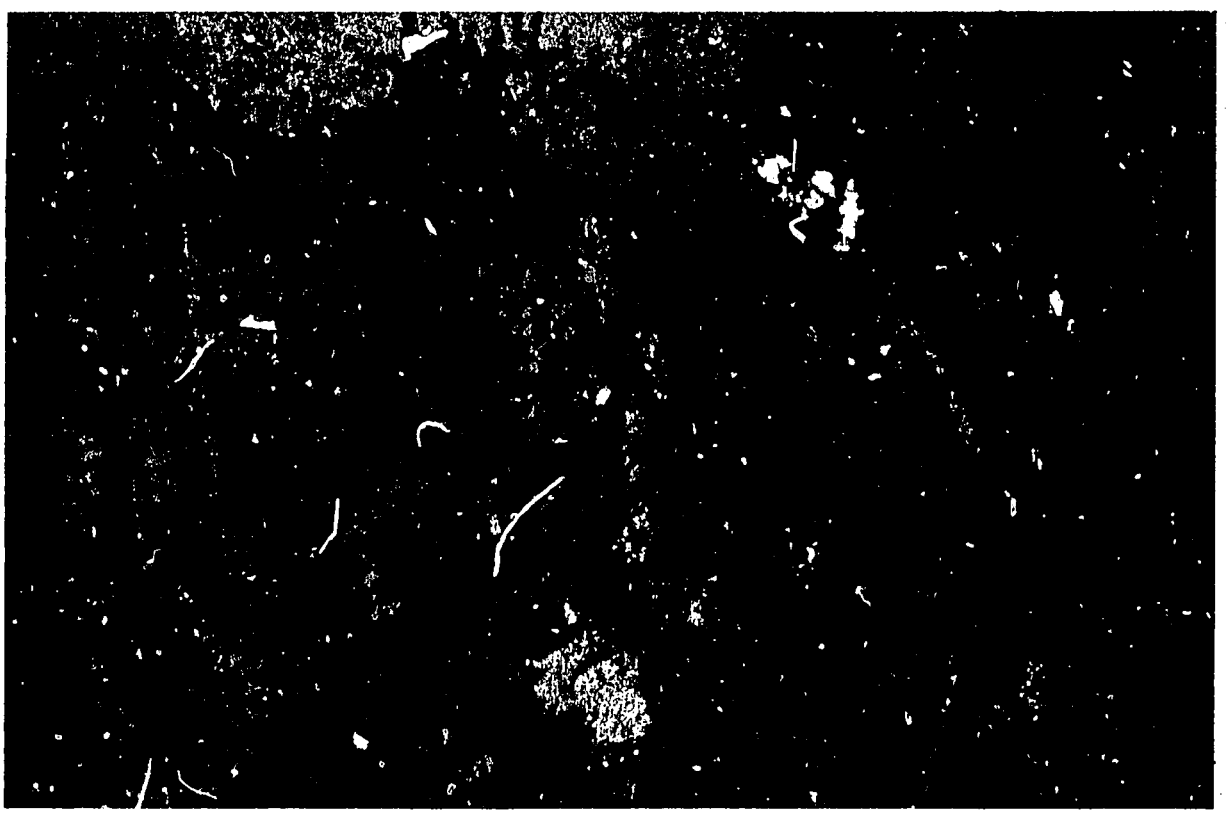
Description	TDN Value (%)	Period of Availability
Green forage	65	Monsoons and part winter
Hay	50-55	Throughout the year
Green roughage	40-45	Monsoon and part winter
Dry roughage	20-25	Throughout the year
Prepared feed		
Hay with grain	55-60	Throughout the year
Dry roughage with grain	40-45	Throughout the year

Dry roughage is the only cattle feed available to small scale and marginal farmers from their own agricultural operations. From the table above, it may be observed that if green roughage in place of dry roughage is made available, substantial benefit will accur to the small scale and marginal farmers because of its high TDN value. Because of the seasonal nature of precipitation in our country, the availability of green fodders also follows a seasonal pattern. In the process, the farm animals do not get adequate supply of greens - such as grass and legumes in the summer. This leads to tremendous drop in milk production and scarcity of milk at consumer's level. One conventional method to overcome such situations is to ensile the green fodder when it is excess and utilising the silage in the lean periods to feed the animals. Ensiling is a technique to preserve freshly cut forage/roughage in the absence of air, with or without addition of preservatives like salt, jaggery or molasses, to produce a moist, succulent and palatable feed for cattle. In the ensiling process, freshly cut green forage/roughage is compacted to reduce entrapped air and is stored in an airtight silo or

trench. During storage the material undergoes fermentation and sugars are converted to lactic and other related acids which are normally produced in the digestive system of the cattle. It is very important to exclude air during ensiling as live cells in the freshly cut green forage/roughage will undergo normal respiration in presence of air thus converting sugar/carbohydrates into carbon dioxide, water and indigestible acids, and rendering the feed unpalatable. Quality of silage produced through ensiling is dependent on the time taken in filling the silo after cutting of green forage/roughage, degree of compaction achieved, exclusion of air during storage and addition of preservatives.

Constructing permanent silo like tower silos is beyond the capacity of most of the cultivators while in trench silos there is spoilage due to contamination of fodder with soil and entrapped air. The losses of soluble nutrients due to seepage are also alarming. In view of the above factors, silage making has not been a popular practice with dairy farmers.

Use of low density polyethylene film to modify the conventional silage methods would overcome most of the problems encountered in conventional silage and, at the same time, it would be economical and easy to practice at cultivators level. Research and development work on use of low density polyethylene film for silos was carried out in the USA in early 1050's because of its low air permeability, good moisture barrier property and weatherability. It has been proved through various trials that 'spoilage' is minimum with LDPE silo covers. LDPE film was therefore commercially introduced as silo covers in late 1950's. Limited R&D trials carried out in 1977 under Indian conditions have conformed to the USA test results.



Silage preservation using LDPE film.

LDPE heavy duty black film, both in tubular and flat form, it is used for preparing silos. Plastic silos can be tailor-made to meet individual needs because of its low capital cost and ease of fabrication. Techniques of fabricating bag silo for use at small scale farmer's level and trench/concrete silo with a film cover for use of medium to large scale farmers are given below:-

Recommendations for Fabrication of Polyethylene Bag Silo

I Bag Specification:

1 Bag should be fabricated from black firm to prevent discolouration of silage when stored in open area.
2 Black film should be weather resistance quality.
3 Thickness of the film should be 125 microns so as to withstand compaction operation without tearing.
4 Size of the bag is related to the size of chopped forage/roughage and degree of compaction achieved. For 25 kgs. silage, a bag of 25" L and 24" W is recommended.

II Filling of Foddar:

1 Roughage to be ensiled should be chopped to size 1" and below, which will make it possible to achieve higher degree of compaction.
2 Chopped roughage mixed with preservatives is to be filled in the bag and compacted manually to minimise trapped air and provide at least 8" of the film length for tying the end of the bag
3 The unfilled length of the bag should be twisted to squeeze out the air from the bag, and then tied with a rubber band or string. Excess film should then be doubledback and retired to ensure that the bag is airtight.

III Handling & Storage:

1 Care must be taken to avoid damage to the bag during compacting operation, handling and storage.
2 The bags should be stored on even surface free from sharp projections. Storing of the bags under a tree should be avoided as the twings falling from it are likely to damage the bag.
3 Storage area should preferably be on a plinth and fenced out to keep off rodents and animals.
4 Any damage to the bag should be immediately repaired using a pressure sensitive tape. In case the bag is damaged beyond repair a fresh bag may be slipped over the old one. The ends of the new bag should be tied in a similar manner as discussed above.

Recommendations for fabrication of Trench Silo with Plastic Cover:

I Film Specifications:

1 Polyethylene film for cover should be black in colour to prevent discolouring of silage.
2 The black film should be of weather resistant quality
3 Thickness of film should be 100 microns to provide effective moisture and air barrier.
4 Film used for the cover should be seamless in width. The dimensions of the trench and the stack may be adjusted to suit the film size.

II Selection of Trench Site:

1 Site selected for the trench silo should be comparatively at higher ground level to prevent water logging, etc.
2 Silo should be made in an open area and away from trees.

III Preparation of Trench:

1 Depth of the trench shall be governed by local conditions such as water table, nature of soil, etc.
2 Trench should be lined with 50 microns thick black film for better results.
3 Film used for lining should preferably be seamless in width or joints should be heat-sealed. Loose ends of film lining should be anchored in 8"x8" channel dug around the trench and weighed down with soil.
4 Where the desired depth of the trench cannot be attained due to adverse local conditions mentioned under III(l), the stack may be raised above ground level. Table given hereunder specifies the width and height of the stack above ground level for a given width of film.
5 Length of the trench may be varied according to quantity of forage to be ensiled.

Table- 18

Film width (feet)	Stack width (feet)	Stack height (feet)	*Estimated stack capacity above ground level (tonnes/ft. Run)
20	11.5	6.0	0.85
24	14.0	7.0	1.10

IV Filling of Silo:

1 Freshly chopped forage should be placed in the trench in layers to form a stack and tramped upon to compress the forage.
2 Preservatives shall be added in layers while laying the forage in trench.
3 Where the stack is raised above ground level, the forage laid in layers shall be compacted by use of a steel roller or a tractor. The shape of stack above ground should be circular to withstand wind velocity.
4 Stacking operations should be completed as quickly as possible to minimise spoilage.

V Covering of Stack:

1 Black film cover should be immediately pulled over the stack. Loose ends of the cover should be anchored in 8"x8" channel and weighed down with soil.
2 A few days later as the stack settles down, the cover may develop slack. This loose film should be pulled on the sides of the stack and weighed down by placing soil over it.

VI Precautions:

1 Plastic cover should be protected against damage from external source such as animals, by providing fence all around.
2 Maximum height of stack above ground should not exceed seven feet.
3 Any damage to the film should be immediately repaired. If the damaged cover is beyond repair, then a fresh cover should be pulled over the stack without removing the old one.

Recommendations on Use of Polyethylene Film as Cover in a Concrete Silo:

I Film Specifications:

1 Polyethylene film for cover should be black in colour to prevent discolouring of silage.
2 The black film should be of weather resistant quality and seamless in width.
3 Thickness of film should be 100 microns to provide effective moisture and air barrier.

II Laying of Film Cover:

1 Film should be spread on well compacted forage in the silo.

2 Film should not be stretched while laying. A slack of 8% should be povided to compensate for thermal contraction due to temperature variation.

3 Free ends of film should be carried to a height of 12" along the wall of silo and an earth layer of 6-8 inches should be placed over the film all along the walls of silo to make it air-tight.

1 Cover should be inspected from time to time any damage due to birds, etc. A layer of earth 1/2" to 1' uniformly spread over the film shall protect the film against such damage.
2 Care should be taken that while removing the silage at the bottom of the silo polyethylene cover at the top of the silo is not disturbed thereby exposing the silage to air.

The cost economics of bag silo and concrete/trench silo is at Annexure-X. As per the cost benefit analysis presented at Annexure-X, the net additional income to the farmer by using bag silage technique for preservation of fodder is estimated at Rs. 280/- per cattle per year.

The net saving per cattle per season, therefore, works out to Rs. 690/- in case of concrete silo and Rs. 709/- in case of trench silo.

Development efforts required

Following are the recommendations of the National Committee for popularising the LDPE film silage applications in the dairy farms. The institution of Co-operative Societies for organised dairying would further help in propagation of the silage techniques in the rural areas.

i An audiovisual/documentary film on ensiling technique using LDPE film should be produced for mass exhibition. The film should include cost benefit analysis which can be understood by the cultivators.
ii The modern dairy co-operatives should take up LDPE film silage on trial basis at member dairies on subsidised rates. The resin manufacturers as well as film producers should draw up a joint plan for supply of LDPE film at grass root level for this application.
iii The TV network as well as radio programmes should take up extension of this application during their rural/agricultural programmes.
iv The National Dairy Development Board should evaluate LDPE film silage and produce an independent paper on its technical and economic feasibility.

Salt Pan Lining With LDPE Film

The value of brine in the salt works increases as it gets concentrated and, therefore, any percolation of concentrated brine in the crystalliser pans is disadvantageous. The treatment given to the crystalliser beds for making them impermeable to brine consists of compacting the pan beds with concentrated brine to a small depth and tamping the beds on formation of small sized crystals with wooden 'Tippani' or with the pressure of the heals. At certain places where all other factors are favourable for establishing the salt industry, but the soil condition is unfavourable for preparation of impermeable pan beds, the salt works cannot be set up. Proposals to top dress one crystalliser bed with foreign soil in such areas has not been found satisfactory due to practical difficulties and cost involved in importing the soil from nearby regions.

Cementing the pan bed is also expensive, both in terms of initial cost of construction and its maintenance. Therefore, some economical process which can check percolation in all sorts of soils is required. LDPE film lining of crystalliser beds tried at the experimental farm of the Central Salt and Marine Chemicals Research Institute, Bhavnagar (Gujarat) appears to be suitable.

Before lining of the LDPE film is undertaken, the crystalliser bad is levelled about 3-4 cm deeper than desired. The levelling of beds is an important operation and unless done carefully, will cause rupturing of polyethylene film at the sharp protrusion points. For preparation of a smooth surface a roller is made to passover the mud bed several times and it has been observed to have served the purpose. After one surface of the pan bed is levelled, the LDPE film is spread over and the adjacent lengths of the film are either heat sealed or over lapped. Next the soil removed from the pan bed is spread over LDPE film to the extent of 3-4 cms. and treated in the conventional way so that the top soil layer becomes hard and compact and its contaminating the salt is minimised. Maintenance of a thin permanent layer of salt over this, further avoids chances of contamination with soil. The sides of the crystalliser beds are also lined with LDPE film and dressed well so that the soil on the LDPE film in the sides does not collapse.

In actual experiments carried out at CSMRI, Bhavnagar, it was observed that the specific gravity of discharged brine was 1.262 and 1.260 respectively for LDPE lined pan and pan without lining.

The advantages of lining salt pans with LDPE films are:

i The percolation of brine is checked, thereby the rate of production is increased to the extent the brine would have percolated. Further the heat conduction from the bottom and walls of crystalliser pans is checked due to poor conduction of heat through LDPE film.

ii Physical loss of heat by percolation of hot bottom layer through the crystalliser bed and physical loss of heat due to the presence of underground stream is checked.

iii The process of lining with LDPE film is much simpler compared to other lining modes.

LDPE film lining has been used to check percolation losses in bittern reservoirs at the Hindustan Salt Works, Kharagoda. Originally, the plant authorities had used concrete lining which became ineffective because of cracks which developed in the concrete lining.

At Madangiri Salt Works, Karwar, LDPE film has been used for lining 5 ponds of 200' x 100' dimensions.

Recommendations

Discussion should be initiated with the Central Salt Commission for introducing plastics film in the lining of salt pans. If required, the resin manufacturers/processors should take up free supply of plastics film for trial/demonstration in selected stretches. Besides, the possibility of heavy duty film liners for railway carriages and trucks transporting salt should also be examined.

CHAPTER 9

National Committee Recommendations

The diverse agro-climatic conditions prevailing in the country make the success of most of the plasticulture applications which have been tried in the developed and developing countries as well as small pockets within the country possible. However, promoting all these applictions would be too massive a job and it would, therefore, be desirable that some potential applictions are identified which could be promoted on a large scale all over the country. The selected applications should either have large volume demand for plastics products such as canal lining or have high socio-economic benefits.

The following applications can be considered for such large scale adoption:

i Pond/Reservoir lining;
ii Canal lining;
iii Plastics pipes for water distribution;
iv Drip irrigation;
v Mulching;
vi Greenhouses and tunnels;
vii Silage;
viii Packaging and storage of agricultural produce.

The promotional and developmental measures which should be adopted are discussed below:

i Pond/Reservoir Lining

The pond lining work established in the country has been discussed in detail in the previous chapters.

In the Sixth Five Year Plan, high priority has been given to "minimising the losses at the storage/diversion point" and it lays great emphasis on increasing agricultural production in dry land/rainfed arable lands. In selecting such areas, availability of technical knowhow, based on research and development, and recommendations for crop planning either from ICAR's dry land research centres or from Agricultural Universities, will be relied upon. A programme of propagation of water harvesting technology in medium rainfall areas will be introduced in order to conserve available moisture and utilise it for supplementary irrigation. The run-off of water collected in farm ponds can be used for saving standing Kharif crops, providing presowing irrigation and extending the growing season as well as providing a minimal irrigation for growing vegetables, fruits or fodder in small areas.

The use of plastics film in the lining of water harvesting ponds, village ponds as well as reservoirs can be taken up with the existing budgetary provision.

The ICAR should explore the areas where LDPE film lining can be promoted, and identify projects where these modern methods could be used with economic advantage. In fact, it is quite likely that introduction of LDPE film lining may result in substantial saving.

One important area where LDPE film lining can be used is the tank lining in Churu district of Rajasthan. The State Government may request the Public Health Engineering Department to explore the possibility of LDPE film lining on a large scale. The resin manufacturers should assist the State Government authorities in taking up demonstrations at field level.

ii Canal lining

Lining of canals is an established application in the country. We have a vast experience available in the country in the lining of canals. Heavy duty LDPE film, which could be most suitably adopted for the lining of canals and reservoirs, is being manufactured in the country by several processors. The resin manufacturers as well as converters have done a commandable work in spreading the message regarding LDPE film canal lining to almost all the irrigation projects in the counry.

It is estimated that there exists a vast potential for LDPE film canal lining in the country. The tables below indicate the quantity of LDPE film which would be required to line the existing canal network.

Table-19

LDPE film potential for Canal Lining (All India)

Average Canal Dimension (Bed width)	Canal	LDPE film potential
15 metres	18,000 km	for 1000 guage film 68,000 MT or for 400 guage film 27,000 MT

Table-20

LDPE film potential for Distributary Lining

Distributary Dimension (Bed Width)	Distributary length	LDPE film potential
5 metres	90,000 km	for 1000 guage film 113,000 MT OR for 400 guage film 45,000 MT

The use of LDPE film lining would mean seepage free service for the canal network which can increase the total irrigated area appreciably. Thus, with marginal increase in investment, the effectiveness of the canal network could be increased. Besides saving in water losses due to seepage, the use of LDPE film lining would prevent water logging and salinity. Use of LDPE film lining also may reduce costs in terms of decrease in cross section of concrete lining as well as use of single tile lining instead of double tile lining. The LDPE film below the brick or concrete lining further helps in better curing of the concrete or masonry work.

