MAURITANIA VEGETABLE PRODUCTION PROJECT

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SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1. The potential benefits to Mauritania from increasing vegetable production are improved nutrition for the population, improvements to the balance of payments, stable and lower average prices for consumers, and increased incomes for vegetable growers and marketers.

2. Natural resource constraints on vegetable production include insufficient and poorly distributed rainfall, strong winds, high temperatures, and relatively few areas where fertile soils and ample water resources occur in combination.

3. A total of approximately 600 hectares of vegetables are presently cultivated primarily in small plots under four major, distinct cropping systems: rainfed, flood recessional, oasis agriculture, and irrigated perimeters. Most commonly grown crops are tomatoes, onions, cabbage, carrots, turnips, and potatoes. Three variations of irrigated perimeters exist including large scale, small scale, and cooperative gardens. An additional estimated 1,800 hectares will be needed by the year 2000 to satisfy major urban Nouakchott/Rosso market demands and to supply rural nutritional needs based on current increased consumption trends and population growth. Current annual per capita vegetable consumption in Mauritania is approximately 50 kg for the Nouakchott/Rosso area and 10 kg in other areas and increasing. Per capita consumption by the year 2000 could reach 80 kg for the Nouakchott/Rosso area and 20 kg in other areas. This projected increased coupled with a conservatively estimated 2.7 percent annual population increase would increase total consumption about three times. Mauritania should strive to at least triple vegetable production to 37,000 tons by the year 2000 to supply areas other than Nouakchott/Rosso. Even at this production level, vegetable imports are expected to triple to 48,000 tons by the year 2000 to meet the demands as Mauritania urbanizes. Therefore in order to minimize import it is imperative that a national vegetable production program be implemented.

4. Several major agronomic constraints to expanding vegetable production were identified including lack of sufficient water for irrigation and associated high water resource development costs; difficulty and timeliness in obtaining purchased inputs, i.e., seeds, tools, irrigation equipment, fencing, fertilizers, and pesticides; lack of heat-tolerant varieties to support year-round production; no domestic seed industry for multiplication, processing, and distribution of selected cultivars; lack of protection from animals; and difficulty in controlling insects, diseases, and nematodes.

5. From February to June salinity levels in the lower reaches of the Senegal River are too high to support vegetable production. With construction of the salt water intrusion barrier, Diama Dam near St. Louis, salinity levels in the river will be reduced so that a larger portion of the Trarza region can be used to expand irrigated vegetable production.

6. Estimated average vegetable crop yields are lower than average world yields in all instances except for tomatoes, and lower than African average yields except for tomatoes and potatoes.

7. Vegetable production technology is rudimentary, labor intensive, and stagnant due to lack of investment capital, technical expertise, supplies of both modern and traditional inputs, and research and extension services.

8. Subsidy of production inputs, principally seeds, tools and fertilizer, has encouraged dependence by farmers on the Government, but the supply and price of these production inputs are major problems due to high import costs, lack of participation by the private sector, and periodic failure to deliver these inputs at the times and in the quantities needed.

9. Post-harvest vegetable losses on the farm and in transit are suspected to be high, but no firm evidence is available. The principal reasons for losses are high temperatures, dryness, sun and sand damage, and bruising during transport on rough roads. Produce packing is often inadequate to protect against bruising, sand, and sun damage. Nylon sacks are the most common packing container because of low initial cost. All packing materials are in short supply.

10. Shallow wells are hand-dug, costly, and short-lived due to cave-in of the unlined walls. The costs of well depreciation, interest, and maintenance amount to nearly 2,800 UM per year for a typical garden of 650 square meters planted, which represents approximately 20 percent of total production cost.

11. Fencing in the rural areas to protect crops from roaming animals is necessary but expensive, the cost varying a great deal depending upon materials used. The least expensive fence to enclose 1,000 square meters represents approximately 20 percent of total production cost on an annual basis.

12. Imported tools are preferred because of quality and because the government subsidizes them, but domestic tools are less expensive considering full market prices. Annual tool costs represent 10 to 15 percent of total production cost.

13. Labor consists almost entirely of unpaid family members--mostly women and children. The imputed wage rate is approximately 16 UM per hour, but cash payments for labor are uncommon.

14. Few chemical fertilizers, pesticides, or herbicides are used. Animal manure is available in moderate supply and its use is encouraged. No formal agricultural credit is available to the farmers.

15. Vegetable production can be risky but profitable, depending upon yields and product prices at the time of sale. Great potential for increased profits exists in off-season production to capture high market prices.

The technology required includes protection of crops from heat and an assured water supply.

16. Farmers diversify crop mix to provide themselves with dietal variety, to mitigate production risks (e.g., crop-specific diseases and/or insects), and to mitigate marketing risks (e.g., low prices, transport availability).

17. Marketing infrastructure is inadequate to move perishable vegetables great distances in time to avoid spoilage.

18. The principal trade channels for domestically-produced vegetables are from producers direct to consumer or via rural retailers. Outside of the Rosso-Nouakchott strip most vegetables are grown for home consumption.

19. The Nouakchott vegetable market is unique and atypical of the rest of Mauritania in terms of clientele and marketing infrastructure. Nouakchott depends heavily on vegetable imports from Senegal and abroad. The vegetable market exhibits marked stratification by clientele, as exhibited by retail price differences. Wholesale-retail price markups appear to be set in accordance with marketing costs, varying from 10-20 UM per kilogram.