In view of the multiple advantages which could be derived from LDPE film lining, it is highly desirable that all the State Govt. irrigation departments use this mode of lining in all their future lining programmes.

The Ministry of Irrigation in collaboration with the Department of Petroleum organised a national seminar 'The Use of Plastics for Lining of Water Conveyance Systems in Irrigated Agriculture; on 20th September, 1982. This seminar brought about the interaction and exchange of ideas and dissemination of data between the industry engineers and the scientists working in this field.

The main recommendations of the Seminar are:

1 It was agreed that resources of water through renewable is a precious commodity. All steps should be taken to conserve and utilise with due consideration to cost and benefits.
2 The experience in the country for the last 2 decades and for longer period in other parts of the world, has shown that LDPE film can be used with confidence and can be recommended for use as one of the lining materials.
3 However, there was need to continue further study on one use of LDPE by pooling of the experience in and outside the country and to draw up the detailed code of practice suited to different soils conditions in different parts of India.
4 The use of plastic as lining material will be of help in preventing breaches wherever the banks are porous, and it can act as proof against damage by the burrowing animals as it does not allow seepage of water. It also inhibits the weed growth due to sealing effect on seepage. Use of plastics for lining would also result in incidental savings of scarce materials of cement and coal required for conventional lining work.
5 Further studies will have to be carried out with regard to thickness of LDPE i.e. to be adopted in the lining of canals for various hydraulic parameters.
6 It is necessary that wherever LDPE is used as a lining material, the information should be monitered, data should be collected and analysed and assessment made at interval, and reviewed.
7 The plastic formulations such as HDPE may also be effective but because of its high cost and limited availability in India, they have not been used as a canal lining material.

The following steps are suggested for immediate implementation for popularising LDPE film lining in the country

a The government of Gujarat has issued a directive in consultation with World Bank authorities for the use of LDPE film lining in all the World Bank aided projects in the State. Similar guidelines should be issued by all the state irrigation departments to all the existing irrigation projects in the States so that LDPE film is definitely used as a lining material. Only in case LDPE film lining is not technically feasibile, the State Government irrigation departments can consider alternate mode of lining.

b The Central water Commission should take up immediately the preparation of a manual on the lining of canals with LDPE film so that the State irrigation departments can use this as a reference manual for their lining programmes.

c High level committees may be constituted at State level to study the possibility of using LDPE film lining in all the irrigation projects in the state. This committee can also go into the details of lining mode to be adopted, depending on availability of construction materials locally.

d Central and State level seminars should be organised by the irrigation departments to discuss in detail the possibility of using LDPE film lining. Such seminars can help in bridging the communication gap.

e The resin manufacturers and processors should be liberal in taking up trials at field level so that the engineers get fully conversant with LDPE film lining through live demonstrations.

iii Plastics Pipes for Water Distribution

PVC, HDPE as well as LDPE pipes and tubings are going to play an increasingly important role in all our tubewell/well irrigation schemes as well as on-the-farm water management.

PVC pipes, because of the combination of unique properties, can be better in tubewell application than metallic piples. Plastics pipes offer advantages over conventional pipes right from handling stage through installation and operation. Over a period of time, the energy saving offered by PVC pipes would be also appreciable.

In spite of the growing popularity of PVC pipes in tubewell construction there are not engough trained peronnel available at state level for the installation and correct handling of PVC pipes. It is felt that the PVC pipe manufacturers should sell a package of practices so that people at State Government level are properly trained for installation of PVC pipes in the tubewells.

The PVC pipe manufacturer should also initiate trials in all the States on the use of PVC strainers as well as pipes in the installation of tubewells in different states so that the State authorities get first hand information on the use of these pipes as well as techniques involved in the installation of these pipes.

At present the PVC/LDPE layflat tubings being used for irrigation water conveyance from tubewells are being manufactured from reprocessed granules. There is no study available regarding durability of these tubings. It is, therefore, necessary that the resin manufacturer generate data on economics of PVC/LDPE layflat tubings manufactured out of virgin material as well as reprocessed material.

iv Drip Irrigation

The advantages of drip system are so numerous that one can safely forecast a tremendous growth for this system in our country. The limited water resources we have must be utilised most prudently so that every drop of water is utilised for productive purpose. Like deficiency in irrigtion, over-irrigation is also dangerous and harmful to the plants. Drip irrigation helps in optimising the application of water to the plants and thereby achieves the dual objective of water saving and better plant growth.

The drip irrigation industry in the country is in the infant stage and considerable developments must take place before an economic and effective system could be offered to the cultivator. It is understood that some firms have obtained foreign know-how on manufacture and installation of sophisticated drip systems which are moderately priced. The Gujarat Government's move to install a 500 hectare drip system is also timely in popularising this mode of irrigation in our country.

Following are the recommendations for propagation of drip system concept in our country:

a The Indian Council of Agricultural Research should evaluate the drip systems being manufactured in the country. The systems already in operation could be studied so that techno-economic feasibility of installation of these systems for various crops could be worked out.

b The agricultural universities should train people on drip system so that these trained personnel can render services to cultivators who are interested in the installation of drip systems in their farms. The Indian Agricultural Research Institute can arrange for training programmes for State Govt. irrigation departments on drip system.

c Since the drip system is comparatively expensive, the drip manufacturers as well as resin manufacturers should take up presentations to the lead banks on the techno-economic viability of drip systems so that the cultivator can obtain timely loan for installation of the systems.

d The ICAR should consider including drip systems in their operation research projects in all the States.

v Mulching

Mulching is not developed in our country but this application can have tremendous potential in certain forward areas where nothing could be grown today because of adverse agroclimatic conditions.

The ICAR should take up a study on feasibility of mulching application on the basis of data available from within the country as well as from abroad so that a definite action programme could be formulated for propagaion of this appliction for moisture conservation, increased agricultural yield and better quality of production.

vi Greenhouses and Tunnels

In the cold forward areas, as well as for the production of quality high value crops in milder climates, it would be necessary that the plants are protected from the outside atmosphere. The use of plastics tunnels and greenhouses precisely does this by creating a favourable microclimate where all the conditions of optimum growth could be regulated at will.

Almost all the agricultural universities have such protected environment sheds where various plants are grown for experimental purpose. Near Bangalore, a private entrepreneur also has constructed plastics greenhouse for the cultivation of flowers for export purposes.

Immediate steps should be initiated by the ICAR for conducting trials on greenhouse cultivation in the severe agro climatic zones of Ladakh and other forward areas, so that data is generated on feasibility of the plastics greenhouse application in these forward areas.

The resin manufacturers should take up the development of raw material being manufactured by them so that a more weatherable film could be produced indigenously for use in greenhouses Both PVC and LDPE film could be tried for greenhouse applications.

A sub-group has already been formed by the ICAR for studying the feasibility of greenhouse cultivation in the country. This group also can study the various structures being used all over the world for construction of greenhouses and inexpensive greenhouses should be developed for propagation in the country.

vii Silage

The Operation Flood-1 project launched in 1970 was continued and a sum of Rs.112.60 crores was generated upto March 1980. Cattle-cum-dairy projects have been started in Rajasthan, Madhya Pradesh and Karnataka. Under these project areas, a large number of primary milk producers'societies and district dairy unions have been started on Anand pattern. Feed and fodder production forms an integral part of the daily development programmes.

The use of plastics film in the preservation of silage could be integrated into the dairy project schemes so that the cultivator co-opertives can take full advantage of this mode . method of silage preservation.

Work can be immediately initiated with the dairies briefing them on the advantages of plastic film silage.

The resin manufacturers should support demonstration of trench silage as well as bag silage. The demonstrations should be taken up right at the co-operative level.

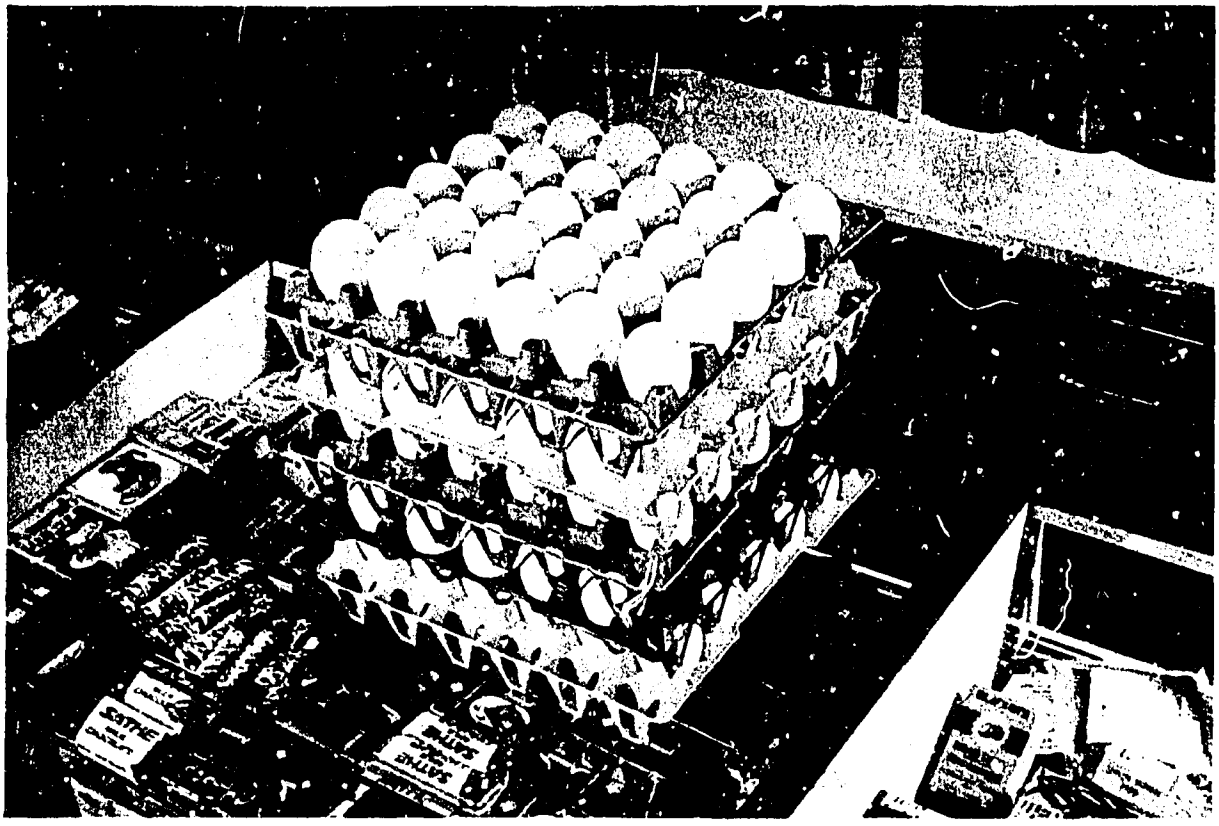
Since correct technique of silage preservation must be followed for good results, it is necessary that the demonstration is carried out by people having experience in this mode of silage preservation. A few technical officers from each State could be trained up on plastics silage preparation.

viii Packaging and storage of Fruits and Vegetables with the use of Plastics Bags and Crates

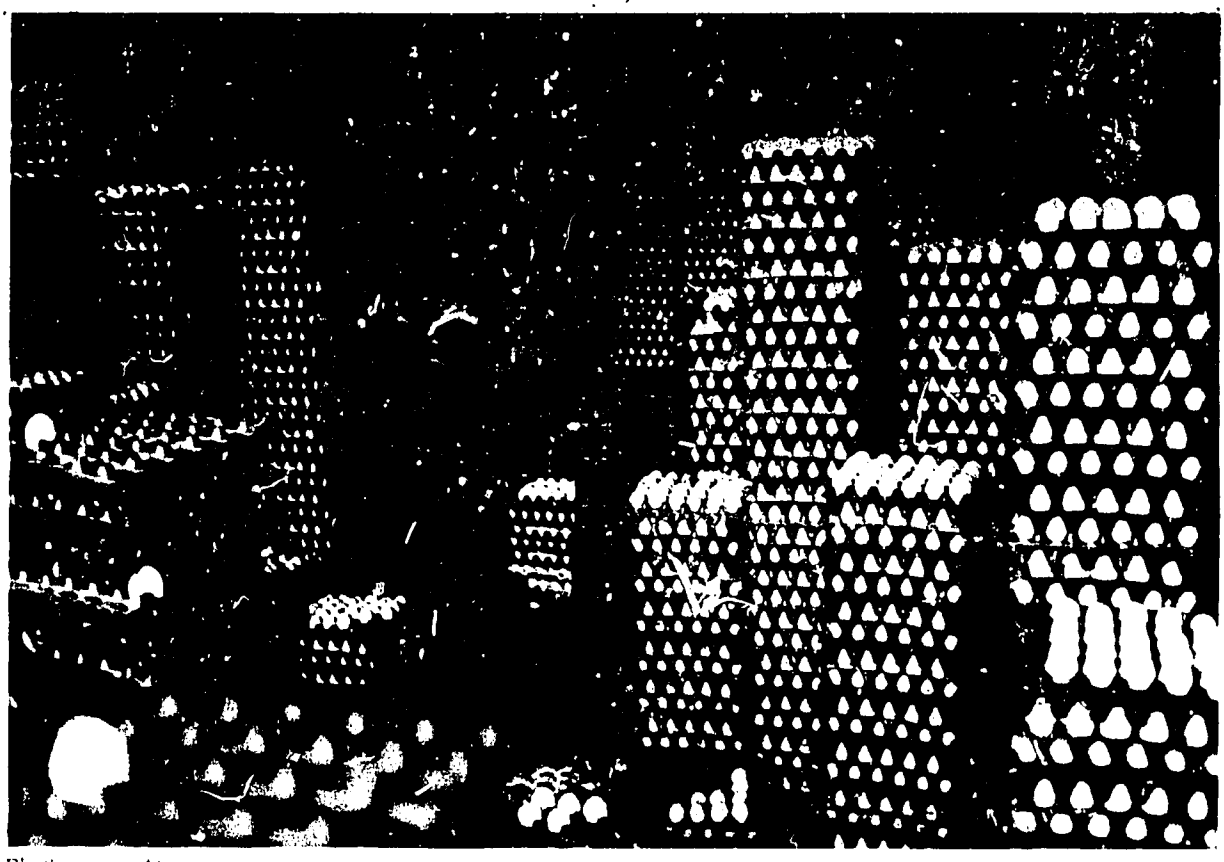
Innumerable trees are felled for the manufacture of wooden crates used in the packaging of fruits for transportation over long distances. Suitable collapsible plastics crates could be developed for transportation of fruits which would serve the dual purpose of economy and preservation of the ecology in the forest regions.

One of the resin manufacturers is taking up a study on alternate plastics crates which can be produced in the country for fruit packaging and transport.

Use of LDPE bags for packaging of banana, apples and other fruits should also be taken up by fruit research stations so that quality packaging methods are developed for safe storage of fruits over a prolonged period of time. Use of such plastics packaging systems would also fetch better price for our exported fruits and vegetables. The ICAR can study the present packaging mode being adopted and suggest alternate modes of economic and technically superior packaging which can be immediately adopted by the producers and fruit traders.



Plastics egg crates for storage, transportation and display of eggs.



Plastics egg crates.

The popularisation and propagation of agricultural applications of plastics would require the mobilisation of several organisations who have to work together with coherent objectives so as to achieve fast results. The various organisations which should come into play are: Central Government Departments, State Government Departments, Agricultural Universities and Research Institutions, Resin Manufacturers, Plastics Processors, etc.

The formation of the State level committees would expedite this process of transfer of viable technology to the field through close coordination with intermediate agencies such as the extension agencies, Agro Industries Corporations and the like. Smooth functioning of the State Committees is therefore, a must in achieving the goals of the National Committee on all India level.

State Level Committees

State level committees have been formed in 14 states for propagating the plasticulture applications.

The State level committees have a very important role to play in the formulation of time bound programmes for propagation of viable plasticulture applications.

However, it is necessary all the State level committees follow a general pattern for identification of economically viable applications, take up field level demonstrations, and formulate directives for adoption of viable applications. The following steps are envisaged for the State level committee's functioning:

a The State level committee should draw its members from all the beneficiary government departments - Agriculture, Irrigation, Animal Husbandary, Horticulture, Soil Conservation and Water Management. Besides, the Government departments, the membership should include representatives of:
   i Agriculture Universities;
   ii Agro Industries Corporation;
   iii Tubewell Corporation;
   iv Resin manufacturers;
   v Important processors; and
   vi State Plastics Manufacturers Association.

b) The State level committee should form tank forces for exploring the possibility of propagation of various agricultural applications of plastics. On the basis of their findings, these task forces should submit reports to the state level committee, giving status of the appliction in the State, status of the application in other states, places where such applications can be tried in the State, budgetary provision available in the sanctioned budget, steps which should be taken in terms of demonstrations, meetings with financial institutions, seminars, agricultural fairs, etc.

c) The State level committees should organise seminars and exhibitions on the applications of plastics in agriculture. These exhibitions should be so arranged as to project the technical and economic viability of applications most suitable to the local socio-economic and agro-climatic conditions.

d) In case certain applications require central level change in policy matters, recommendations may be sent to the National Committee for necessary representation and follow up. Similarly change in policy matters at the State level should be taken up by the Committee with the respective State Government.

e) The minutes and procedings of the State level committee meetings should be sent to the National Committee.

f) Methods should be devised for exchange of information about experience/success stories/problems encountered, between different States. The National Committee should arrange for periodic meetings of experts in Irrigation/Agriculture etc. to enable the systematic dissemination of information.

Communication Strategy

The unlimited benefits one can derive from the application of plastics in the agricultural sector is amply evident from the earlier chapters of this report. Many of the applications which have been developed in the advanced countries are yet to surface in our country. There exists a tremendous scope for transferring this modern technology to the fields and farms all over the country. It would not be an exaggeration to mention that to almost all the agricultural problems such as water management, crop growth, pest control, agricultural storage, land reclamation and the likes there is a solution through the use of plastics. The total international and Indian information available on plastics technology and its application in the field of agriculture is vast and it offers great challenge to the industry and to Government to disseminate this information to where it is most wanted. Thus, the communiction strategy forms a vital link to the fast adoption of the agricultural applications of plastics in our country.

The communication strategy could be divided into the following group of activities:

i Collection of information on plastics application in the agricultural sector from all over the country and the world;
ii Identify the applications which can suit the agroclimatic conditions prevailing in the country and also with reference to the socio-economic environment;
iii Since most of the information readily available would be in English and other foreign languages, steps are to be taken for translating this information into regional languages.
iv Last but not the least, the carrier for the information should be carefully chosen so that the information reaches the maximum number of beneficiaries, with minimum expenditure and time.