20. Regional vegetable markets differ considerably, but most are characterized by short seasons, relatively few imports and exports, and large retail price variations over time. Prices at the beginning or end of the production season range from two to ten times those of peak-season prices. Price multiples tend to be greatest for the more perishable products such as tomatoes.

21. Except for Nouakchott, there is almost a complete absence of "facilitating functions" in vegetable marketing--financing, marketing information, demand creation, and research.

22. Transportation is expensive and slow due to high vehicle operating costs and poor roads. Government regulation of freight and passenger tariffs, plus lower-priced competition from Mauritanian Government enterprises and Senegalese truckers, have probably been detrimental to private-sector motor vehicle operators. Since vegetable hauling alone cannot support the private sector, vegetable marketing suffers from the restricted service and higher costs resulting from the vehicle operators' predicament.

23. Vegetable preservation by drying appears to hold promise for some crops. This would mitigate seasonal product supply gluts and shortages, as well as their consequent price variations.

24. There is no formal vegetable quality grading or standardization program in Mauritania outside of Nouakchott.

25. Institutional development for extension, research, and credit has not kept pace with the needs of a developing agriculture. Trained

specialists to conduct extension and research field trials to evaluate and recommend varietal and seed improvements, irrigation practices, cultural improvements, and crop protection practices are needed to develop vegetable production.

26. In spite of the physical, economic, and institutional constraints on increasing vegetable production and consumption in Mauritania, there is considerable scope for exploiting existing natural, physical, and human resources more efficiently as well as investing more resources profitably.

27. The most potentially effective vegetable development programs identified for expanding production are (a) production extension services, i.e., varietal and seed improvement, irrigation, cultural improvements, and crop protection, (b) purchased input distribution, (c) production infrastructure, i.e., water supply and fencing, and (d) marketing, i.e., transportation, storage and handling, and produce drying.

28. With the completion of the Manantali Reservoir on the Senegal River, both quality and quantity of water available for irrigation will be adequate to support a significant expansion in irrigated vegetable production. Large (with ownership of 2 to 20 hectares) vegetable irrigated perimeters on the river should be developed near the major Rosso-Nouakchott highway for easy access to urban markets.

29. Among all the cropping systems, the irrigated perimeter is the only one with potential to produce enough for major markets and to replace current imported produce which will reduce the balance of payments deficit. The GIRM optionally could develop large irrigated perimeters owned and operated completely by the Government, develop the land and water resources and then lease to private parties or may provide loans for private development. Alternatively, the GIRM could use a state enterprise such as SONADER to guide development of irrigated perimeters.

30. The conditions and philosophies underlying a vegetable development strategy are that (a) the principal characteristics of the four cropping systems should be preserved and strengthened, (b) production technology should remain simple and low cost, (c) government intervention is necessary and desirable to stimulate vegetable production, and (d) transport of fresh vegetables should be minimized except for the Rosso-Nouakchott strip.

31. The most effective program components for increasing production in the rural cropping systems are improvement of seeds and crop varieties, distribution of inputs, and produce drying. Water supply development and fencing are important for oasis cropping systems and small irrigated perimeters. The principal impact of a rural strategy for expanding production would be increased rural nutrition and real incomes.

32. Varietal and seed improvement would generate production and profit gains by selecting for use strains of crops more tolerant to heat and drought,

thereby effectively lengthening the season during which the crops can be produced.

33. Vegetable production for canning purposes may not be economically feasible for current production areas or near-future expanded areas.

34. A dual strategy of vegetable development is envisaged for Mauritania--one to supply the urban Nouakchott/Rosso markets using high input technology on large irrigated perimeters, and the other to supply rural areas using lower input technology on all cropping systems. The rural strategy seeks to achieve local supply and demand equilibrium to minimize transportation costs and post-harvest product losses.

35. Allocation of scarce resources between the urban-rural strategies and among program alternatives is a matter of Government policy, but a balanced strategy is recommended which would involve all the alternatives on a limited basis.

36. The next step in vegetable development should be a pilot program of at least three years to design and test improvements in each cropping system in each of the 9 agricultural administrative regions.

CHAPTER 1

INTRODUCTION

General

Agricultural production in Mauritania has traditionally focused on cattle and goat products, sorghum, millet, and dates. However, gradual demographic changes from nomadic to sedentary, and from rural to urban have been accompanied by increased incomes and preferences for improved variety and quality in diets. These influences have been manifested by increasing demand for fresh and processed vegetables which, at the national level, has not been met by domestic production. The reasons why domestic production has not kept pace with demand include a harsh climatic environment, lack of natural resources such as water and fertile soils, insufficient capital for development of infrastructure such as roads, marketing facilities, and extension services, and institutional constraints such as deficiencies in trained manpower for extension and research functions. The results of domestic inability to meet demand include a reliance on imports of fresh and processed vegetables (over half are imported), dominance of the largest and most lucrative vegetable markets by importers, a drain on the national balance of payments, and volatile market prices in rural areas where imports cannot compete with domestic produce.

The potential benefits to Mauritania from increasing vegetable production are improvements to the balance of payments, improved nutrition for the population, stable and lower average prices for consumers, and increased incomes for vegetable producers and marketers. Realization of the potential benefits from increased self-sufficiency in vegetable production will be an arduous and lengthy task because of the current state of resource availability, production technology, marketing infrastructure, and institutional development.