The communication link should form part of the package for promoting applications of plastics in the agricultural sector. It is not only important that the cultivator knows what he can do to protect his crop from birds, but the actual products also must be available at a place conveniently approachable to him so that the full benefit of the communication is derived in terms of utilisation of a new product in the field and the results derived therefrom.

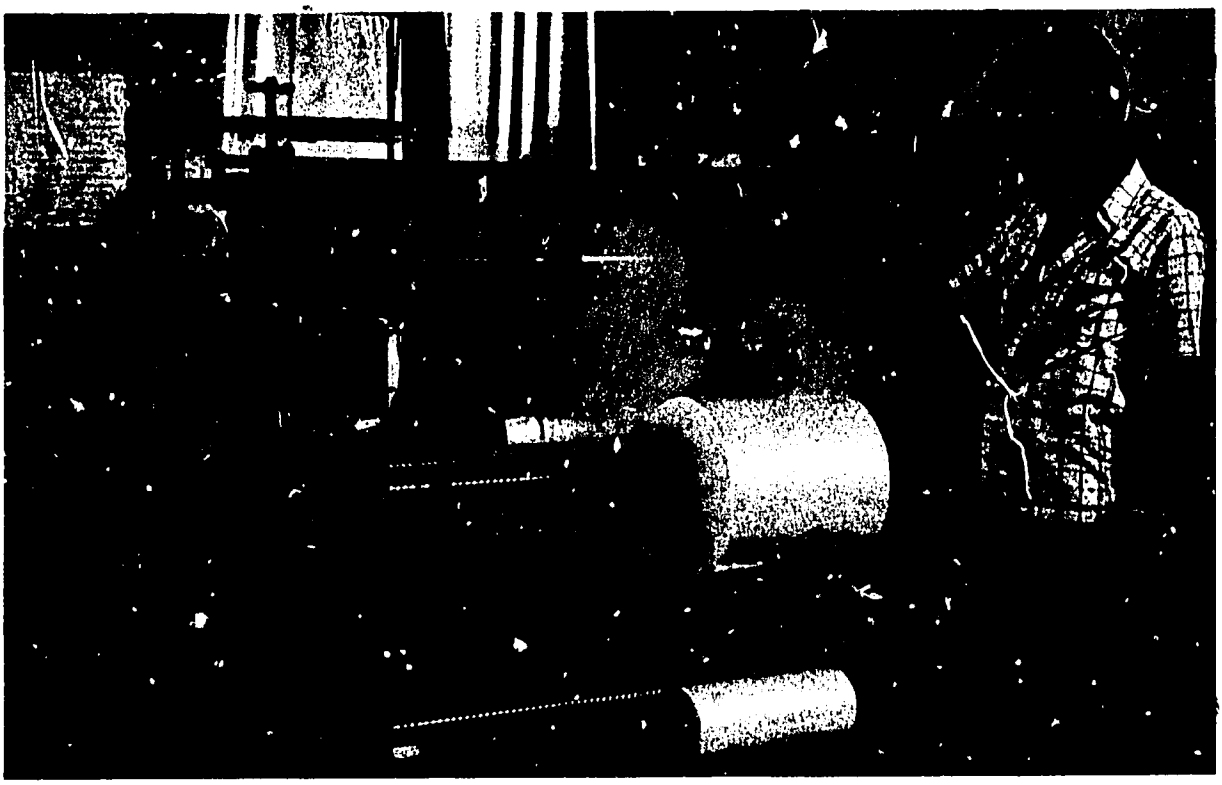
Each application would have to be treated separately for arriving at an optimum communication stretagy.

Standards

The plastics finished products used in agriculture could be fabricated out of several types of plastics raw materials available in the country. Further, the fabricator/processor has a choice to choose either first quality mateial or reprocessed material. Plastics being new to almost eveybody and the knowledge about plastics materials being what it is, it is possible inferior quality of products could be sold to the consumer without his knowledge.

Large scale adoption of agricultural applications of plastics would necessiate the formulation and administration of standards, so that the consumers of such products could know for sure the quality of material they are purchasing. In the initial stages of introduction of plastics in the agricultural sector, it is very important that the products do not fail under field condition because of inferior quality of base resin used for the manufacture of such products.

On the basis of applications which have been developed within the country as well as abroad, the Indian Standard Institution should immediately set up a committee to look into the possibilities of standardising the plastics products used in the agricultural sector. Proper identification marks are also to be selected so that the consumer can easily identify the quality of products he is purchasing.



Quality control of LDPE film used for milk packaging.

Plasticulture Development Centre

Mr Arthur D Clarke, Plastics Technologist, UNIDO, had visited India during mid-seventies and had recommended the establishment of research-cum-demonstration centres where developments in the filed of agricultural uses of plastics can be exclusively taken up. These development centres would deal with both manufacturing/fabrication aspects of plastics products used in agriculture and would take up application development of plastics in agriculture, water management and other related areas.

The Plasticulture Development Centres (PDC) could be located in various agroclimatic zones prevalent in the country, so that appropriate, and relevant practices are developed which would be most suitable for that agroclimatic condition. Location of these centres in different agro climatic zones would lend better credibility and fast adoption of these applications. The socio-economic parameters also could be effectively looked into so that the developed applications would be accepted very fast.

The objectives of the PDC would be:

i Testing of various plastics products used in the agricultural and related applications for finding durability/suitability of use in particular climatic condition.

ii Identify new applications successfully adopted elsewhere in the country or abroad which can be tried in the agroclimatic conditions prevailing in the PDC location.

iii Develop information library on plasticulrure applications and take up translation to local languages so that these informations percolate down to the grass root level.

iv Organise seminars/exhibitions and participation at village fairs on plasticulture applications.

v Take up training of village level workers (Gram sevaks/sevikas) on use of plastics in agriculture. Training of agro service centre entrepreneurs also could be taken up by the PDC.

vi Develop local artisans to handle plastics pipes/films in terms of jointing, overlapping, welding etc.

vii Take up preliminery testing of plastics products used by the local cultivators so that inferior quality material could be isolated for further testing in better equipped laboratories.

The exact location of the PDC's would be decided on the basis of the various distinct agro climatic zones prevalent in various parts of the country so that data on plasticulture applications in these varying climatic conditions could be made available for further propagation.

Some of the PDCs also could be located on the basis of major crops grown in the area so that appropriate plasticulture applications are tested and developed for commercial adoption in these localities.

Where possible these PDCs could be developed within the framework of Agricultural Universities and Institutions which are already operating in these regions. This would facilitate the centres to be spread almost all over the country with little extra investment in terms of men, machinery and land. In places where agricultural institutions do not exist, the establishment of exclusive PDCs could be considered.

The major application areas which would be immediately taken up for trial through the PDCs or its branches are:

i Pond/reservoir lining with plastics film for village water storage ponds as well as water harvesting ponds;

ii Plastics pipes, tubes and hoses for irrigation water distribution;

iii Lining of water courses and channels with plastics film;

iv Drip irrigation;

v Mulching;

vi Cover bags;

vii Nursery covers and nursery bags;

viii Greenhouses and tunnels;

ix Silage - bag and trench silage;

x Packaging and storage of agricultural produce - in plastics bags, woven sacks;

xi Nets for orchard protection;

xii Gobar gas plants;

xiii PUSA bin and outdoor storage covers.

Many of these applications would require minor/major modifications for adaptation in different climatological and topographical conditions. The PDCs would be required to evaluate these applications to take up suitable modifications for optimum performance and favourable cost benefits to the cultivtors in that locality.

The activities of the PDCs would be regulated and controlled through a central co-ordination committee, the members for which could be drawn from the National Committee itself.

There is a likelihood of UNIDO funds being made available for the opening of the PDCs. Action is being initiated in this respect. The National Committee of other countries have been also requested to send details regarding organisations which are operating in their country having similar activities as PDCs.

SUMMARY

The findings of the National Committee during one year of its operation reveals that there exists a vast untapped potential for the applications of plastics in agriculture, water management and related areas.

The use of plastics in irrigation and water management areas would prove a boon to increased water use efficiency, decreased water logging and soil salinity. Prudent application of advanced methods of irrigation, such as drip system, would make possible the utilisation of scarce water resources most beneficially in the desert, arid and semi-arid regions. The financial institutions and Government departments must understand the scope these advanced irrigation methods would offer to the agriculturist so that adequate finances could be made available to the cultivators for adopting these modern irrigation methods.

The Central and State extension agencies should be mobilised to propagate the use of plastics in the agricultural sector so that plastics-which so far has confined its appearance to the urban areas - could change its image of luxury item so that of productivity and long-term usage.

It would be the endeavour of the National Committee to disseminate the message regarding benefits of plastics in the agricultural sector so that plastics can make a mark in increasing our agricultural productivity both in quantity and quality.

The Committee is in the process of gathering more information on plasticulture applications, both from inside the country and abroad, so that all these could be included in the final report of the Committee.

The National Committee during its one and half years of operation has met number of State Government's officials of the Deptt. of Agriculture, Irrigation, Horticulture and related areas for discussions regarding work being undertaken in the states on the use of plastics in agriculture and also to brief the State agencies regarding the possibilities of other plasticulture applications which can be pursued by the State Government. At the instance of the National Committee state level Committees have been formed for promoting the agricultural applications. The main functions of the State Committees would be to identify potential plasticulture applications which can be promoted in the State. The Chairman alongwith members of the Committee also have discussed in depth with the state level Committees of Punjab, Haryana, Andhra Pradesh, Tamilnadu, Karnataka, Madhya Pradesh and Himachal Pradesh. This first report prepared by the National Committee would serve as a guide line to the state level committees in their plasticulture promotion efforts.

The National Committee has identified many other areas where intensive developmental efforts have to be directed over the coming years. It is necessary that the National Committee's term of existence must be extended by several years so that the recommendations are properly followed and on the basis of feed back obtained the strategy of propagation can be modified from time to time.

It may be mentioned here that the Plastics Export Council which was formed as a temporary body has been operating as a standing body. The National Committee also could be made a permanent standing committee for the promotion of important area of application. In various developed and developing countries National Committees have been formed to perform on a permanent basis drawing their members from the resin manufcturers, processors, as well as research bodies. It is essential that the National Committee is made a permanent body so that various schemes envisaged by the Committee are properly followed up and a longterm action programme is drawn up for expansion of activities in this important sector. On these lines it is felt that the National Committee would have a continuing role in promoting the applications of plastics in agriculture, irrigation and related areas and it is therefore considered to be worthwhile that the National Committee must operate on a permanent basis; the Government may like to consider this aspect.

Annexure 1

LDPE: Availability (1978-79 to 1988-89) (Metric tonnes)

Year	Opening	Production	Imports	Total	Consumption
1978-79	—	56,000	24,000	80,000	72,000
1979-80	8000	72,000	3,000	83,000	70,000
1980-81	13000	82,000	1,500	98,500	72,000
1981-82	26500	90,000	500	1,17,000	86,000
1982-83	31000	95,000	—	1,26,000	97,000
1983-84	29000	1,05,000	—	1,34,000	1,09,000
1984-85	25000	1,10,000	—	1,35,000	1,22,000
1985-86	13000	1,10,000	14,000	1,37,000	1,37,000
1986-87	—	1,10,000	43,000	1,53,000	1,53,000
1987-88	—	1,74,000	—	1,74,000	1,72,000
1988-89	2000	2,06,000	—	2,08,000	1,93,000

Assumptions:
1. Growth rate 12%
2. Imports to bridge the gap during '85-86 and '86-87.
3. Proposed LDPE Plant of Maharashtra Gas Cracker Complex of 160,000 capacity is likely to go on stream from 1987-88 with 40% capacity utilisation during 1987-88 and 60% during 1988-89.

Annexure 2

Past and Future Supply/Demand/Consumption of HDPE in India - (Metric Tonnes)

YEAR	Supply				Consum-ption	Growth %	Remarks
	Local Prodn.	Imports	Exports	Net			
1966	—	1762	—	1762	1800	—	Free availability
1967	—	5534	—	5534	5500	205	-do
1968	8542	2533	2814	8261	2265	−59	-do-
1969	17043	289	10296	7036	7006	209	-do-
1970	18109	37	4727	13419	12997	85	-do-
1971	23766	55	2495	21326	19220	48	-do-
1972	18608	600	450	19254	19254	0.2	Restricted supply
1973	21770	3000	—	18758	19823	3	-do-
1974	25867	700	—	26567	23657	19	Rise in oil price
1975	22145	1500	—	23080	23080	−2.5	Economic recession
1976	22283	2000	—	24283	21126	−8.5	-do-
1977	24000	11000	—	35000	35000	65.7	Free availability
1978	27000	18000	—	45000	45000	28.5	Free availability assumed
1979	30000	20500	—	50500	50500	***12.2	-do-
1980	35000*	21650	—	56650	56650	12.2	-do-
1981	38000*	25560	—	63560	63560	12.2	-do-
1982	40000*	31300	—	71300	71300	12.2	-do-
1983	40000*	40000	—	80000	80000	12.2	-do-
1984	55000**	33200	—	88200	88200	10.2	-do-
1985	70000	27150	—	97150	97150	10.2	-do-
1986	70000	37000	—	107000	107000	10.2	-do-
1987	70000	47900	—	117900	117900	10.2	-do-
1988	70000	60000	--	130000	130000	10.2	-do-

* Subject to availability of ethylene from NOCIL or any other source.

** Assumed WBIDC, at Haldia, goes on stream by 1984

*** Reduction in growth percentage beginning 1979 due to free availability of polypropylene at competitive prices from indigenous sources assumed.

Annexure 3

Past and Future Supply/Demand/Consumption of PVC in India (Metric Tonnes)

Year	Supply			Consum-ption	Growth % (Annualised)	Remarks
	Local prodn.	Imports	Net			
1965	22200	602	12802	12802	—	Free availability
1966	10800	372	11172	11172	– 12.8	-do-
1967	13600	537	14137	14137	26.5	-do-
1968	17560	1396	18956	18956	34.1	-do-
1969	34400	160	34560	34560	82.3	-do-
1970	38700	23	38723	38723	12.0	-do-
1971	42500	—	42500	42500	9.7	-do-
1972	46835	—	46835	46835	10.2	-do-
1973	48486	1865	50351	50351	7.5	-do-
1974	47432	707	48139	48139	– 4.4	Rise in oil price
1975	43000	403	43403	43403	– 9.8	Economic recession
1976	47000	350	47350	47350	9.1	Restricted supplies
1977	55000	—	55000	55000	16.1	-do-
1978	76000	—	76000	76000	38.0	Free availability assumed
1979	84000	5680	89680	89680	18.0	-do-
1980	84000	21800	105800	105800	18.0	-do-
1981	84000	39780	123780	123780	17.0	-do-
1982	109000	34600	143600	143600	16.0	-do-
1983*	109000	47000	156000	156000	8.7	-do-
1984**	164000	29200	193200	193200	16.0	-do-
1985	174000	50000	224000	224000	16.0	-do-
1986	184000	75800	259800	259800	16.0	-do-
1987	184000	117400	301400	301400	16.0	-do-
1988	184000	165600	349600	349600	16.0	-do-

* IPCL Comes On Stream In 1983
** WBIDC Comes On Stream In 1984

Annexure 4

Polypropylene Imports and Indigenous Production (Metric Tonnes)

Year	Imports	Indigenous Production
1965-66	216	—
1966-67	764	—
1967-68	1425	—
1968-69	1069	—
1969-70	903	—
1970-71	603	—
1971-72	175	—
1972-73	789	—
1973-74	837	—
1974-75	NA	—
1975-76	NA	—
1976-77	5863	—
1977-78	1891	—
1978-79	—	4207
1979-80	1674	12920
1980-81	1374	16956
1981-82	1292	20220
1982-83	5000*	25000*
1983-84	8000*	30000*

*Estimated

Annexure 5

Resume of Applications of Plastics in China's Agriculture

The application of plastics in China's agriculture began with the use of plastics film for the raising of rice seedling. In 1958, some agricultural research institutes began to carry out experiments in using plastics film for rice seedling raising. In 1963, over 20 tons of plastics film was used to conduct simultaneously those tests in Guandong, Hebei and Liaoning provinces, all of which indicated marked increase in production yield. In 1964, application of plastics film for rice-seedling raising spreaded over 18 provinces in China and the field of application was also widened. In 1965, rice-seedling growing with plastics film propagated to 28 provinces. In 1973, the total actual consumption of agricultural plastics film was 5 times over the figure of 1965.

Following the success of using plastics film to breed rice spouts, it is applied gradually to sweet potatoes, tobaccos, cotton breeding, vegetable cultivation, sericulture and duckweed protection, and successes achieved in these fields enhanced greater demand of plastics film. In order to ensure the supply of plastics film to the most important field, the Ministry of Agriculture has specified the principles for the supply of plastics film, i.e. priority should be given to rice and other cereal crops, and then to vegetable cultivation in big city suburbs, and after all these, it can be used for other purposes.

In recent years, plastics agricultural film has been extensively used in large quantity, and better result of increased yield has been achieved, thus it has become one of the indispensible and important agricultural production materials.

According to the successful experiences in the previous years from various provinces, the advantages of using plastics film for rice-seedlings growing can be roughly summed up as follows:

1 Saving of rice seeds used. Practical experiences from the southern and northern rice production regions have proved that by using plastics film, about 5 kg of rice seeds may be saved per Mu (one Mu = 1/15 hectare) of paddy field as compared with field rice breeding without plastics film.

2 It prevents rot of rice shoots, breeds healthy rice shoots, furnishes early transplanting and is favourable for higher production. Early rice of double crops in provinces in the Yangze river valley and Southern China, and early and middle season rice in North and Northeast China were often subjected to cold current attacks. As the climate in early spring is very treacherous, resulting in rottening and death of rice shoots in different extent, and a lot of seeds were wasted. Due to the use of plastics film, better -micro-climate-environment suitable for rice seedling was created, cold current attacks were protected and healthy rice seedling guaranteed. Production practice from all parts of our country has shown that by the use of plastics film in rice seedling breeding the sowing time can begin about 15 days earlier than normal field rice-seedling breeding. It gives more healthy rice shoots and less underdeveloped shoots. Good rice shoots are about 10 to 20 per cent more than field seedling breeding. It ensures good and earlier transplanting time. On an average, increased per Mu is reported about 25 kilograms.