Natural resource constraints on vegetable production include insufficient and poorly distributed rainfall, strong winds, high temperatures, and relatively few areas where fertile soils and ample water resources occur in combination. Except for relatively few commercial gardens in the Rosso area production technology is rudimentary; small garden plots are cultivated almost entirely with family labor using basic hand tools and no mechanized power. Irrigation--the most labor-using activity--is accomplished by hauling buckets of water from wells and applying it with watering cans. Yields are low because improved seeds, chemical fertilizers, and pesticides are commonly unavailable, unaffordable, or unmanageable for the small farmer.

Marketing infrastructure is inadequate to move perishable products great distances in time to avoid spoilage. Poor roads result in slow truck transport, high shipping costs, and product damage. Improved shipping containers, grading, standardization and refrigeration are virtually nonexistent. A consequence of rural market isolation and a short growing season is extreme local price fluctuations caused by supply gluts at peak harvest times, which create high risks for producers. Since most producers

sell only small amounts of surplus from their garden plots, cooperative marketing is usually economically and managerially infeasible.

Institutional development has not kept pace with the needs of a developing agriculture. In spite of recent allocation of agricultural extension agents to vegetable production, their number and resources are few. Furthermore, the government has encouraged farmers' dependence on the State by providing heavily-subsidized inputs such as seed, tools, and fencing. This role might have discouraged participation by the private sector and has surely hindered production in instances when the government could not deliver inputs on time or in sufficient quantity. Finally, there is no formal agricultural production credit institution in Mauritania.

In spite of the physical, economic, and institutional constraints on increasing vegetable production and consumption in Mauritania, there is considerable scope for exploiting existing physical and human resources more efficiently as well as investing more resources profitably. The general objective of this study is to assess feasibility of alternatives for increasing vegetable production in Mauritania which would lead to a net improvement in the physical and economic welfare of the people.

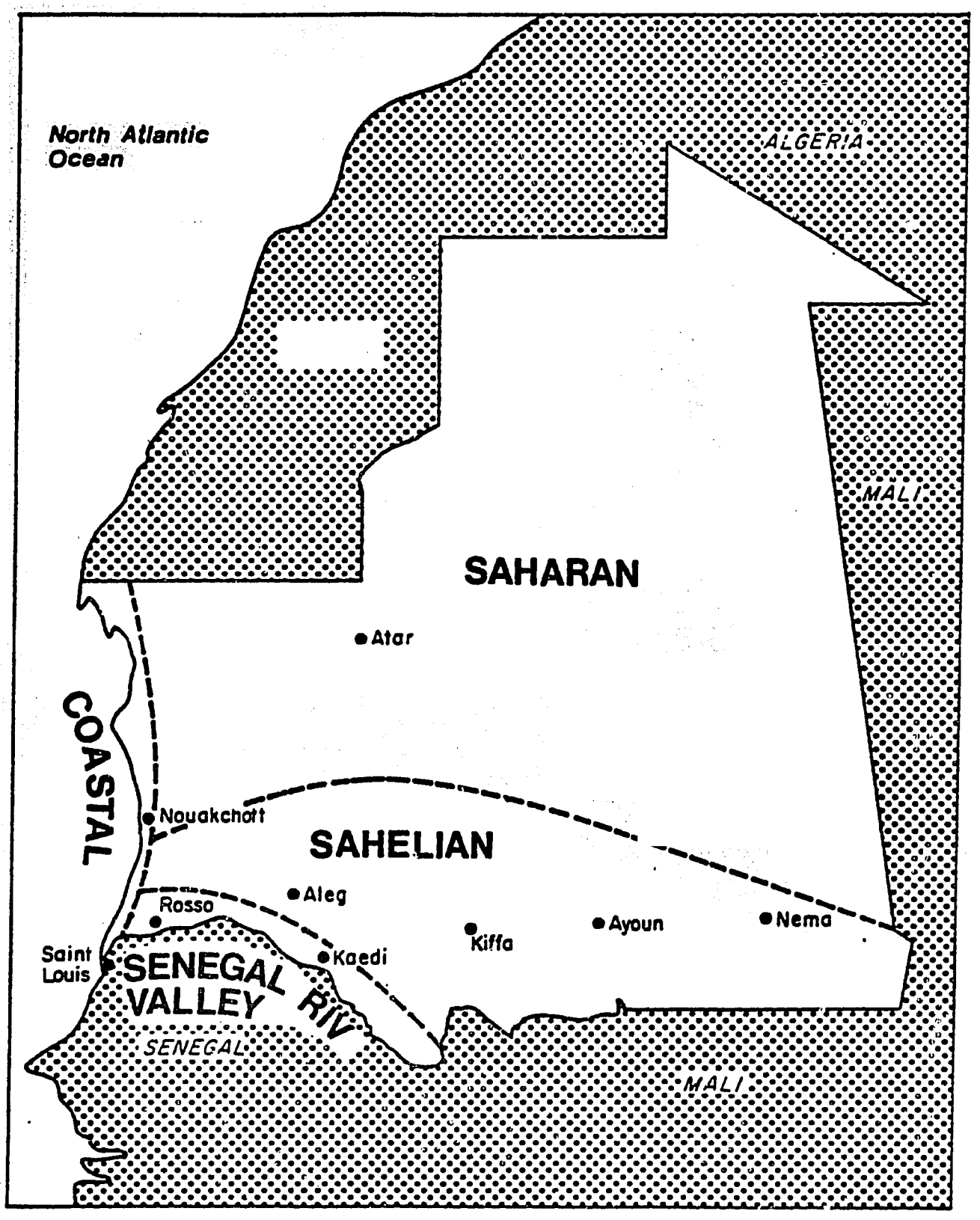
Physical Setting

Mauritania, located on the West African Coast between latitudes 15° and 25° north, is generally divided into four zones corresponding to precipitation, vegetation, and temperature variation: Saharan, Sahelian, Sengal River Valley, and Coastal zones. Although marked differences exist among zones, no natural boundaries clearly delineate them (Figure 1-1).

The Saharan zone comprises the northern two-thirds of the country with an annual precipitation range of 0 to 150 mm. The Sahelian zone extends south of the Saharan zone to within 30 km of the Senegal River with an annual normal precipitation ranging from 150 mm in the northern portions to 450 mm at Kankossa in the south. The Senegal River Valley, also known as the Chemama or pre-Sahel zone, consists of a narrow land belt extending 15 to 30 km north of the Senegal River. It has annual precipitation ranging normally from 350 to 650 mm. The Coastal zone extends the length of the 650 kilometers along the Atlantic Coast, and receives annual precipitation ranging normally from 25 mm on the northern coast to between 100 and 150 mm in Nouakchott and the south. The Senegal River Valley, with the highest annual precipitation, is the most important agricultural zone; it produces 60 to 70 percent of the country's food crops. Rainfall and annual flooding of the river provide sufficient water for extensive agricultural production. Rainfall is concentrated during the months of July, August, and September; almost no rainfall occurs from November to June, during which time irrigation is a requirement for all crop production. Annual rainfall during the last ten years has been significantly below normal.

Administratively Mauritania is divided into 12 regions and one district--Nouakchott. The Vegetable Production Project's technical efforts were designated for three of the 12 regions: the third (Assaba), fifth (Brakna), and sixth (Trarza) regions. All three project regions are located in southern

FIGURE 1-1



4 AGRICULTURAL ZONES

Mauritania

3

Mauritania, embracing three agricultural climatic zones, the Coastal, Senegal River, and Sahelian.

Project regions can be characterized by certain similarities and differences in climate, culture, farm cropping systems, irrigation, and availability of and distances from market centers. Rural population density in the three project regions is similar. Ethnically, rural residents are mostly Black and White Maures, Toucouleur, and Wolof. Each region has its own distinct culture and ratios of population groups. Population groups heavily involved with vegetable production consist of the Wolofs in the Trarza region, the Toucouleur in the Brakna region, and the Black and White Maures in the Assaba region. In all three regions, production labor is provided mostly by women using similar basic hand cultivation tools and traditional production techniques on small irrigated plots.

In the Trarza region, with relatively better roads and a more favorable climate, vegetables are produced primarily for home consumption, with small surpluses sold to the Rosso and Nouakchott markets. Production is more established in the Trarza region than in the other regions.

Production in the Brakna region is increasing, but marketing is limited by poor roads. Boghe, located near the Senegal River above the salt water intrusion zone, could expand production if better access to markets were available.

The Assaba region produces relatively few vegetables, with those mainly limited to oases. However, production, especially around Kiffa, has expanded in recent years. High transportation costs and product losses due to unfavorable climatic conditions limit production.

Climate in the three zones is characterized by temperature extremes and insufficient and irregular rainfall. Hot dry winds that blow from the Sahara throughout most of the year create high evapotranspiration and water requirements. With the exception of moderate temperatures in the Coastal zone, all other zones exhibit temperature extremes with mean monthly averages above 25°C. during most of the year, with peak daily temperatures above 40°C. during the May-June period.

Project Focus and Purpose

The Project purpose was to assist the Mauritanian Government in establishing the basis for a nationwide vegetable production program to improve production, seed preservation, and marketing, and to train GIRM personnel. A five-member technical assistance team sponsored by USAID under contract to Frederiksen, Kamine and Associates coordinated and carried out the two-year program to determine the feasibility of expanding vegetable production in Mauritania.

As part of this project, vegetable demonstration and field trial areas were created for research and extension activities to: (1) collect production data required for analysis of agronomic feasibility, (2) evaluate the horticultural and agronomic technologies most suitable for the Mauritanian environment, (3) identify production constraints, and (4) provide on-the-job vegetable

production training for GIRM agricultural extension agents and village farmers. Field extension activities, applied research work, and data collection were supported by a group of nine Peace Corps Volunteers assigned to the project. On-the-job vegetable production training of GIRM personnel and farmers was carried out on over 300 hectares of vegetables affecting 2,000 farm families. The effort, in collaboration with the GIRM Chef de Secteur Agricoles with assigned extension agents, involved over half of the vegetable production areas of the country. Improved production practices, seed preservation, and marketing of vegetables were demonstrated to local farmers. Formal classroom training in horticulture for the Chief of Vegetable Production at Hassan II University in Morocco was provided. Arrangements and contacts were made at the Centre du Developpement Horticole at Camberene, Senegal, to train four agricultural sector chiefs in vegetable production. Marketing surveys and production economic data investigations were designed and conducted by the team's agricultural economist to analyze the marketing, economic, and financial feasibility of expanding vegetable production. Surveys were conducted by the nutritionist to assess vegetable consumption and the nutrient value of the Mauritanian diet. Water sources and availability, water quality, and water requirements were evaluated by the team's agricultural engineer. Instruction and demonstrations were given in well drilling.