3 It can ensure early sowing, early transplanting and early harvesting so that natural disasters during the last stage of rice growing can be avoided. In the Northeastern China, for instance, the using of plastics films for rice-seedling growing not only resolves the problem of rottening of rice seedling in spring but also avoids damage from early frosting. In this way, sowing can be shifted earlier to middle April and transplanting in middle May, 15 to 20 days earlier than in the case with rice seedling bed, therefore, transplanting is done about half a month earlier accordingly. The period suitable for rice growing thus is prolonged from 130 days to 145 days, and it is sufficient for rice growing. The crop will be matured and ready for harvesting before the early frosts (generally early frosts would come during the last ten days of September) avoiding frost-bitten in the last stage of growth. In some regions, after using plastics film, the growing season is prolonged to such an extent that it is changed from single crop rice to double crop rice, and increase in production is more notable. Owing to the use of plastics film for rice seedling and the earlier harvest of early rice, the paddy field for early rice may also be used as rice seedling bed for late rice, with the result of effective use of land, and hence raising the productivity.

4 It can regulate the requirements of labour and water, to solve the problem of shortage of labour needed both in paddy field and upland field, and it also can prevent damage by sparrow, wild ducks, pink nematode and saline-alkali soil.

There are a lot of advantages in using plastics film for sweat potato seedling growing, and the increase in production is also very remarkable. Breeding sweet potato shoots can be done 15 days ahead of season, the rate of seedlings emergence can be raised by 30% while production increases by 20-30%, some times

even by 100% or more. In the cold area like Northeastern and Northern China, a lot of coal should be used to warm up the house to create ideal atmosphere for sweet potato shoots breeding. By using plastics film a large quantity of coal fuel can be saved. It's reported that the coal fuel consumption has been cut 50% by the use of plastics film, What's more, reports from many areas reveal that the rottening of sweet potato seedlings have been decreased.

In recent years, the application of plastics film for vegetable production in the suburbs of big cities has been popularised, which has brought about very good results by doubling production output. In involves less investment, but gives better harvest, resulting in increasing both in production and income. The rich harvest of cucumbers, tomatoes, kidney beans, eggplants and leek etc. in the outskirts of Beijing can be cited a good example. Both autumn and spring are prolonged by a month and half, and the productive period for the whole year is prolonged for 3 months. The application of plastics film is popularised and some experiences have been gained, in the cultivation of cotton, tobacco, fruit trees, sericulture and duckweed protection in winter in South China. It is reported that by using plastics film to breed cotton seedling for transplantation, cotton plants may bear more early bells with better quality, and gin tournout may be increased by 20% generally speaking, production is 20% more than that of direct sowing.

In tobacco testplots in China, the application of plastics film in cultivating tobacco brought about such a good temperature and humidity condition that tobacco seeds germinate earlier, grows faster, and therefore can be transplanted earlier, harvested and cured earlier, and aftercrop tobacco can begin to grow earlier. It is more important that tobacco can be cured before or in summer time thus achieving not only increase in production but also improvement in quality. On the average per Mu increase is about 50 kg.

In recent years, we have begun to use plastics film in field covering practices have shown that before ridging of crops the soil temperature can be increased by 2°C to 4°C approximately by the use of plastics film covering. Due to the preservation of misture for the top soil, vegetable irrigating interval can be longer. The soil covered with plastics film is loose and soft with higher temperature, thus promotes decomposition of bacterium, increasing soil fertility and accelerating the growth of crops. The cultivation with field covering creates a better physical and chemical characteristics of soil which is beneficial to the growth of roots. To sum it up, employment of plastics film in field covering has brought about quicker growth, earlier maturity and higher yield and thus greater economical result. Therefore, it is a new reliable technical measure to improve vegetable production. It is not limited to vegetables (such as cucumber, tomato, chilli, peas and potato) only, with peanuts, the result is also remarkable. After it is used for vegetable growth in a region in the Northeast part of China large scale increase in production has been achieved, such crop like peanut which was not suited to the climate has come to stay with a yield of 250 kg per Mu. Production increase in eggplant is 20-40%. It enables cucumber to grow to its size 9 days earlier and eggplant 19 days earlier. Thus the problem of vegetable scarcity from middle of June to beginning of July had been solved.

In livestock breeding, the use of plastics film to set up sheep sheds may protect sheep in winter, in Northern China, employment of plastics film to cover pig stalls in winter can increase pork production.

With the daily enlargement of the scope of application of plastics film in agriculture and increase in consumption, there has been a new development of varieties of plastics film for agriculture.

Mainly PVC film was used in the previous years in China. In recent years, because of the development of petro-chemical industry and increase in production of polyethylene, the production of polyethylene film for agriculture now has been going up continuously and used extensively. Polyethylene film is lighter than PVC film. With the same quantity in weight larger area can be covered and it also has a good resistance to severe cold weather. Due to the fact that polyethylene film contains no plasticizers it does not cause any problems like plasticizer migration and water extraction etc. Due to research work done to enhance mechanical strength and ageing resistance of polyethylene film, the service life of polyethylene agricultural film produced in recent years surpassed more than one year. Previously, agricultural film used in China was only 1 to 2 metres in width, but now it has been in mass manufcture with a flatwidth of 3 to 5 metres. Heavy labour intensity for parallel welding of small width into large width has been avoided when used for large area. Wide width PE film has been applied with satisfied results in agriculture, livestock breeding and water conservation etc.

In Northern China, the film used for greenhosue of winter vegetables has to ensure such severe cold as 30°C below zero and heat of 30°C and to stand such attacks of hail and gale of 7 to 8 degree. Ordinary manufactured agriculture film was not up to this standard.

Through hundreds of times of scientific experiments during previous years, low temperature, age-resistant PVC film has finally been produced in China. As is indicated with tests and practical application, this kind of film does meet the above requirements. It can give successive service for more than one year, doubling that of ordinary agricultural film.

In recent years, experiments on application of coloured plastics film in agriculture had been done in China. Coloured plastics agricultural film may be considered as a kind of light filter, suitable selection of film colour will facilitate penetrating of the light which benefits the growth of plants and improve light quality, enhance effect of photosynthesis of plants resulting to increase production. Experiments indicated that to compare with colourless film; blue film when used for paddy seedling, can ensure about 5% production increase, while red film when used for cotton seedling, more than 10% production increase. It has also been found that the use of coloured film has a controlling effect on diseases of some plants (such as withering and peronosporacease of cucumber).

Anti-fogging film, weed killing film, two-coloured film and film preventing cotton aphides etc., are still in the stage of research, experimental manufacturing and trail application in China.

In irrigation works various plastics pipings, plastics sprinklers and triklers are extensively used in China. Advantages of plastics piping are light in weight, corrosion resistant, rustless and cheap in price, etc. So the consumption is going up with each passing day.

One province in Southern China, to meet the need in draining of water-clogging area, 1600 tons of heavy calcium carbonate-filled PVC piping material were produced just in 1976 and 1977. Not only the consumption of PVC resin was saved, product cost was also reduced.

Sprinkler irrigation is a kind of advanced irrigation technique and it has already been extensively adopted in China. In 1975, success was achieved in manufacturing portable plastics equipment for sprinkling irrigation, and commercial manufacturing started. Experiences indicate the following economical result in the application of plastics equipment for sprinkling irrigation:

1 **Saving Water**
About 50% of water is saved in comparision with canal irrigation;

2 **Higher yield**
With sprinkler irrigation, yield of cereal crops can be increased by 10-30%, yield of vegetable crops increased by more than 50%;

3 **Labour saving**
Working pressure of the equipment is 4 kg/cm^2, spraying range of the nozzle; 18-20 metres, spraying capacity: 4-5 M$_3$/h, irrigated area each time: 10 Mu, and 100 Mu can be covered. To compare with canal irrigation, not only labour power can be saved. working effeciency also can be increased;

4 Due to the evenness of sprinkling, slight water drops will not cause soil erosion, thus soil and its fertility and kept intact.

In 1975, success was also achieved in research work of plastics equipment for trickle irrigation, which has the following advantages:

1 It saves water and increases production. To compare with ordinary furrow irrigation, trickle irrigation can save about 75% of water, the increase in yield of cereal crops: 20-30%; vegetable crops: over 50%; fruit: 20-50%;

2 It saves land usually occupied by canals, the rate of land utilisation is increased;

3 It avoids soil binding, water loss and soil erosion, so labour needed for applying fertiliser and intertillage is saved;

4 It's suitable to irrigate saline-alkaline land, and also can reduce rate of diseases and insect pest of plants;

Trickle irrigation technique has been popularised in more than 100 places of China, area under trickle irrigation has gone up to more than 40,000 Mu and has made contribution to development of irrigation work in mountainous area.

Portable trickle irrigation system is mostly adopted in China. Its cost is only one tenth that of stationary type. The investment is 70 yuan for trickling irrigation equipment per Mu of fruit trees, 30 yuan for agricultural land.

Trickle irrigation system is mostly applied to crops of cereal, cotton, peanut, fruit, sesame and vegetable. At present, the irrigation area of fruit trees has gone up to 22,000 Mu, to compare with ordinary furrow irrigation, increase in yield may be 16.3%, and it can be increased by 33.6% against non-irrigated land, and when applied to orange, the increase is 40%.

In agricultural farming, ropes made of polyethylene and polypropylene filament are used in large quantity. This kind of ropes are light in weight, rustless, corrosion resistant, high in strength and durable, etc. The use of it saves a great deal of iron wire and cotton, hemp ropes, etc. Plastics ropes are used as a part of substitution for coir ropes for ordinary ploughing and shoulder-pole, wires for setting up various sheds, cable ropes for ships, iron for breeding aquatic plants in large area and straw ropes for transplanting rice shoots. With application of plastics ropes, cost can also be reduced. For instance, the cost is only less than tenth of ordinary rope when use for breeding aquatic plants.

Plastics is also applied in production of machine parts for agriculture Plastics machine parts for agriculture are corrosion resistant, durable, high temperature resistant, easy to be manufactured, low in cost, and it can substitute non-ferrous metals. In Beijing Mini-tractor Factory several dozens types of machine parts are made of plastics. If we take the output of tracters for one year as 10,000 sets, 280,000 work hours can be saved.

Plastics is also used extensively to make small farm tools, for instance, sprayer, aqueous ammonia container, rice shoot holder, seedling breeding trays, night soil bucket, etc. These plastics made articles are light, rustless, lasting and the cost of some of them is reduced. In Southern China, the use of plastics seedling trays in rice seedling breeding can ensure higher temperature and higher moisture, bring about healthy and better rice shoots, and earlier maturity for 7 to 10 days and output increase by 6 to 10%.

Agriculture is the foundation of our national economy. We always attach great importance to the development of agriculture and also the applications of plastics in agriculture.
Decision of the Central Committee of the Communist Party of China on Problems Concerning the Accelleration of Agriculture Development-adopted by the Fourth Plenary Session of the Eleventh Central duction of chemical fertiliser, pesticide and plastics for agriculture, up-keeping of product quality, so as to furnish agriculture, step by step, with chemical fertiliser, pesticide, plastics film and weed killer of sufficient quantity, excellent quality, rich variety and of low cost, thus meet the need in developing our agriculture in high speed. It is the concern shown and the support given by the state and the formulation of series of corresponding policies that have made it possible for the applications of plastics for agriculture reaches present extent.

The history on application of plastics in agriculture in China is not long, and scope of application is still limited, some problems are yet to be solved.

At present, we mainly use plastics film for agriculture, PVC film is in particular popular. In order to widen the applictions of PE film, the industrial, agricultural and scientific research departments in China are making their join efforts to raise the strength, ageing resistence and termal insultating properties of the film so that to improve its duration. Furthermore, it is expected to extend the scope of application and varieties of the film for field covering, and to reduce the cost and use the film in a more economic way. There also exists a great potential in using the film for seepage resistance in irrigation. Besides, the production and application of the film, such as shrink film etc., for preserving fresh vegetables, fruits and other produce is now under way.

Due to the vast domain of our country, to solve the problem of preserving and transporting the agricultural produce is of great significance. For this reason, we are now doing our endeavour to popularize the applications of plastic woven bags, returnable cases and other plastics containers, for grain, meat, eggs fruit and milk product etc.

There is a big demand for various kind of pipes for sprinkling, draining and water supplying etc. Of late, while increasing the production, we are also producing more varieties and working out standards for various types of agricultural pipes.

Our experience proves that in order to popularise the application of plastic in agriculture, the co-operation of plastics products (industry) and the users (agriculture) is very important. Each achievement obtain in the past is closely connected with this kind of cooperation. We shall continue to strengthen this cooperation and do a better job in promoting the applications of plastics in agriculture. There are quite a number of scientific research institutes being involved in the applications of plastics in agriculture. There are quite a number of scientific research institutes being involved in the applications of plastics in agriculture. It will be taken as one of the important subjects in the future in the plastics development centre, a project to be set up in China with the assistance of UNIDO, to develop further the applications of plastics in agriculture, and to coordinate the research work and standardization.

We have done something in the applications of plastics in agriculture, but there is still a gap in comparison with the advanced countries. For example, plastics is not commonly used in constructing a new countryside in China.

In the process of developing the agricultural plastics, we have learnt a lot of valuable experiences from the advanced countries. We will continue to strengthen the technical exchange with other countries and learn from them. We deem that this congress is an excellent change for us to learn from the experts of various countries. We are determined to double our efforts to learn from other countries to bring about a new level in using plastics in China's agriculture by self reliance.

Annexure 6

Applications of Plastics in Agriculture in Cyprus

General

Cyprus with an area of 9,250 km² (926,747 ha) and population of about 640,000, is the third largest island in the Mediterranean, lying between 34°33' to 35°41' North and between 32°20' to 34°35' East. The Island has two mountain ranges: in the North the long narrow Kyrenia range rising to about 900 m and in the centre, the Troodes range, a great mountain massif rising to 2000 m at its higher point on mount Olympus. Between the two mountain ranges lies the wide central plain of Messoaria while between the mountains and the sea there are narrow coastal plains.

Introduction and evolution of plastics in agriculture

In Cyprus the introduction of plastics in agriculture started in 1958. At that time transparent PE film was imported by the Department of Agriculture and was used in cooperation with progressive growers to protect short type cucumber crops against low temperatures during the early spring period by means of low tunnels. The first trials had shown that there was great potential for protected crops and as a result of those successful trials the area and the crops under protected cultivation have been increasing yearly since then. It was of course evident that the new method of cultivation required more capital and labour investment for production but prices of the produce were high (off-season production) and the production period was extended. Furthermore the water economy with the new method was significant.

In 1959, PVC was imported and used to cover low tunnels. Soon it was found that PVC, although more expensive, offers more advantages compared to the PE film. The Cyprus Government initiated in 1965 projects to assist growers by subsidising the PVC film and the wire arches, in order to promote the cultivation and production of off-season vegetables. All technical advice was given free to the growers by the extension service of the Ministry of Agriculture. In parallel research work was initiated to develop the most suitable cultivation techniques.

Although production in plastic-covered low tunnels was successful it was soon realised that there were certain disadvantages, ie, difficulties in management during winter, labour requirements for ventilation were high, problems from very low and very high temperatures, the quality of produce not always of very high standard, not possible to grow pole vegetable species etc. Some of the above disadvantages were overcome by constructing the walk-in tunnel, but a more significant development was the introduction in 1967 of the high multispan greenhouse, by the Agricultural Research Institute and progressive growers. Research work was then intensified covering all aspects of cultivation and management in the high plastic-covered greenhouse. New varieties and hybrids were imported and after evaluation the selected ones were given to the growers for cultivation. In parallel, cultural practices, irrigation, nutritional and all related aspects were studied. Trickle irrigation was first introduced and tested under Cyprus conditions in 1970. It revolutionised irrigated agriculture. The use of mini-sprinklers has also spread in the last four years.

In the mean time local plastics factories have been producing since 1972, agricultural film, PVC and PE pipes both LD and RD for irrigation. The events of 1974 and the Turkish invasion were detrimental for both the plastic industries (all but one were in areas now occupied by the Turkish army) and for most of the greenhouse installations. Recently, the area under protected cultivation has been increased.

Farmers are very conservative and do not easily change their working methods unless there is a well worthwhile incentive for doing so. In the case of plastics in agriculture increased profits from more efficient production were obvious, hence their rather quick adoption.

The appearance of plasics in Cyprus and their use in agriculture has changed completely the outlook of certain sectors of production. Two examples will be given: (a) It is now possible to produce and supply the local market with all kinds of vegetables during the winter months. This was not possible 20 years ago. Not only the local demand was satisfied but big quantities are exported to other countries. Prospects for incresing exports in the future and during winter are favourable for a number of crops. Cyprus with its mild winter climate has an advantage over the northern European countries, where, due to the oil crisis, the cost of production is high because of the need to burn fuel for heating. (b) Introduction of the new irrigation systems (trickle, mini sprinklers, spray nozzles) has changed completely the picture of irrigated agriculture in Cyprus. With the available water resources it is now possible to irrigate bigger areas with higher efficiencies, higher returns and all related benefits. This has been achieved with the introduction of plastics for irrigation.

Annexure 7

Applications of Plastics in Agriculture and Horticulture in Egypt

Types of Plastics Utilized:

The utilization of plastics is now mostly polyethylene which accounted for 42% of total consumption in 1975, followed by polyvinylchloride (23%), and polystrene (16%).

Principal Agricultural & Horticultural Applications:

Consumption at present and for the next few years is expected to be concentrated in the following purposes:

a Semi-forcing and Forcing of plants:

Semi-forcing techniques to modify the plant environment is predicted to have great future in Egypt. The moderate climate of Egypt gives the advantage of simplifying the plastic structures, as the environment for temperature is modified to a lesser degree. Low plastic tunnels and top covers are being used in several locations to produce vegetables and flowers for the early market and export.

Continued growth is expected in the acreage covered with plastic greenhouses for vegetables and flowers production mainly for export market and also for local consumption. A five year research project on plastic cropping in Egypt has started in 1979 by the Vegetables Research Branch of the Horticulture Institute in Cairo. The research programme covers all aspects of crops production including cultivar selection, nutrition, environmental control, and crops production economics and marketing. Sixteen plastic greenhouse were constructed in 1979 on 4000 square metres at Kaha Experimental Station 40 Kilometers north Cairo. They were planted during winter of 1979/1980 with cultivars of tomatoes, peppers and green beans. Results on yield and quality are encouraging.

Work is going on to cover another area of 8000 square meters with plastic houses this year. This project should also determine the suitable plastic greenhouse structures regarding the potential export of vegetables in winter in Europe and the Middle East countries. The target is to cover 100 acres of commercial plastic houses during the next few years.

b Irrigation and pipes:

A large increase in consumption of plastics for irrigation pipes has occured in Egypt. Further rapid expansion of this application is expected.

Drip plastic irrigation systems is currently being widely utilised in greenhouses and in intensive field production of vegetables and flower crope.

c Packages of crops and heavy duty bags:

Heavy duty plastic bags are being used for packages of manure and grains. PE and PP are usually used for woven plastics closed bags. Agricultural plastics are used in the form of films for soil mulching and fumigation in limited areas.

d Farm equipments and plant containers:

Large portion of plastics are utilised to produce plant growing containers and field crates to handle agricultural production.

A plastic crate has been produced in Egypt of constant size: it is built in protective features for the cranges, and the percentage of damaged fruits has been cut down significantly. Several standard models are available and used by growers as general produce handling crates; all these have in common the advantage of plastics, they are lightweight, easy to handle and durable.

Plastic farm tools and materials such as growing plastic pots, become so common in daily use in farming. The rapid growth of established applications of agricultural plastic material indicates a bright future for plastics production in Egypt.

Annexure 8

Protected Vegetable Growing in Jordan

Production Area

Protected vegetable growing is confined to the Jordan Valley area which is a deep depression with an altitude ranging from 197 meter below see level in the northen part to 392 meters below sea level at Dead Sea.

The coldest period is from December to February. The minimum temperature during this period is relatively low and might cause physiological disorders to the sensetive vine crops. Occasionally frost occur and wipe out vine crops grown under open field culture.

Rainfall in the Jordan Valley is during November-May. Annual rainfall ranges between 400 mm in the northern part to 10 mm in the southern part.

During winter the prevailing winds in the Jordan Valley are mainly N-ly, sometimes S-ly.

Strong winds (40-50 km/h) are generally from S-wly direction. Gale wind is very rare. Calm wind is very often at night and early morning. Water for irrigation is provided from the East Ghor Canal. Some farms in the southern part are irrigated by ground water.

Statistics

Total areas of vegetables planted under plastic structures in the last three seasons are shown in table (1).

Areas under plastic houses are doubling every year while the areas under row cover are increasing at a slower rate.

TABLE 1 TOTAL AREAS OF VEGETABLES GROWN UNDER PLASTIC STRUCTURES IN THE JORDAN VALLEY DURING THE PERIOD 1977-1980.

YEAR	AREA (DUNUM)		
	Row tunnels	Plastic house	Total
1977-1978	3310	285	3595
1978-1979	5296	735	6031
1979-1980	7227	1366	8593

Areas of vegetable planted under plastic structure are irrigated by surface irrigation, but areas irrigated by drip irrigation are increasing year after year (Table) 2.

TABLE 2 TOTAL AREAS OF VEGETABLES IRRIGATED BY SURFACE AND DRIP IRRIGATION

Structure	Irrigation method	Areas dunum		
		1977-1978	1978-1979	1979-80
Plastic houses	Surface	179	417.3	625.9
	Drip	106	323.9	729.9
Plastic tunnels	Surface	3410	4420	5538
	Drip	385	1585	1587

Major Vegetables

Major vegetables grown in the plastic houses are shown in Table 3 and major vegetable grown in plastic row tunnels are shown in Table 4 It is shown that yields obtained from row tunnels are low and this explains why most farmers are shifting to plastic house.

TABLE 3 MAJOR VEGETABLE GROWN UNDER PLASTIC HOUSE, IN THE JORDAN VALLEY

Kind	Relative importance	Growing period 1979-80	Yield range Ton/dunum	Varieties
Cucumber	96.4%	Oct/May/Dec	6-85	Special Dalella Miracross
Tomato	0.4%	Nov/July/Dec	8-12	Claidia Rat
Muskmelon	0.3%	Dec/May	2-4	Annanas
Fewemellows	1.95%	Feb/April	1-2	Shamia, Egyptia

TABLE 4 Major vegetables grown under plastic row tunnels in the Jordan Valley

Kind	Relative importance	Growing period 1979-80	Yield range Ton/dunum	Varieties
Cucumber	74%	Nov/March/ Jan/May	7-22	Dallela, Special
Tomato	7%	Nov/June	3-5	Claudia Raf
Squash	4%	Jan/April	3-4	Victoria
Eggplant	2%	Nov/June	5-6	Black Beauty
Pepper	2%	Nov/June	2-3	Deer horn, Fancy long chilly
Mush melon	5%	Jan/June	2-3	Annanas

The plastic houses structures are mainly imported single span houses.

These houses are 7-8 m. in width 2.75-3m in height but have different length, fifty meters is the most common length used in the Jordan Valley

Ventilation in houses is accomplished by opening the doors, and by sliding the film edges manually or by mechanical devices. Fans are seldom used for ventillation.

Plastic films for covering are now produced locally. The films are guaranteed to live 30 months provided they are removed during hot summer months.

Annexure 9

Plastics Industry and its Applications in Agriculture in Pakistan

The present pipe manufacturing capacity of Pakistan PVC limited is 2,000 tons per year which includes PVC pipes (rigid and perforated). It is estimated that the present demand of PVC pipes is around 6,000 tons per year in Pakistan and this will rise to 7,000-8,000 tons by 1981, including PVC corrugated and perforated pipes.

The use of PVC corrugated and perforated pipes for control of water logging is a very recent development in the field of Agriculture in Pakistan. The future demand of these pipes is expected to be substantial due to the continuing acute problems of salinity and water logging in the country. The great demand of PVC pipes is mainly due to good chemical stability, excellent corrosion resistance and low weight to strength ratio. Smooth finish of PVC pipe provides considerable saving in energy required for flow of fluids. The cost of PVC pipes is also very favourable as compared to pipes made from conventional materials. PVC pipes have also been successfully used in tube-wells as strainers and blind pipes. Because of the good chemical stability and other advantages, PVC pipes in tube-wells have proved to be very economical and efficient.

In 1975, the demand for PVC pipes was 3,800 tons while the demand met from local production was 1,000 tons. In 1979, existing demand was 6,000 tons while the demand met from local production was 2,200 tons. The Nowshera PVC Company has started manufacturing PVC perforated and corrugated pipes to be used for reclamation of water logged soil.

Another use of Plastics in Agriculture is its use as plastic bags for the packaging of fertilisers and agricultural products. Two plants; one in Karachi and the other at Multan are engaged in the production of polypropylene bags, especially for bagging fertilisers. Each plant has the capacity to produce 8.10 million bags per annum. However, one of these plants, has expanded the capacity to 20 million bags. At Mirpur, one unit is being established with the capacity of 10 million bags per annum. Similarly one more unit in addition to above has also been sanctioned under NRI Scheme with a proposed capacity of 8.1 million bags. Moreover the Fauji Foundation has also initiated a project for establishing a plant with a capacity of 16.0 million propylene bags per annum. Thus the total capacity (installed and proposed) in this industry be about 62.0 million bags against which production in the existing two units is said to be in the vicinity of 14.0 million bags although the installed capacity is for 16.2 million bags. According to a survey, the demand for polypropylene bags is expected to increase over 100 million bags by 1982-83 after the commissioning of the under construction fertiliser plants in the country. Inview of the prospects of increase in demand, there has been a marked increase in investment interest for the establishment of plants manufacturing polypropylene bags.

Some plastic bags are also being used for disposable items in the household article market.

There are some other uses of plastic products, about which no statistical data is available. Plastic pipes are used in shifting water from one place to another. Small plastic bags are used in collecting, preserving plant material. Plastic is also used in green houses as plastic is more cheaper than glass. Plastic sheets are used in lining water courses and canals in order to check seepage, in which a large quantity of water is wasted and further causes water logging. Plastic sheets (thin) are used in plant grafting for retaining soil moisture. Hand gloves, shoes, rain coats, hand sprayers for agricultural crops made of plastic are also gaining popularity in the country.

Use of Polyethylene bags of different sizes is also getting popularity for raising seedlings of various plants as well as flower and vegetable nurseries because its handling is much easier and cheeper as compared to earthen pots.

Plastic sheets are also getting popularity day by day in raising of fruit plants, flower and vegetable and tobacco nurseries in order to protect them from severe cold winds and frost during winter.

Annexure 10

Curing of Concrete Using LDPE Film Curing Blankets

Sample coarse cut from site slabs for compressive strength tests used to be kept immersed in water in curing tanks to ensure that hydration proceeded under ideal conditions. Now-a-days these coarse are simply placed in polythene bags. This accepted practice clearly demonstrates the efficiency of polythene as a curing medium and virtually the same conditions can be reproduced on the site concrete itself by using polythene sheeting as the curing blanket.

The recommended grade is 150 (lightweight) and this can be placed either directly on to the surface of the concrete or supported on reinforced mesh. If the sheeting is placed over the slab immediately after casting, it will give a glaze like finish to the concrete and tend to eradicate tamping or brush marks. The smoothness imparted is in relation to the time that elapses between pouring and covering; after the concrete has taken its initial set the surface will be unaffected by the sheeting.

Once the polythene is in position, no further watering or supervision is necessary. Even when the weather is hot or there are strong drying winds, the moisture content will remain virtually constant and there will be no premature drying out of the mix. In the case of granolithic floor finishes, the slow curing rate in hot weather is particularly important to prevent excessive or too rapid shrinkage and the risk of edge curling.

Subject to the sheeting not being mechanically damaged, it can of course be re-used after the curing period on further bays or employed as an underlay.

Polythene sheeting can also be used to give protection to green concrete from both rain and frost. Against rain, the lightweight sheeting is adequate if laid directly on to the slab. For frost protection, the heavier grade is necessary as it must be mounted on a frame, which, when placed over the bay, will trap a layer of static air to act as an insulant. Because site conditions vary so much and the type of frost differs, the degree of protection afforded by the covered frames may be only marginal, giving an internal temperature of approx. 4°F above the ambient, but this can be increased of oil lamps are placed underneath them.

R.H. Harry Stanger Tests

On the following pages are the results of a series of tests carried out by R.H. Harry Stanger at the request of British Vasqueen Ltd. These test were divided into curing of slabs and also of columns and beams.

DETAILS OF CONCRETE MIX

Proportions by volume	1:2:4	Cement	Typical ordinary Portland.
Proportions by weight	1:2.08:4.42	Water/Cement ratio	0.55
Maximum size of aggregate	¾ in	slump	2 in
Type of coarse aggregate	Gravel		

1. The curing of concrete slabs:

This report presents the results of tests made in the laboratory to assess the value of 'Visqueen' as a curing medium for concrete. The effect of using different methods and materials for curing was studied in relation to compressive strength and resistance to abrasion.

Compression Tests:

Three batches of six 6-in. cubes were cast and cured in different ways as follows. Batch A was cured in standard fashion at about 60°F, i.e. for the first twenty-four hours in a humid atmosphere and then in water unit tested. Batch B was cured by allowing the concrete to mature in air in the laboratory. Batch C cubes were

sealed in 'Visqueen' packages and left in the laboratory. Three cubes of each batch were tested in compression at an age of seven days and the other three after twenty-eight days.

The results of these tests were as follows:

Batch averages	After 7 days		After 28 days	
	Compressive strength lb/sq.in.	Density lb./cu.ft	Compressive strength lb/sq.in	Density lb/cu.ft
A	4,400	149½	6,150	150
B	3,570	144½	4,630	143½
C	4,100	148½	5,640	149

In the following table, the compressive strengths of the three batches are expressed as percentages of the values obtained by standard water curing;

Batch	At 7 days	At 28 days
A	100%	100%
B	81%	75%
C	92%	92%

This shows that air-tight 'Visqueen' covering is nearly as efficient a method of curing as immersion in water, and that the efficiency is unaffected by time, at least upto twenty-eight days. Air curing gave much lower strengths than either of the other two methods, and the results become relatively worse with time, upto twenty-eight days.

Abrasion Tests:

With the same mix, three sets of concrete slabs were prepared, measuring 24 in. × 12 in. × 2 in. The faces which were to be subjected to abrasion action were cured as follows:

A Under sacking which was kept damp.
B In the laboratory air
C Under 'Visqueen' which was placed in contact with the concrete as soon as it was strong enough to support the sheet.

The slabs were cured for fourteen days and then tested using the method described in B.S. 368:1956, Precast Concrete Flags. This requires the test surface to be exposed to the action of steel balls contained in a roating prism, the sides of which are formed by the test surfaces.

The rate of wear was as follows:

Slab	A	B	C
Average loss of material, lb	1.17	1.73	0.95

In the abrasion tests the order of merit for the curing method was:

Best: 'Visqueen': Intermediate: Damp sacking: Worst: Air Curing

If the losses due to abrasion are expressed on a percentage basis, the three curing methods would be rated as follows:

Air curing: Loss = 100%: Damp sacking:Loss = 68% 'Visqueen': Loss = 55%.

Curing with 'Visqueen' in contact with the concrete produced a surface that was appreciably more resistant to abrasion than either of the other two method.

2. Curing of columns and beams:

The tests dealt with in this report were undertaken to investigate the efficiency of 'Visqueen' when used as a curing medium for concrete structural members, of relatively small cross-section. Comparative tests were made in which identical concrete members were cured in different ways, the effectiveness of each method being assessed from the compressive strength developed.

Three concrete members measuring 5 ft × 6 in × 6 in. were cast from the same mix. They were demoulded after twenty-four hours and placed on end side by side near a radiator in the laboratory where the temperature was about 80°F. One unit was not protected in any way so that the drying out was uninterrupted. The second was swathed in sacking which was kept damp, while the third member was closely wrapped in 'Visqueen'. The units were cured for twenty eight days, after which time three 6-in. cubes were cut from the middle part of the length of each. Densities were determined and the cubes capped and crushed.

The concrete was a nominal 1:2:4 mix having a water/cement ratio of 0.55 and a slump of 2 in. gravel aggregates and natural sand were used. The proportion by weight were as follows:

Ordinary portland cement	1.0 part
Sand	2.1 parts
Aggregate 3/16 in. to 3/8 in.	1.2 parts
Aggregate 3/8 in. to 3/4 in.	2.7 parts

The results of these tests were as follows:

Method of curing	Exposed to air	Damp sacking	'Visqueen'
Compressive strength lb/sq.in.	2,920	2,930	4,080
	2,940	3,700	3,990
	3,000	3,780	3,970
	2,950	3,800	4,010
Density lb/cu.ft.	145	146	146
	144½	146	146
	145	145	146
	145	145½	146

The results clearly demonstrate the benefits of preventing loss of water from concrete during curing. When nothing was done to prevent evaporation once the concrete was cast, the compressive strength developed in the 6 in. × 6 in. section after twenty-eight days was 2,950 lb/sq.in. Curing under damp sacks resulted in the strength at the same age being increased to 3,800 lb/sq. in., again of 850 lb/sq.in., i.e. 29 percent. When the 'Visqueen' covers was used a further increase in strength of 210 lb/sq.in. was obtained, making a total gain over that associated with air curing of 36 per cent.

It was found, therefore, that 'Visqueen' was more efficient as a curing medium than damp sacking. It was also more convenient, as once in place it required no further attention.

Part 4: Impermeable underlays

Whilst precautions are taken to prevent moisture evaporating from the top surfaces of the concrete slab a further serious source of loss can be seepage of fat and fines into the sub-base, if it is porous. This may lead not only to an ultimate loss of compressive strength in the top slab but also to inconsistent mix ratios. Where the floor or bay areas are very large this inconsistency might result in weak patches and possible breakdown.

Concreting paper has been a traditional material for this application but it has a low tear strength and only temporary moisture resistance. Whilst these properties are in many cases adequate, polythene sheeting has additional and specific advantages of which the foremost is natural impermeability to liquid water and moisture vapour In addition to its low weight per unit area, polythene sheeting will not shatter, and the fact that it is available in wide seamless sheeting means that all likely casting widths can be matched, and wastage due to overlaps avoided.

An underlay of polythene sheeting can be particularly useful where floor labs are subjected to steam or hot water sterilisation as in food processing factories, abattoirs, hospitals, etc. Often in these circumstances weak acid build-up occurs. In ground floors this may not be trouble some although the base concrete can ultimately be affected; in floorings above ground level, leakage and chemical attack are liable to have serious consequences. The use of 'Visqueen' 1000 (double heavyweight) as an impermeable underlay in these cases provides an insurance and a second line of defence.

Alternatively, where concrete floors have been eroded or contaminated by acids, oils, etc., and the surface has to be re-screeded either because of breakdown or the area is to be used for a different purpose, a polythene underlay (again the 1000 grade) will act as an isolating barrier. As this type of flooring will normally be used for industrial purposes and subject to heavy traffic, a thicker topping of approximately 4 inches is recommended, because this will be unbounded and have a greater tendency to curl up at the corners and edges of the bays. Polythene sheeting is permeable to mineral oils and absorbs petrol causing swelling. For this reason it is not usually recommended where these products are known to be present. However, a number of garage floors have been re-screeded using 'Visqueen' as the underlay with apparent success.

In industrial concrete flooring where steel reinforcement has been included in the specifiction, the fabric may be laid either directly on top of the polythene underlay, or raised to the required height by placing it on blocks distributed at intervals along the sheeting.

Annexure 11

No. S.9581 413-K
Government of Gujarat
Irrigation Department
Sachivalaya, Gandhinagar
Dtd. 14th December 1981.

To
The Superintending Engineers:

1 Vadodara Irrigation Circle, Vadodara
2 Sukhi Project Circle, Alkapuri,Vadodara-5.
3 Panam Project Circle, Godhra
4 Kadana Project Circle, Diwada Colony, Via Santrampur, Distt. Panchamahals.
5 Karjan Irrigation Circle, Rajpipla
6 Damanganga Canal Circle, Valsad
7 Rajkot Irrigation Project Circle, Valsad
8 North Gujarat Irrigation Project Circle, Himatnagar.
9 Ahmedabad Irrigation Project Circle, Ahmedabad.
10 Kakrapar Modernisation Circle, Surat
11 Rajkot Irrigation Circle, Rajkot
12 Ukai Civil Circle, Ukai, Via Fort Songadh, Distt.Surat.
13 Salinity Ingress Prevention Circle, Rajkot.
14 Surat Irrigation Circle, Surat
15 Mahi Irrigation Circle, Nadiad
16 Field Channel Circle, Surat
17 Water Resources Investigation Circle No.1, Ahmedabad
18 Water Resources Investigation Circle No.2, Ahmedabad.
19 Water Resources Investigation Circle No.3, Ahmedabad
20 Central Designs Organisation, Gandhinagar
21 Central Designs Organisation (Hydrology), Gandhinagar.
22 Minor Irrigation Project (C.D.O.) Circle, Gandhinagar
23 Director, Gujarat Engineering Research Institute, Vadodara.