Project Surveys and Intervention

Agronomic information was collected by field interventions to provide the basis for an analysis of methods to expand production. Vegetable demonstration and experimental field trial areas were established at 19 demonstration project garden sites in the three regions. New vegetable crop varieties were introduced and tested in agronomic trials and extension demonstration gardens at these sites. The experimental trials provided research information on varietal adaptation and production constraints as well as a milieu for on-the-job training of farmers and extension agents. Improved cultural practices were demonstrated in seeding, spacing, irrigation, and seed preservation trials. Cultivars from other tropical and temperate regions of the world, through direct contacts made with major international research institutes, were screened, selected, and grown in village vegetable adaptation trials.[1/] With the exception of limited preliminary vegetable production studies from the National Center for Agronomic Research and Agricultural Development initiated in Kaedi in 1974, no long-term vegetable research program aimed at screening and selecting adapted cultivars has been established for Mauritania.

Economic and nutritional information was collected through production surveys. Primary data were collected by direct interviews with farmers and

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1/ Asian Vegetable Research and Development Center (Taiwan), International Potato Center (Peru), Centre du Developpement Horticole (Camberene, Senegal), Cornell University (Ithaca, New York), Louisiana State University Sweet Potato Research Center (Chase, Louisiana).

households in the three project regions. Field investigations were supervised by various members of the technical assistance team--the economist, nutritionist, and horticulturist--with assistance from four local research assistants associated with the Direction d'Agricole, who were familiar with the survey areas and spoke the local languages. The survey data collection method is influenced by memory and recall biases on the part of the farmers. Survey results indicate that most farmers are illiterate and do not keep accounts or receipts of farm transactions related to input costs and products sold. Regional Chefs de Secteur Agricole and extension agents within the Ministry of Rural Development were able to furnish some vegetable production information based on past experience, knowledge of the areas, and their participation in project efforts. It was not possible to verify survey results with existing information from other sources. The survey results are subject to sampling errors because they are based on relatively small sample numbers of less than 25 per region studied. Even with these limitations, the information obtained is considered to be the most comprehensive study thus far completed for vegetable production in the interior of Mauritania. Survey data were collected and analyzed at various intervals from July 1980 to June 1982.

Scope of This Report

This report presents the general status and trends of vegetable production in Mauritania; determines major production constraints and how to overcome them; investigates production volume, production input cost, marketing, and transport limitations; evaluates water constraints to production; provides technical information on improved production; presents alternative modes (scenarios) for an expansion of vegetable production; and draws conclusions and makes production and economic policy recommendations on the feasibility of an expanded vegetable production program.

References are also made to official publications and unpublished statistical information. Careful analysis of these documentations indicates that many of the official vegetable production statistics given are unreliable and do not cover all vegetable crops of interest in the country.

Organization of This Report

This report is divided into three separate sections. Section 1 is an executive summary presenting key findings and recommendations for expanding production. Section 2 presents more detailed data, with analyses of the information collected and presented in the summary. Section 3 presents, for future reference, some of the more important data collected that were too detailed for inclusion in the main text.

CHAPTER 2

AGRONOMICS OF VEGETABLE PRODUCTION

Introduction

Vegetable production is practiced on a limited basis in all Mauritanian agro-ecological zones where water is available. Labor-intensive cultivation systems are used with most production coming from small-scale market gardens in the Senegal River Valley and scattered oases. A large part of Mauritania is unsuitable for vegetable production due primarily to inadequate water resources. The fertile alluvial and clayey soils of the Senegal River Valley are suitable for expanding vegetable production since water can be obtained from the river. In contrast, adequate water resources and fertile soils are rarely found together in other parts of the country.

Survey results indicate that the country's total vegetable production area is less than 600 hectares with tomatoes, potatoes, sweet potatoes, cabbage, onions, eggplant, carrots, okra, cowpeas, and melons considered the most important crops cultivated. Yields are generally lower than world averages and production is constrained by an unfavorable climate and lack of purchased inputs such as high-quality seeds, fertilizers, chemicals, irrigation equipment, and tools. One yield exception is tomato, which yields approximately 20 tons per hectare--slightly higher than the African and world production averages.[2/] Both monoculture and mixed vegetable crop plantings are used. Quick-growing crops such as lettuce, radish, and turnips are often interplanted with larger, wider-spaced, or slower-developing crops such as tomatoes, maize, onions, cabbage, eggplant, and potatoes.

Agronomic trials were established to provide information on improved varieties, to determine production constraints, and demonstrate improved cultural practices to extension agents and farmers in the three project regions.

Cropping Systems

Four major types of vegetable cultural systems are practiced in Mauritania. These systems, defined in terms of water source and other major characteristics, are outlined in Table 2-1 and described below.