Sub: Lining to Canals

At present lining to the canals is being provided with cast-in-situ concrete or pre-cast concrete blocks or hydraulically pressed tiles. Representatives of the World Bank have observed some defects in the workmanship and the materials used in the lining work. It has been desired by the World Bank that the workmanship should be improved and specifications should be upgraded. After careful consideration, Govt. has accepted the suggestion made by the World Bank. The Standards proposed for lining the canal have been finalised in consultation on with the Central Water and the World Bank. A note containing the standards stated above is enclosed. I am directed to request you to follow the same in respect of the projects for which World Bank assistance is being obtained.

The Superintending Engineer at Sr.No. 1 to 13 are requested to work-out cost per sq.m. of each type of lining and submit the same alongwith the supporting details for it at the earliest.

Superintending Engineers are requested to get financial implications approved, if any, in adopting the standards as per the note enclosed from the competent authority.

Sd/- S J Patel
Officer on Special Duty(Project)
Irrigation Department

D A: Note (25 copies to each S.E. marked as*)

Copy with the copy of the note to all Technical Officers of Irrigation Department in Sachivalaya.

D A: Note

Accompaniment To Government Letter No. S-9581-413-K
Dated 14TH December 1981

Lining to Canals to be Adopted

Sr. No.	Type of Lining	Application	Remarks
a	b	c	d
1	Precast concrete troughs 40 mm (4 cm) thick	Water depth up to 30 cm (12 inch)	A Base layer of Polyethylene film (100 micron) over 20 mm sand. B Precast elements with slightly roundish edges to be set dry, joints to be filled in 1:3 cement mortar. C Precast elements to be prepared in extrusion machine or on vibrated platform. D No(A) can be eliminated where dense (Impervious) concrete can be ensured. E Cement concrete to be minimum M 150 proper grading of the aggregates mix design and curing of the elements to be ensured.
2	Precast concrete troughs 50 mm (5 cm) thick	Water depth up to 50 cm (20 inch)	A Base layer of polyethylene film (100 micron) over 20 mm fine sand. B Precast elements with slightly roundish edges to be set dry, joints to be filled in 1:3 cement mortar. C Precast elements to be prepared in extrusion machine or on vibrated platform. Proper grading of the aggregates, mix design and curing of the elements to be ensured. D No.(A) can be eliminated where dense (impervious) concrete can be ensured.
3	Cement tiles 23 mm (2.3 cm) thick single layer over polyethylene		A Base layer of polyethylene film (100 micron) over 20 mm fine sand. B 20 mm thick plaster in 1:5 cement sand mortar and two days gap. C Lay tile in cement and lime (fat or hydraulic) paste 3 mm thick. Joints to be 10 mm wide and filled in 1:3 cement sand mortar flush with face of tile. D Tiles to be soaked in water and paste to be applied on tiles E This item is for use of tiles on order. F This item not to be used in expansive soils. G When embankment compaction is not done wait for one monsoon to pass.
4	Cement tiles 23 cm thick single layer over two plasters.	Water depth upto 30 cm (1 foot)	A 10 mm thick base plaster 1:5 cement sand mortar two days gap. B 10 mm thick accond plaster ot 1:3 cement sand mortar-two days gap. C Lay tile in cement & lime (fat or hydraulic) paste 3 mm thick. Joints to be 10 mm wide and filled in 1:3 cement sand mortar flush with face of tile.

Sr. No.	Type of Lining	Application	Remarks
a	b	c	d
			D Tiles to be soaked in water & paste to be applied on tiles. E This item is for use of tiles on order. F This item not to be used in expansive soils. G When embankment compaction is not done wait for one monsoon to pass.
5	Double cement tiles 23 mm (2.3 cm) thick on polyethylene layer	Water depth up to 75 cm (2.5')	A Base layer of polyethylene film (100 micron) over 20 mm fine sand. B Lay first layer of tile on 6 mm thick 1:5 cement sand mortar, with 10 mm wide joints to be filled in 1:3 cement sand mortar 2 days gap. C Second layer of tile in cement & lime (fat or hydraulic) paste 3 mm thick joints to be 10 mm wide and filled in 1:3 cement sand mortar flush with face of tile. D Joints in two layers to be staggered. E This item is for use of tiles on order. F This item not to be used in expansive soils. G When embankment compaction is not done wait for one monsoon to pass.
6	Sandwiched cement tile 23mm (2.3 cm) thick on cement plaster	Water depth up to 75 cm (2.5')	A Lay first layer of tile on 6 mm thick 1:5 cement sand mortar with 10 mm wide. Joints to be filled in 1:3 cement sand mortar - 2 days gap. B 10 mm thick plaster in 1:3 cement and sand 2 days gap. C Lay tile in cement and lime (fat or hydraulic) paste 3 mm thick. Joints to be 10 mm wide and filled in 1:3 cement sand mortar flush with face of tile. D Tiles to be soaked in water and paste to be applied on tiles. E This item is for use of tiles on order. F This item is not to be used in expansive soil. G. When embankment compaction is not done wait for one monsoon to pass.
7	Cement concrete blocks 50mm (2inch) thick laid on polyethylene (size of block not less than 25 cm (10 inch) in one dimension.	A Water depth up to 1.5 metres. B Canals of capacity up to 3 cumecs in expansive soils.	A. Base layer of polyethylene film (100 micron) over 20 mm fine sand. B Lay blocks on 6 mm thick 1:5 cement sand mortar with 10 mm wide. Joints to be filled with 1:3 cement sand mortar. C When embankment compaction is not done wait for one monsoon to pass. D Blocks to be manufactured in machine or on vibrated platform with slightly roundish edges.

Sr. No.	Type of Lining	Application	Remarks
a	b	c	d
			E Concrete minimum M 100. F Articulated edges to be provided if possible. G Concrete aggregates to be graded and mix to be designed. H With blocks of articulated edges base layer of 1:5 mortar may be eliminated after experimentation.
8	Cement concrete blocks 50 mm (2 inch) thick laid over two plasters.	A Water depth up to 1.5 metres. B Canals of capacity up to 3 cumecs in expansive soils	A Base plaster 10 mm thick in 1:5 cement sand mortar-2 days gap. B Second plaster 10 mm thick in 1:3 cement sand mortar-2 days gap. C Lay blocks 6 mm thick 1:3 cement sand mortar with 10 mm wide joints filled with 1:3 cement sand mortar. D Blocks to be manufactured in machine or on vibrated platform with slightly roundish edges. E Concrete minimum M 100. F Articulated edges to be provided if possible. G Concrete aggregates to be graded and mix to be designed. H With blocks of articulated edges base layer of 1:5 mortar may be eliminated after experimentation.
9	Pre-stressed concrete blocks 35 mm (3.5cm) thick with laying materials and specifications as per (7) above	A Up to 1.5 m. water depth B Canals of capacity up to 3 cumecs in expansive soils	A To be designed (longitudinal and transverse stress) and experimented. Cost efections established and proved before large scale applications.
10	In-situ-concrete lining with layer of fine sand and polyethylene.	All canals with capacity above 3 cumecs	A Cement mortar to be maximum M 100. B Lining thickness as per (5) above. C Joints should invariably be located near junction of natural ground and embankment. D Joints to be provided as per (5) above. E Joints to be adjusted to take care of differential behaviour of soils. F Aggregates to be graded and concrete mix to be designed.

Sr. No.	Type of Lining	Application	Remarks
a	b	c	d
11	Troughs to be constructed with brick masonry or with precast concrete slabs	Water depth upto 50 cm (1' 8")	A Bottom layer of 20 mm fine sand followed by polyethylene 100 microns. B Set base bricks 75 mm or 50 mm precast concrete slabs in 1:3 cement sand mortar, no base plaster over polyethylene. C Construct 11.5 mm (4½ in) side brick wall in 1:3 cement, sand mortar for side of trough up to 30 cm depth of water and 230 mm thick side brick wall for the first 25 cm and 115 mm thick for the next 25 cm for the side of the trough with 50 cm depth of water
12	Sandwiched brick lining	Canals with capacity above 3 cumecs.	A 50 mm brick tile to be set in cement mortar 1:5 B Plaster 10 mm with 1:3 cement mortar-2 days gap C 50 mm brick tile set on 6 mm cement mortar 1:3 layer and joints in cement mortar 1:3. D In canal bed one layer of brick with top plaster may be eliminated if polyethylene (100 micron) on sand layer 5 mm is used as bottom layer.

Annexure 12

Details of Recent Tenders floated in Gujarat and MP for LDPE Film to be used in Canal Lining

Name of the project	LDPE film required	Width of the film
GUJARAT		
1 Damanganga Project No. II	10.0 MT	1.5 M and above
2 Kakraparcanal Remodelling Division, Surat	22.5 MT	1.5 M and above
3 Sukhi Project, Bodeli	2.4 MT	3 M and above
4 Panam Project, Godhra	8.0 MT	3 M and above
5 Modernisatton Divn. Rajkot	118.0 MT	1.5 M and above
6 Irrigation Project, Dantiwada	68.0 MT	1.5 M and above
7 Damanganga Project, Valsad (for 17.9 km of canal)		Not available
MP		
1 Hasdeo Bango Project, Div. I	50 MT	7 M and above
2 Hasdeo Bango Project Div. II	80 MT	7 M and above
3 Mahanadi Project, Rudri	60 MT	7 M and above

All the above projects have tendered for 100 micron thick heavy duty LDPE film.

Annexure 13

A Note on Canal Lining with Low Density Polyethylene (LDPE) Film -M.R.B.C. Project, Stage I

Brief specifications and cost-analysis:

Brief specifications of the materials and works for sandwich-type double brick-tile lining in slopes and single brick-tile lining with 100 micron LDPE film in bed are given in Figs. 1 and 2. Statements showing quantities and cost-analysis of composite lining works on Main Canal M. 36 to 46 and Petlad Branch M.O to 12. Petlad Branch M.12 to 29.4 and Borsad Branch M.O to 14.8 are given below:

Cost analysis of composite lining:

(i) Double tile lining on canal sides:

Item: Lining the canal with brick-tiles (30 × 15 × 5 cms. i.e. 12″ × 6″ × 2″) in two layers, the bottom layer on 10 mm thick red cement mortar (1:5) with sandwich layer on 15 mm thickness 1:3 of red cement mortar layer, laid on sandwich layer including pointing in 1:3 of red cement mortar on the top with necessary earthwork to accommodate the lining dressing work on the bed and sides and berms including depositing the same as directed.

(A) Material

Item		Qty.for 100sq. ft.	Providing rate (Rs)	Cost Rs
1 Brick-tiles (incld. 10% wastage) 2(188 + 19)		414 Nos.	140.00 per 1000 Nos.	57.96
2 Sand	13.54	15 cu.ft.	79.00 per 100 cu.ft	10.50
Add 5%	0.68			
	14.22 cu.ft.			
	(rounded upto 15 cu.ft.)			
3 Cement		2.68 bags	17.00 per bag	45.56
4 Sukhi		0.67 bag	5.80 per bag	3.35
			Total of (A)	117.37

(B) Labour charges for 100 sq. ft.

Note: One mason with 4 labourers will do 100 sq. ft. of lining per day

	No. of days	Rate (Rs)	Cost (Rs)
1 Mason	1	11.00	11.00
2 Labour	4	4.00	16.00
3 Bhisti (water charges)	½	7.00	3.50
4 Dressing the surface	Job	—	3.00
5 Sundries	Job	—	1.00
		Total of (B):	34.50

Total of (A) & (B) = Rs.117.37 + Rs.34.50 = Rs.151.87

(C) Other costs

Contractor's profit & overhead charges of T&P etc. @10% 15.18

Grand Total (per 100 sq.ft.) 167.05

Thus the rate per square metre works out to Rs.17.98 (rounded upto Rs.18.00)

(ii) Single tile lining on canal bed

Item: Providing and laying brick-tiles (30 × 15 × 5 cms. i.e. 12″ × 6″ × 2″) lining in the bed of the canal in red cement mortar 1:5 over 10 mm thick layer of red cement mortar 1:6 including finishing true to line and level, watering, curing etc., complete.

(A) Material

Item	Qty. for 100 sq. ft.	Providing rate (Rs)	Cost Rs
1 Brick-tiles (including 10% wastage)	207 Nos.	140.00 per 1000 Nos.	28.98
2 Sand with 5% wastage	5.10 cu.ft.	70.00 per 100 cu.ft.	3.70
3 Cement	0.667 bags	17.00 per bag	11.34
4 Surkhi	0.167 bag	5.00 per bag	0.84
		Total of (A):	44.86

(B) Labour charges:
Noate: One mason with 4 labourers will do 250 sq. ft. of work per day

	Note of days	Rate	Cost Rs
1 Mason	$1 \times \frac{100}{250}$	11.00	4.40
2 Labour	$4 \times \frac{100}{250}$	4.00	6.40
3 Bhisti (water charges)	$\frac{1}{2} \times \frac{100}{}$	7.00	1.40
4 Sundries	Job	—	2.00
	Total of (B):		14.20

Total of (A) & (B) = Rs.44.86 + Rs.14.20 = 59.06

(C) Other costs
Contractor's profit & overhead charges of T & P etc. @ 10% 5.90
Grand Total (per 100 sq. ft.) 64.96

Thus the rate per square netre works out to Rs.6.99 (rounded up to Rs.7.00

iii LDPE film lining on canal bed

Item: Providing and laying black LDPE film of 100 microns (400 guage) in the bed of the canal with subgrade of ½" sand
Unit: 1 square metre

(A) Material

Item	Qty.	Rate (Rs)	Amount (Rs)
1 LDPE film @ Rs.18/- per kg (1 kg of LDPE film provides a coverage of 10 square metres area)	1 sq. ft.	1.80 per sq. mt.	1.80
2 Sand ½" thick as subgrade	0.025 cu.mt	24.50 per cu. mr.	0.61
3 Sundries	Job		0.29
		Total of (A):	2.70

(B) Labour Charges

Labour charges for laying LDPE film	0.15
Labour charges for screening the sand taken to the bed and spreading it in ½" layers	0.15
Total of (B):	0.30
Total of (A) & (B) = Rs.2.70 + Rs.0.30	3.00

(C) Other costs

Contractor's profit @ 15%	0.45
Grand Total:	3.45

Thus the rate per square metre works out to Rs.3.45

Accordingly, the cost per square metre of composite lining for the above Branch canals works out as under:

	Cost per sq. mt. of composite lining	
	With earthwork	**Without earthwork**
	Rs	**Rs**
1 Main canal (Q. 1552 cusecs uniform)	16.20	13.97
2 Petlad Branch M.O. to 12 (Q.1273-1103 cusecs)	14.36	11.91
3 Petlad Branch M 12 to 29.4 (Q.1103-521 cusecs)	16.95	15.92
4 Borsad Branch M.O. to 14.8 (Q.1346-293 cusecs)	15.64	14.92

Annexure 14

ASAE Engineering Practice: ASAE EP 340.1
Installation of Flexible Membrane Linings

Developed by Flexible Membrane Linings Committee SW-247: approved by Soil and Water Division Standards Committee; adopted as a Recommendation by ASAE December 1970; reconfirmed for one year December 1975; revised and reclassified April 1977.

SECTION 1 - PURPOSE AND SCOPE:

1.1 Flexible rubber and plastic membranes are used extensively as seepage barriers for ponds, reservoirs and canals. These membranes, when properly installed, may be expected to render satisfactory service in controlling liquid loss and pollution.

1.2 Their use should be considered wherever liquid loss due to seepage is of such proportion as to prevent the facility from economically fulfilling its planned function; where the conservation of soil or liquid resources is being impaired; or where liquid leekage is damaging land or creating pollution.

1.3 The purpose of this Engineering Practice is to provide the designer of water or speciality liquid facilities with guidelines for the proper installation of membrane materials. It is not intended to serve as a complete set of specifications. Neither is it intended to replace the judgement of personnel who are intimately familiar with site conditions or the overriding circumstances of the project.

SECTION 2 - GENERAL REQUIREMENTS:

2.1 Since relatively thin membranes may be subjected to mechanical damage during installation, it is important to consider beforehand the field procedure which will be utilized in the actual lining operation. The manufacturer or his local representative may provide assistance, especially in selecting the proper prefabricated membrane width and method of packaging or delivery.

2.2 It is desirable that soil subgrades be firm enough to support the men or equipment to be used during the lining installation. Adequate structural bearing shall be provided. Generally, the native soil subgrade should be disturbed as little as possible in the excavation or reshaping operation.

2.2.1 All large soil clods, brush, roots, rocks, sod, or foreign material which might puncture the lining material shall be eliminated from the area. Rolling or surface compaction of the subgrade is encouraged to provide an extra measure of safety. Backfilled depressions, including areas where stumps, trees or large rocks have been removed are practically subject to localized settling and should always be compacted with care.

2.2.2 If the subgrade is coarse-textured and open after preparing and compacting, or in rocky soils, a one to two inch cushion layer of well-graded sands and gravelly sands (soil group SW or finer, Table 1) should be applied.

2.2.3 After preparation of the subgrade, the soil surface under the lining should be treated with a high quality, no selective soil sterilant, if weed growth is considered to be a likely problem. Care should be taken not to apply sterilants outside the lined area if land scaping or grasses are to be established later.

2.3 When a flexible membrane lining is installed over deteriorated rigid (concrete) or semirigid (asphalt) linings, the same precautions regarding foreign materials or sharp projections which could puncture the membrane apply. The deteriorated structure should be inspected carefully and all such hazards smoothed over. In addition, cracks, nominally; wider than 5mm (0.2 in.) should be filled with mortar or other suitable material.

2.3.1 While properly installed membrane linings are durable and water-tight, they should not be counted on for

structural support. The structural stability of badly deteriorated and cracked rigid linings shall be ascertained prior to relining with a flexible membrane.

2.4 Membrane thickness: Selection of the membrane thickness should be based on the texture of the soil and the susceptibility of the lining to damage during or after installation. Table 1 may be used as a guide in selecting the proper membrane thickness relative to soil subgrade conditions. Membrane thickness should not be increased to compensate for improper subgrade preparation.