Rainfed Cultivation ("Diere")

Rainfed vegetable production is generally limited to melons (*Citrullus lanatus*) for edible dry seeds and cowpeas (*Vigna sinensis*), which are commonly produced with interplantings of sorghum and millet. Production is practiced mostly on non-alluvial, sandy soils. Plantings are initiated at the time of

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2/ Source: USAID, Rural Assessment of Manpower Survey, 1979-80. Nouakchott, Mauritania.

TABLE 2-1

CHARACTERISTICS OF MAURITANIAN VEGETABLE PRODUCTION CULTURAL SYSTEM

Characteristics	CULTURAL SYSTEM					
	RAINFED	FLOOD RECESSION	OASIS AGRICULTURE	IRRIGATED PERIMETERS		
				Co-op Gardens	Large-Scale Commercial	Small-Scale Private
Water Lifting		Buckets with Rope	Pump Shaduaf	Buckets with Rope Pumps	Pumps	Buckets with Rope Pumps
Water Conveyance		Sprinkling Cans	Sprinkling Cans Canals	Sprinkling Cans Canals	Canals	Sprinkling Cans
Management System	Subsistence	Subsistence	Subsistence	Subsistence Commercial	Commercial	Subsistence Commercial
Cropping Methods	Monoculture Intercropping	Mixed Intercropping	Mixed Intercropping	Mixed Monoculture	Monoculture	Mixed Intercropping
Labor Source	Family	Family	Family	Family	Family/Hired	Family
Farm Equipment	Hand Tools	Hand Tools	Hand Tools	Hand Tools	Tractor Hand Sprayers Hand Tools	Hand Tools
Growing Season	July-September	August-December	September-March	September-March	September-March	September-March
Fertilization	None	Manure	Manure	Manure Fertilizer	Manure Fertilizer	Manure
Pest Control	Limited	Limited	Limited	Limited	Limited	Limited
Fencing	None	Limited Protection	Protection	Protection	Limited Protection	Protection
Soils	Sandy	Clayey	Varies	Varies	Varies	Varies
Farm Size (Ha)	Vary 0.5 - 20	0.5 - 3	0.5 - 2	0.5 - 3	2 - 20	0.5 - 1
Yields	Very Low	Low/Average	Low/Average	Low/Average	High/Average	Low/Average
Percent of Vegetables Sold	0 - 5%	0 - 20%	0 - 10%	0 - 20%	80 - 100%	0 - 40%

the late June or early July rains, and the growing season continues until September or early October when rains stop and soil moisture is depleted. Generally, short-cycle cowpea varieties are more adapted to scarce rainfall and soil moisture than is the Citrullus species, which is cultivated for the dry seeds. Citrullus are moderately drought tolerant and their seeds are rich in protein and oil with a high nutritional value. Very little information on these locally important crops is available.

Flood Recession

Flood recession vegetable production is termed "Oualo" and is practiced on the retreating margins of the Senegal River and marigots. Flooding of marigots is seasonal; when the surface waters completely disappear, shallow wells are hand-dug and crops are irrigated until hand-watering labor requirements become too great because of increasing water depth and crop water requirements. A wide variety of vegetable crops is produced in the "Oualo," mostly for home consumption, although a small portion is sold in local markets. Among the most common crops are tomatoes, eggplant, onions, sweet potatoes, potatoes, okra, cabbage, cowpeas, squash, maize, and melons.

Oasis Agriculture

Vegetable production sites adjacent to or interplanted within date palm groves are common. The favorable effects from wind protection and shading provided by the palms makes vegetable production feasible even under hot and windy conditions. Gardens are irrigated from shallow wells that are usually concrete lined. Since lined wells can provide a reliable water supply, production can be extended to March, April and May when produce prices are attractive. Production trials conducted at Sani as part of this project demonstrated that production of several tomato varieties could be extended into June. These were marketed in the off-season and obtained prices ten times higher than in the regular season.

Irrigated Perimeters

Irrigated perimeters refers to lands irrigated in contiguous blocks of land up to 20 hectares in size, depending on location. Generally three types exist: (1) cooperative gardens, (2) large scale perimeters, and (3) small-scale private perimeters. Cooperative gardens are irrigated from wells or the river, and vary in size from less than one to a maximum of three hectares. Labor consists of women and children from co-op member families. Large scale perimeters, varying in size from 2 to 20 hectares, are irrigated by pumping river water. Production is usually destined for sale. Small-scale private perimeters, usually less than one-half hectare in size, are irrigated using well or river water and are operated entirely with family labor. The vegetable crops produced in irrigated perimeters range from tomatoes, potatoes, onions, and cabbage grown in monoculture to a wide variety of crops such as lettuce, turnips, radishes, onions, potatoes, okra, maize, tomatoes, cowpeas, cabbage, carrots, eggplant, melons, and peppers grown in mixed cultures.

Climate As An Important Constraint

Temperature

Much of Mauritania consists of deserts, barren hills, sand dunes, and mountains unsuitable for vegetable production. The climate is generally hot and dry in the summer and mild to warm in the winter. Temperatures as high as 50°C have been recorded, with average maximum temperatures during June exceeding 40°C in most interior vegetable production regions. Monthly average maximum and minimum temperatures for five vegetable production areas--Rosso, Nouakchott, Kaedi, Kankossa, and Kiffa--are given in Figure 2-1. The highest average maximum temperature of 42°C at Kankossa and Kiffa occurs in May and June. Average maximum temperatures for Nouakchott and Rosso are 2° to 7°C lower than interior project sites. Temperature differences among regions lead to differences in crop water requirements and irrigation frequency. Moreover, length of the growing season and specific crop adaptation varies for each region. High temperatures can have detrimental effects on crop production, depending on the growth stage. Most crops cannot tolerate temperatures in excess of 35°C unless cultural practices such as mulching and shading are used to reduce root and leaf temperatures. At mean temperatures in excess of 35°C, photosynthesis is reduced, growth is retarded, evapotranspiration and water loss is increased, and fruit set and fertilization processes are inhibited, reducing crop yields and productivity. The lowest minimum temperature of 12°C occurs in December and January. These cooler temperatures are ideal for most vegetable crops.