Table-1

MINIMUM MEMBRANE THICKNESS RELATED TO SOIL SUBGRADE CLASSIFICATION

Soil Subgrade Description*	Elastomeric Sheeting Fabric-Reinforced		Unreinforced		Plastic Sheeting	
	mm	mils	mm	mils	mm	mils
Sands, greater than 50% of the soil particles pass No. 4 sieve, includes groups SM, SP, SW	0.50	20	0.75	30	0.25	10
Gravels, greater than 50% of the soil particles retained on No. 4 sieve, includes group GC, GM, GP, GW.						

Both sizes reported are classified as coarse-grained (more than 50% of the material passing a 75 mm (3 in.) sieve is retained on a No.200 sieve as defined in ASTM D2487. Classification of Soils for Engineering Purposes.

2.5 **SIZING:** Membrane linings should be supplied in sections as large as practical. However, availability of equipment to handle large rolls or packages may limit the section size specified. Table 2 indicates the approximate unit weight of typical rubber and plastic sheeting.

2.5.1 All field splices shall be made in accordance with the manufacturers' recommended technique, using materials finished for the purpose. Field splices shall be formed by a minimum overlap of 50 mm (2 in.). The joint shall be water tight and maintain its integrity through the expected life of the lining.

2.5.2 Field splices on the side slopes or banks should be oriented perpendicular to the liquid surface whenever practical (with the slope), to reduce stress on the joint.

2.5.3 The two sections of lining material to be field spliced shall lay flat against one another, that is, one section shall not be drawn taut over an adjoining section that is wrinkled.

TABLE - 2 - Approximate Unit Weight Of Sheeting Types

Membrane type	Gram per square metre per millimetre thickness	Pound per square yard per mil. thickness
Rubber	0.625	0.065
Plastic (Depends on Type)	0.385 to 0.625	0.040 to 0.065

2.6 **PLACEMENT:** Flexible membrane linings should not be stretched during installation. Both reinforced and unreinforced rubber linings, as well as polyvinyl chloride plastic sheeting should be installed in a relaxed state or with slight slack allowed in both directions. Polyethylene and copolymer films should have approximately 5 percent slack (5 m in 100 m) in both directions, distributed evenly along the membrane length and width.

2.7 **PLACEMENT OF COVER MATERIAL:** The use of cover material (earth sand, gunite, concrete) is important for most membrane linings to reduce mechanical damage as well as reduce the effect of holes on the seepage rate. The sequence for placement of cover material must be determined by the peculiarities of the job and site. In general, cover material on all slopes shall be placed beginning at the bottom and proceeding towards the top. Placing of cover soil shall be conducted in such a manner that the lining will not be displaced or damaged by equipment or overburden. Sliding of cover material over the lining should be avoided. The cover material shall not be placed when the temperature is below 0°C (32°F), unless the condition of the cover soil is such that its placement will not rupture the lining (relatively dry and free flowing). Care must also be taken in the placement of cover material when temperatures are over 38°C (100°F), as the puncture resistance of plastic membranes diminishes as the temperature increases.

SECTION 3 - RESERVOIR AND POND LINING:

3.1 **DESIGN CRITERIA:** Agricultural or conservation reservoirs and ponds to be lined shall be designed to meet the general requirements of United States Department of Agriculture Soil Conservation Service Standards and Specifications. SCS 521. Pond Sealing or Lining; SCS 552. Irrigation Pit or Regulating Reservoirs; SCS 436, Irrigation Storage Reservoirs; or SCS 648 Wildlife Watering Facilities.

3.1.1 All facilities should be designed so that they will not fail structurally without a lining, since there is always the possibility of the lining being damaged.

3.2 **MEMBRANE TYPE SELECTION:** In general, the flexible membrane lining materials commercially available for this application are divided into rubber and plastic types. Field experience has dictated that all plastic film membranes must be buried under an earthen cover to insure long-term watertight integrity. The rubber membranes need not be covered for protection from atmospheric weathering but burial is advised if external mechanical damage from operating equipment, livestock, vandals, etc. is expected.

3.2.1 Where a plastic film membrane is to be buried in the structure for seepage control, the over-excavation of the earthen structure must be considered in the design. Soil cover should be a minimum of 150 mm thick (6 in.). The bottom 75 mm (3 in.) next to the membrane should not be coarser than silty sand (soil group SM). Where a flexible membrane is to be buried for protection against livestock or mechanical damage, a minimum of 225 mm (9 in.) of cover is required, with additional thickness desirable when the cover material is of high plasticity.

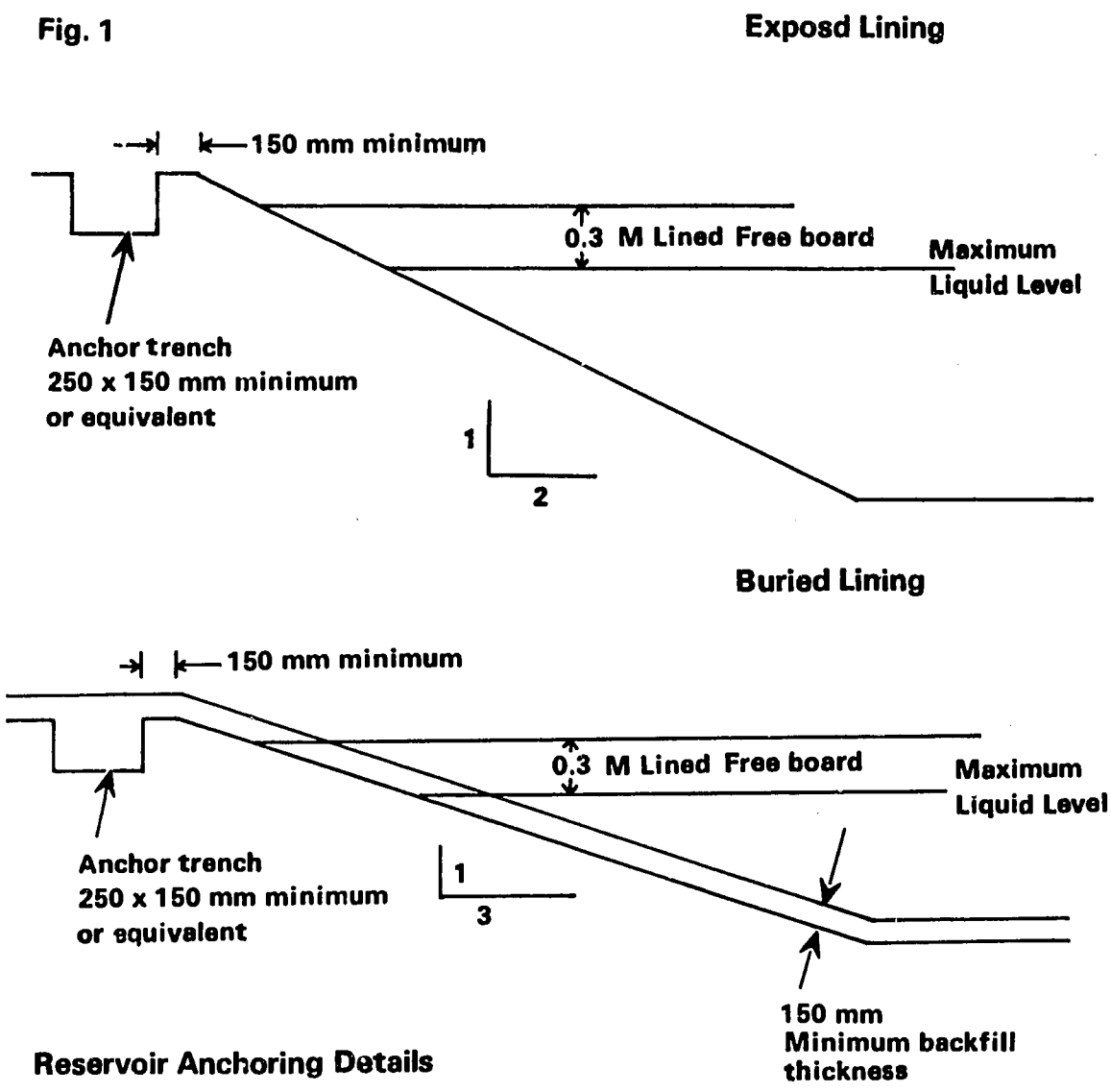
3.2.2 Cover material shall be sufficiently stable to minimize wind erosion and liquid scouring on the sloping sides as the liquid level in the facility is varied. Likewise, all cover material must be sufficiently stable to resist sliding on the side slopes because of the weak shear plan created by the membrane. Side slopes for reservoirs utilizing buried linings should not be steeper than 3 to 1. In some cases side slope can be increased to 1 to 1 if a rigid cover of reinforced mortar is used.

3.2.3 Where exposed rubber membrane linings are to be utilized in earthen structures, the side slope of the reservoir may be increased to 2 to 1, provided this does not exceed the angle of repose for the embankment material. Where side slopes of 6 m (20 ft.) or more are encountered, reinforced material should be considered.

3.2.4 When exposed membranes are used to line deteriorated rigid reservoir structures having side wall or abutments steeper than 1 to 1, the membrane should be held in place on the side wall. This may be done either mechanically or with suitable adhesives recommended by the membrane manufacturer. Redwood nailing strips, rolled galvanized strips and aluminium bar stock are often used above the liquid level to hold the vertical membrane in position. Only reinforced membranes should be used when slopes are steeper than 2 to 1.

3.2.5 The lined freeboard should be at least 0.3 m (1 ft.) above the maximum level of the liquid surface in reservoirs of less than 0.4 ha (1 acre) surface. In larger reservoirs, additional bank height should be provided to prevent over-topping by wind-generated waves. Generally, add 0.3 m (1 ft.) of lined bank height for every 240 m (800 ft.) of additional wind reach, above 60 m (200 ft.). The lined freeboard should be equivalent to the minimum permissible bank height to prevent overtopping of the reservoir liquid. (See Fig. 1).

Fig. 1



Reservoir Anchoring Details

3.2.6 Provision must be made to prevent surface flooding from run-off around the reservoir perimeter due to poor drainage. The reservoir design should not permit surface run-off, or other incident liquid, from eroding the soil bank structure or seeping between the subgrade and the membrane. Where ground water tables intercept the facility invert, provision should also be made for drainage beneath the membrane. (Reference: ASAE Recommendation ASAE R302. Design and Construction of Surface Drainage Systems on Farms in Humid Areas).

3.2.7 The flexible membrane lining shall be anchored about its perimeter at the top of the reservoir embankment. In earthen structures this may be accomplished by means of an anchor trench at least 250 mm (10 in.) wide and 150 mm (6 in.) deep. The membrane should extend across the bottom and up the far side at the trench to form a "U" shape as shown in Fig. 1 The trench may be located either on the side slope of the embankment or on the bench level if one is established. When located on the bench level, the trench should not be closer than 150 mm (6 in.) to the top of the side slope. Anchor trenches shall be carefully backfilled and compacted after the membrane is in place.

3.2.8 Fill pipes, drains, overflow structures, gauge supports, or other fixtures that penetrate the membrane lining shall be suitably flashed and sealed to prevent leakage. Care should be exercised to insure that appurtenances remain in position when the facility is filled. Any shifting would tend to damage or overstress the flexible membrane where it is flashed on to the appurtenance.

3.2.9 In lined resrvoirs where the flexible membrane is buried, the liquid entrance-way should be protected with an additional heavy covering of large gravel or riprap to protect the earthen covering from erosion. A de-energizing structure may also be needed to reduce turbulence of the entering liquid, particularly if the intake structure is a pipe or flume. Likewise, drainage outlets should utilize vertex breakers to minimize disturbance of the protective earthen cover. In lined reservoirs where an exposed membrane is utilized, similar precautions are recommended to insure lining stability and positioning.

SECTION 4 - CANAL LINING:

4.1 **Design criteria:** Irrigation canals and ditches to be lined shall be designed to meet the general requirements of existing USDA Soil Conservation Service Standards and Specifications or existing United State Department of Interior Bureau of Reclamation Standards were applicable. In this case, however, a flexible membrane lining is to be utilized as the impervious material to control seepage.

4.1.1 All facilities should be designed so that they will not fail structurally without a lining, since there is always the possibility of the lining being damaged.

4.1.2 A lined irrigation canal shall have enough capacity to functioning as designed without danger of overtopping.

4.2 All flexible membrane linings should be buried under suitable cover to protect them from damage when the canal is empty or being mechanically cleaned. A soil cover should be a minimum 150 mm (6 in.) thick. The bottom 75 mm (3 in.) next to the membrance should not be coarser than silty sand (soil group SM). Where a flexible membrane is to be buried for protection against livestock or mechanical damage, a minimum of 225 mm (9 in.) of cover is required. Sufficient over-excavation of the earthen structure to provide for covering the membrane must be considered in the canal design. A reinforced mortar cover for plastic or rubber membrane is particularly effective in canal linings.

4.2.1 Canal with buried membrane linings must be constructed so that side slopes will be stable. Slope requirements will vary with different types of cover soil, but shall not be steeper than 3 to 1.

4.2.2 Stream velocities in canals lined with buried flexible membranes shall not exceed the non-erosive velocity for the earth cover material. Local information on velocity limits for specific soils should be used when available, however design stream velocity generally should not exceed 1 m/s (3 ft/s).

4.2.3 The canal cross-section shall be sized for sufficient capacity to carry the required flow under maximum retardance conditions. For capacity design purposes, a value for average roughness (Manning's "n" coefficient) which considers changes due to potential weed and silt hazard in the water-carrying prism should be used. A minimum value of 0.030 for the Manning "n" coefficient is recommended.

4.2.4 Water surface elevations should be established to provide adequate hydraulic head for successful operation of all ditches or other conveyance structures diverting from the canal. A minimum head of 150 mm (6 in.) shall be provided, with 300 mm (12 in.) preferred.

4.2.5 The lined freeboard allowed in canals should not be less than 150 mm (6 in.) above maximum design operating level, increasing to 1 m (3 ft.) as the canal capacity increases from 3 to 400 m^3/s (110 to 14,000 ft^3/s). The design bank height above the maximum surface level should be twice the permissible lined freeboard. (See Fig. 2). In addition, provision should be made to prevent soil bank erosion from surface run-off around the canal perimeter caused by poor drainage.

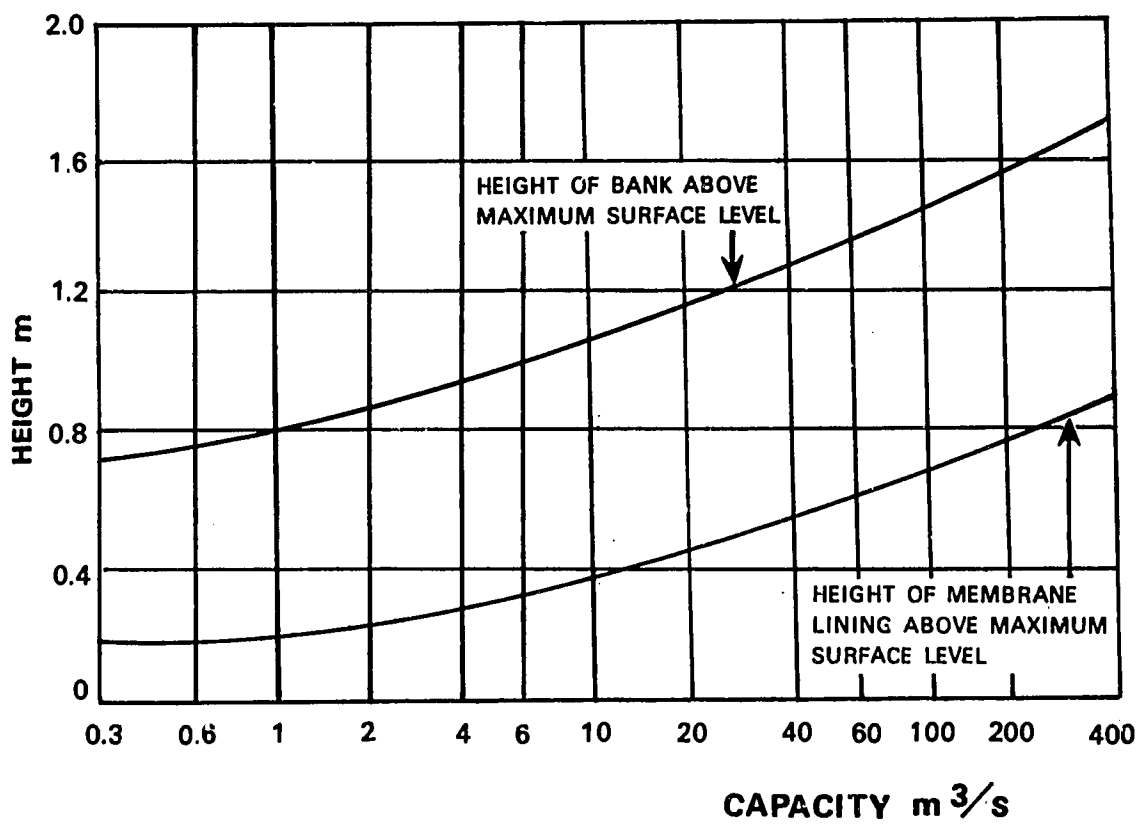


Fig. 2 Bank height and freeboard for Membrane – Lined Canals

4.2.6 The buried membrane lining shall be anchored on each side of the canal along the berm so that the specified freeboard will be maintained. This is usually accomplished by means of an anchor trench as described in paragraph 3.2.7. The upstream and downstream ends of respective membrane sections are overlapped in the downstream direction – minimum of 1 m (3 ft.). The placement of the protective cover material will secure the lap joint. Since the cover material will be utilized to stabilize the membrane, care should be taken to ensure full cover depth over the upstream end of the first upstream section of lining.

4.2.7 In some instances, notably the rehabilitation of deteriorated rigid canal linings (cracked concrete or asphalt), it may be desirable and economical to install a flexible membrane lining inside the structure over the old lining. This should be considered only after the possibility of damage to the exposed lining from cleaning equipment, vandals or other causes has been carefully weighed.

4.2.7.1 Only weatherable membrane materials should be selected for this application, since the lining will be exposed to the elements.

4.2.7.2 The membrane should be totally adhered to the rigid canal structure to preclude movement when the canal is in service and minimize susceptibility to vandalism when the canal is empty. Membrane suppliers can provide information and adhesive recommendations for this procedure.

4.2.7.3 The upstream end of each exposed membrane piece shall also be mechanically fixed to the canal structure across its width. The downstream end shall be lapped for a minimum of 1 m (3 ft.) over the mechanically anchored upstream end of its succeeding section. A fail-safensplice, designed to fail at about 30 percent of the material tensile strength when pulled in shear, shall be made at this lap. The material supplier should be consulted regarding this splice.

4.2.7.4 Stream velocities should be held as low as practical to minimize stress on the membrane, although in remedial work this variable may not be controllable. A Manning "n" coefficient of 0.012 may be used for clean, exposed membrane linings to calculate capacity.

SECTION 5 - MEMBRANE MATERIALS:

5.1 Rubber and plastic materials supplied for installation as flexible linings shall be compounded of high quality ingredients to produce durable, watertight membranes. Ingredients shall be thoroughly mixed to insure complete dispersion throughout the compound prior to processing into sheeting. The finished membrane material shall be free from defects which would affect its long-term serviceability as an impermeable lining.

5.1.1 **Dimensional tolerance:** Where membrane material is purchased under job specifications which detail the physical size of sheeting pieces, actual material dimensions shall not be smaller than those specified. The measurements shall be made ambient temperature in a relaxed state, or under light tension to remove wrinkles in the material. Thickness tolerances shall be as follows:
Rubber sheeting reinforced-specified thickness ± 5 percent or 0.05 mm (2 mils), whichever is greater.
Rubber sheeting, unreinforced-specified thickness ± 10 percent.
Plastic sheeting, polyethylene and copolymer – nominally specified thickness ± 25 percent.
Plastic sheeting, polyvinyl chloride – nominally specified thickness ± 7 percent.

5.1.2 **Certification:** Purchasing authorities vary in their requirements as to material sampling and certification. It is not the intention of these guidelines to restrict this authority. At the very minimum, the purchasing agency should insist on contractor or material supplier certification that the material supplied for the project meets or exceeds the physical and performance properties outlined in this Engineering Practice. Such certification shall

include identification of material, quantity represented, and certified physical test results covering all of the specification test requirements.

5.1.3 **Packaging:** Unless otherwise specified the flexible membrane lining shall be packaged for shipment in rolls or accordion folded. The package shall be suitably protected so that the material will not be damaged by commercial carrier shipment.

5.1.4 The details of roll or package marking shall be outlined in the job specifications. As a minimum, each roll or container of lining material shall be marked or identified with the name of the material, the quantity contained therein (area and thickness), the name of the supplier, and the contract or project identification number.

5.2 **Material Specification:** Minimum physical requirements for some commercially available materials which may be used as flexible membrane linings are shown in Table 3 and 4. Other materials may be used for a particular application and may be so specified. The physical requirements listed are intended to ensure good workmanship and quality, but are not necessarily adequate for design purposes depending on specific performance requirements. The tests shown conform to the American Society for Testing and Materials Standards. ASTM D3020, Specifications for Polyethylene and Ethylene Copolymer Plastic Sheeting for Pond, Canal Reservoir Lining: ASTM D3253, Specifications for non-Fabric Reinforced Vulcanized Rubber Sheeting for Pond, Canal and Reservoir Linings: and ASTM D3254, Specifications for Fabric-Reinforced Vulcanized Rubber Sheeting for Pond, Canal, and Reservoir Linings. Materials differ in their chemical resistance and should be selected for compatibility with the liquid to be stored or conveyed.

TABLE-3 Physical Requirements Of Poly (Vinyl Chloride), Polyethylene And Ethylene Copolymer Plastic Lining

Test Description	Test Method	Poly (Vinyl Chloride)	Poly-ethylene	Copo-lymer
Tensile strength, min. MPa (psi)	*ASTM D882 Method A			
Machine direction		14(2000)	14(2000)	17(2500)
Cross direction		14(2000)	12(1800)	14(2000)
Ultimate elongation at break, both directions minimum percent.	ASTM D882 Method A	250	500	500
Impact reistance, minimum average N/mm (g/mil)	ASTM D1709 Method B	†	17(45)	25(65)
Low temperature impact at $-29 \pm 0.5°C(-20°F \pm 1.0°F)$	ASTM D1790	Not more than 2 specimens out of 10 shall fall	†	†
Tear resistance, both directions, minimum, N/mm (g/mil).	ASTM D1922	60(160)	30(80)	40(100)
Resistance to soil burial, Tensile strength retained, both directions minimum pe.cent	Burial for 30 days at 35°C (95°F) Compost pH of	95	95	95
Elongation retained, both directions, minimum percent.	7.0 ± 0.5 with 25 to 30% moisture dry basis.	80	80	80
Luminous transmittance, maximum percent	ASTM D2103	†	1.0	1.0
Volatile loss, maximum %	ASTM D1203	1.0	†	†
Water extraction, maximum weight loss, percent	ASTM D1239	0.35	†	†
Pinholes and cracks maximum per $8.36m^2$ ($10yd^2$)	Examine film held under slight tension with bright light source behind film	1	1	1
Shrinkage at elevated temperature, maximum %	ASTM D1204	5.0	†	†
Bonded seam strength after 7 days cure at room temp. both directions, minimum percent of tensile strength	ASTM D882 Method A	80	†	†
Ash content, maximum percent	ASTM D1278	†	0.5	0.5

TABLE - 4 PHYSICAL REQUIREMENTS OF UNREINFORCED AND FABRIC - REINFORCED VULCANIZED RUBBER SHEETING

TEST DESCRIPTION	TEST METHOD	IIR	SHEETING TYPE EPDM	CR
Tensile strength, minimum MPa (psi)	ASTM D412	3(1200)	9(1300)	10(1500)
Break strength, both directions, minimum N (lb)	ASTM D751	420(95)	420(95)	420(95)
Ultimate elongation at break minimum, percent	ASTM D412	300	300	250
Maximum, both directions percent	ASTM D751	30	30	30
Shore "A" hardness, points	ASTM D2240	60 ± 10	60 ± 5	60 ± 10
Modulus at 300 percent Elongation, Minimum MPa (psi)	ASTM D412	4(600)	6(900)	†
Ozone resistance, 50 pphm	ASTM D1149			
40°C (104°F), no cracks after, h 40 percent linear strain		168	†	100
100 percent liner strain		†	168	†
Procedure B 0f ASTM D518		168	†	168
Break strength, retention minimum percent	ASTM D751	90	†	90
Heat aging air oven 168 heat 116°C(240°F) unless specified otherwise	ASTM D573 ASTM D412	70	70	35, after 70 hr at 100°C (212°F)
Tensile strength retention,minimum percent of original				
Break strength retention,minimum percent of original	ASTM D751 ASTM D412	90 70	90 70	90 60, after 70 hr at 100°C (212°F)
Elongation retention, minimum percent of original	ASTM D751	90	90	90
Change in hardnesss, maximum points	ASTMI2240	†	†	†10
Change in linear dimension,maximum percent	ASTM D1204	†2‡	†2‡	†2‡
Ozone resistance after heat aging, no cracks after, h	ASTM I1149	†	168	†
Break strength retention after heat aging and ozone exposure, minimum percent of original	ASTM I751	†	90	†
Low temperature brittleness,temperature maximum °C(°F)	ASTM D746	†	−54 (−65)	†
Tear resistance, minimum, force per unit thickness N/mm (lb /in).	ASTM D624 Die B	26(150)	26(150)	21(120)
Minimum, common requirements for three types, N (lb) Thickness, mm (in.)	ASTM D751			

	Warp	Fill	Warp	Fill	Warp	Fill
0.50 (0.020)	22(5)	22(5)	22(5)	22(5)	22(5)	22(5)
0.80 (0.032)	44(10)	44(10)	44(10)	44(10)	44(10)	44(10)
1.15 (0.045)	53(12)	44(10)	53(12)	44(10)	53(12)	44(10)

TEST DESCRIPTION	TEST METHOD	SHEETING TYPE* IIR	EPDM	CR
Hydrostatic resistance, minimum common requirements for three types, MPa(psi)	ASTM D751			
Thickness : mm(in.):				
0.50(0.020)		0.7(100)	0.7(100)	0.7(100)
0.80(0.032)		1.2(180)	1.2(180)	1.2(180)
1.15(0.045)		1.3(190)	1.3(190)	1.3(190)
2.60(0.062)		1.3(190)	1.3(190)	1.3(190)
Hydrostatic resistance retention	ASTM D751		100	100
after ozone exposure percent	ASTM D1149			
Low temperature brittleness temperature, maximum °C(°F)	ASTM D746	−40(−40)	‡	−34(−30)
Weight change after 168 heat 70°C(158°F) in water maximum percent	ASTM D471	†1	†1	†10
Permanent set § after 22 heat 70°C(158°F), maximum percent	ASTM D395	‡	‡	40
Oil resistance § change in volume after 70 heat 100°C(212°F) in ASTM No.3 Oil, maximum percent.	ASTM D471	‡	‡	40
Water vapour permeability at 27°C (80°F), maximum fg/Pa-s-m. (Perms-mils).	ASTM E96 Procedure BW	3(0.002)	72(0.050)	‡
Bended seem strength after 7 days cure at room temperature shear force	ASTM D882 Method A			
percent of minimum tensile		60	60	60
percent of minimum break		75	75	75

* Classification of sheeting is based upon the major elastomer present: IIR(butyl), EPDM (ethylene propylene-dienemonomers), and CR (Chloroprene).

† The test is not required for definition of good quality materials.

‡ Refers to both unreinforced and fabric-reinforced sheeting

§ Percent set and imersion in ASTM No.3 Oil are regarded as important to the definition of good quality, 100 percent polychloroprene compounds, and are not related to service requirements in contact with water.

Annexure 15

Annexure IX

Approximate Cost of Drip Irrigation System from 1-10 Acres under Different Spacings

Crops	Spacings	No. of Plants	Cost of 1 Acre	2 Acres	3 Acres	4 Acres	5 Acres	6 Acres	7 Acres	8 Acres	9 Acres	10 Acres
1. Roses Ornamental Plants	5'×5'	1742	13913 (13913) *8.00	26326 (13163) 7.60	38739 (12913) 7.45	51152 (12788) 7.35	63565 (12713) 7.30	75978 (12663) 7.25	88391 (12628) 7.20	100804 (12600) 7.20	113217 (12579) 7.20	125630 (12563) 7.20
2. Grapes	10'×10'	435	7462 (7462) *17.15	13424 (6712) 15.45	19386 (6462) 14.85	25342 (6337) 14.60	31310 (6262) 14.40	37272 (6212) 14.30	43234 (6176) 14.20	49196 (6150) 14.15	55158 (6128) 14.10	61120 (6112) 14.05
3. Lemon	15'×15'	194	5557 (5557) *28.70	9614 (4807) 24.80	13671 (4557) 23.50	17728 (4432) 22.90	21785 (4357) 22.50	25842 (4307) 22.20	29899 (4271) 22.00	33956 (4244) 21.90	38013 (4223) 21.80	42070 (4207) 21.70
4. Sapota	20'×20'	108	4818 (4818) *44.60	8136 (4068) 37.60	11454 (3818) 35.50	14772 (3693) 34.20	18090 (3618) 33.50	21408 (3568) 33.10	24726 (3532) 32.10	28044 (3506) 32.50	31362 (3484) 32.30	34680 (3468) 32.10
5.	25'×25'	70	4460 (4460) *63.70	7420 (3710) 53.00	10380 (3460) 49.50	13340 (3335) 47.70	16300 (3260) 46.60	19260 (3210) 45.90	22220 (3174) 45.40	25180 (3177) 45.00	28140 (3126) 44.70	31100 (3110) 44.50
6. Coconut & Cranna or Sapota	30'×30'	48	4136 (4136) *86.20	6772 (3386) 70.60	9408 (3136) 65.40	12044 (3011) 62.80	14680 (2936) 61.20	17316 (2886) 60.20	19952 (2850) 59.40	22588 (2823) 58.80	25224 (2802) 58.40	27860 (2786) 58.10
7. Coconut & Cranna with Intercultivation	35'×35'	35	3832 (3832) *109.50	6164 (3082) 88.10	8496 (2832) 88.90	10828 (2707) 77.40	13160 (2632) 75.20	15492 (2582) 73.80	17824 (2546) 72.80	20156 (2519) 72.00	22488 (2498) 71.50	24820 (2482) 70.90
8. Coconut with intercultivation	40'×40'	28	3679 (3679) *131.40	5858 (2929) 104.60	8037 (2679) 95.70	10216 (2554) 91.30	12395 (2429) 88.60	14574 (2429) 86.75	16753 (2393) 85.50	18932 (2366) 84.50	21111 (2345) 84.50	23290 (2329) 83.20

NOTE:- THE FIGURES IN BRACKETS REPRESENT COST PER ACRE & *MARK REPRESENTS COST PER PLANT.

Annexure 16

Cost Economics of Plastics Bag Silo and Concrete/Trench Silo

Plastic Bag Silo:

Bag Silo offers flexibility of preparing silage in small quantities. The size of the bag silo can be so designed that its content can be consumed within 24 hours, once the bag is opened. This provides an opportunity to a small scale farmer for making silage for his own needs.

Small scale and marginal farmer cannot allocate land for growing forage for cattle feed. Neither can he afford to buy prepared feed at higher prices from the market place. Thus, he has to use dry roughage which is normally available to him from his own farming operation as cattle feed. Plastic bag silo, therefore, makes it possible for him to preserve green roughage through ensiling for the loan season at a cost of Rs. 27/-ton - Reference Table 2.

Normal average dry feed requirement of a cattle is 10 kgs. per day. With dry roughage feed, milk yield per cattle is estimated at 3 litres per day. An equivalent silage requirement based on a 70% moisture content in silage would work out ot 34 kgs per day per cattle. Total requirement of silage, will be approximately 7 tonnes per cattie per season of 7 months. The cost of silage preservation per cattle, if fed on 100% silage, would be Rs. 193 on the above basis.

Comparative milk yield per cattle per day with various feeds are given in Table 1 for small and medium/large scale farms. It would be observed from Para A of Table 1, that milk yield per cattle can be improved from 3 litres to 4.5 litres per day by using silage prepared from green roughage. Income to the farmer due to incremental milk production is Rs. 1.50 per litre. Therefore, net additional income to the farmer by using silage feed is estimated at Rs. 280/- per cattle per season.

Besides, cattle health is likely to improve due to nutritive feed. Better health may extent the lactation period which can bring additional income to the farmer. Health of other non-milch cattle such as bullocks can also be improved, resulting in improved motive power.

Trench/Concrete Silos:

Farmers with medium to large land holdings, who can afford to grow forage crops for feeding cattle can also be benefitted by adopting ensiling practices. This is true especially in the areas where availability of water to the farmer is limited and growing forage crops throughout the year is not economically feasible.

An affluent farmer, therefore, converts green forage to hay as cattle feed for the lean season. During the late winter and summer, farmers improve the TDN value of feed by adding prepared feed to hay.

Generally, farmers use hay and prepared feeds combination for 5 months in a year as cattle feed. Total cost of hay/prepared feed per cattle per season is estimated at Rs. 1320/- The cost of equivalent hay/silage feed is estimated at Rs. 610/- for trench and Rs. 630/- for cement silo. The net savings per cattle per season therefore, works out to Rs. 690/- in case of concrete silo and Rs. 709/- in case of trench silo, as given in Table 3.

A reference to Table 1, Para B will show that there is no increase in milk production pattern per cattle because of change of feed. Hence, there is no gain or loss of income due to milk production for medium/large scale farmers.

Table-1

COMPARATIVE MILK YIELD PER CATTLE PER DAY WITH DIFFERENT FEEDS

A. Small Farm		
Dry Roughage.	:	3 litres
Silage - Green roughage	:	4.5 litres
B. Medium/Large Farm		
Hay	:	4.5 litres
Hay with prepared feeds	:	5.5 litres
Hay with forage silage	:	5.5 litres
Forage silage	:	6.0 litres

Table-2

COMPARATIVE COST OF SILAGE PRESERVATION IN PLASTIC & TRENCH/CONCRETE SILOS ADVANTAGES AND DISADVANTAGES

	Plastic bag silo	Trench silo with Plastic Cover	Concrete silo with Plastic cover
Dimensions	25"L×24"W	40'L×14'W×10'H	16' dia×16'H
Plastic film thickness	125 mic	100 mic & 50 mic	100 mic
Capacity	25 kgs	67 tonnes	400 tonnes
Life of installation	3 seasons	2 seasons	25 seasons
Cost of installation	Rs.1.64	Rs.266.00	Rs.28,200.00
Fixed cost of making/ silage/tonne	Rs.23.20	Rs.2.15	Rs.7.72
Operating charges/tonne	Rs.4.00	Rs.1.46	Rs.2.10
Total cost of silage preservation	Rs.27.20/tonne	Rs.3.62/tonne	Rs.9.82/tonne
Advantages:	1. Capacity is flexible 2. Minimum labour cost 3. Minimum time for filling 4. Easy to compact 5. Minimum spoilage 6. Minimum dry losses 7. Low maintenance cost 8. Packaged product ready for use	1. Size is flexible; can be varied at will 2. Lower labour cost 3. Lower time for filling 4. Easy to compact 5. Minimum spoilage 6. Minimum dry loses 7. Low maintenance cost	1. Large capacity 2. Surface losses limited to top surface.
Disadvantages:	1. Requires careful handling to prevent puncture in film.	1. Requires careful handling to prevent punctures in film.	1. Large forage need 2. Longer time to fill 3. Difficult to compact fill 4. Heavy spoilage 5. Considerable dry losses 6. High labour cost 7. Higher maintenance cost 8. Fixed capacity 9. Limits silage removal in small quantities
Recommended for:	Small scale farmer	Medium/large scale farmer	Large scale farmer

Table-3

SILAGE FEED FOR MEDIUM/L/ ɪGE FARM

	Rate Rs/tonne		Qty. required per season of 5 months	Total cost (Rs)	
A. Current feed pattern per day:					
7 kgs of prepared feed	900.00		1.05	945.00	
6 kgs of hay	400.00		0.90	315 00	
2 kgs of greens	200.00*		0.30	60.00	
Total cost of feed/cattle head per season				1320.00	
B. Recommended feed pattern per day:	Trench Rs	Concrete Rs		Trench Rs	Concrete Rs
20 kgs of silage	103.60*	110.00*	3.00	310.80	330.00
5 kgs of hay	400.00		0.75	300.00	300.00
Total cost of feed/cattle head per season				610.80	630.00
C. Net savings per season per cattle head				709.20	690.00

(*Basic cost of green forage is Rs.100/- per tonne in season and Rs.200/- per tonne in off-season).

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