Vegetable production can be divided into two growing seasons according to temperature: (1) the winter season from October to March corresponding to preferred plantings and (2) the summer season from April to September associated with elevated temperatures, high evapotranspiration, and poor production potential. The average high temperature difference between the summer season and the winter season is approximately 10°C at Kiffa and Rosso (Figure 2-1). The difference between the two growing seasons for all vegetable crops is not clearly marked since there are cool season crops which can tolerate warm weather and develop satisfactorily; however, quality is not as good under the higher temperature conditions. Table 2-2 divides crops into cool and warm season vegetables according to temperature requirement for optimum yields.

TABLE 2-2

CLASSIFICATION OF VEGETABLES BY TEMPERATURE REQUIREMENTS

Cool Season		Warm Season	
Beets	Onions	Eggplant	Maize
Beans	Parsley	Melons	Sweet Potato
Cabbage	Potatoes	Okra	Tomato
Carrots	Radish	Pepper	Watermelon
Lettuce	Turnips	Squash	Cowpeas

MONTHLY TEMPERATURE AVERAGES

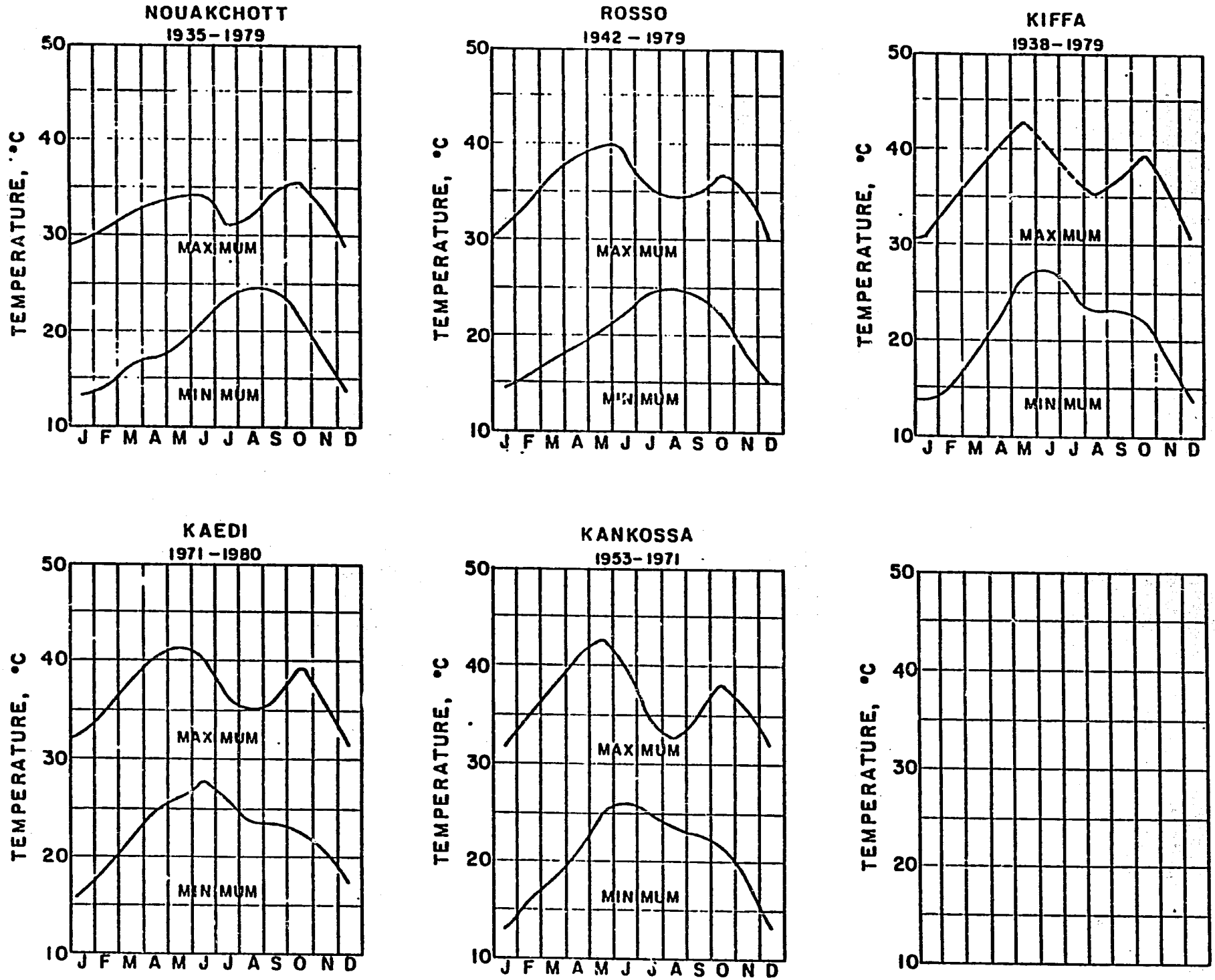


FIGURE 2-1

Cool season crops are more productive if the monthly average temperatures are 20°C and maximum average temperatures do not exceed 30°C. Warm season crops do best if the monthly average temperatures are 25°C and can tolerate average maximum temperatures to 35°C.

To provide growing season adaptive information for vegetables, major seed varieties were tested in agronomic trials on farm demonstration plots in the three project regions. Adaptation ratings are based on yield results with ratings divided into three categories: non-adapted, marginally adapted, and adapted. Non-adapted crops provided insignificant yields for varieties tested at all locations. Marginally adapted crops provided very low yields of poor quality. Adapted crops provided locally accepted yields. Table 2-3 summarizes crop adaptation results for 36 crops tested. Most cool and warm season vegetables grown during the warm October to March season were adapted at all project locations. Exceptions were asparagus, celery, fennel, and peas which could not be successfully grown in either season. Few vegetable crops have been identified that are sufficiently heat tolerant and drought resistant to generate economic yield during the hot season. Of the 36 crops tested, none were considered adapted and only 8 were rated marginally adapted. The latter include maize, cowpeas, eggplant, okra, peppers, roselle, sweet potatoes, and squash. Under the high temperature conditions, most crops fail to develop, showing visual signs of severe moisture stress and premature senescence. Seedling emergence, leaf and root growth were inhibited, and developing flowers failed to pollinate and set fruit, providing insignificant yields and production of low quality.

Rainfall

Rainfall ranges from an average of less than 150 mm in the Coastal and Saharan zones to an average of just over 600 mm in the Senegal River Valley (Guidamaka) region of Southern Mauritania. A comparison of monthly rainfall averages and seasonal distribution for six locations in Nouakchott and southern Mauritania is presented in Figure 2-2. The Assaba region (Kiffa and Kankossa) receive 350 to 430 mm annually, the Brakna region (Boghe) receives 310 mm, the Coastal Trarza region near to Rosso receives 275 mm, but Nouakchott, 200 km further north, receives but 120 mm annually.

Ninety percent of the rainfall is concentrated in the July to September months with little or no rainfall between November and June. Even during the July to September period, rainfall amounts are inadequate and distribution too sporadic to support vegetable production in the absence of supplemental irrigation. Further, the July to September rainy period coincides with high temperature and high evaporative demand. Insufficient rainfall will always inhibit the potential for expansion of rainfed vegetable production. Lack of rainfall also inhibits vegetable production based on flood recessional irrigation from marigots. Long-term drought can affect production in oases and in irrigated perimeters if the water source is from a well in which the water table falls markedly because of insufficient rains. Droughts in Mauritania are less likely to affect irrigated perimeters supplied from the Senegal River since the headwaters are not always affected by the same drought. In recent years, Mauritania has experienced periodic droughts. For

TABLE 2-3

VEGETABLE CROPS ADAPTED FOR PRODUCTION IN SOUTHERN MAURITANIA

Vegetable Crop	Adaptability: Winter Season October-March	Adaptability: Summer Season April-September
Asparagus (Asparagus officinalis)	non-adapted	non-adapted
Bean, Snap (Phaseolus vulgaris)	adapted	non-adapted
Beet (Beta vulgaris)	adapted	non-adapted
Broccoli (Brassica oleracea, var. italica)	adapted	non-adapted
Cabbage (Brassica oleracea L., var. Capitala)	adapted	non-adapted
Carrot (Dancus carota, var. sativa)	adapted	non-adapted
Cauliflower (Brassica oleracea L., var. Botrytis)	adapted	non-adapted
Celery (Apium graveolens, var. dulce)	non-adapted	non-adapted
Chard, Swiss (Beta vulgaris, var. cicla)	adapted	non-adapted
Collard (Brassica oleracea, var. acephala)	adapted	non-adapted
Cowpea (Vigna sinensis)	adapted	marginally adapted
Cucumber (Cucumis sativus)	adapted	non-adapted
Eggplant (Solanum melongen L.)	adapted	marginally adapted
Fennel (Foeniculum vulgare Mill)	non-adapted	non-adapted
Garlic (Allium sativum)	adapted	non-adapted
Kale (Brassica oleracea, var. acephala)	adapted	non-adapted
Kohlrabi (Brassica oleracea, var. gongylodes)	adapted	non-adapted
Lettuce (Lactuca sativa)	adapted	non-adapted
Maize (Zea mays)	adapted	marginally adapted
Mustard (Brassica juncea)	adapted	non-adapted
Okra (Hibiscus esculentus)	adapted	marginally adapted
Onion (Allium cepa)	adapted	non-adapted
Parsley (Petroselinum crispum)	adapted	non-adapted
Pea (Pisum sativum)	non-adapted	non-adapted
Pepper, Hot (Capsicum frutescens)	adapted	marginally adapted
Pepper, Sweet (Capsicum annum)	adapted	marginally adapted
Potato (Solanum tuberosum)	adapted	non-adapted
Pumpkin (Cucurbita pepo)	adapted	non-adapted
Radish (Raphanus sativus)	adapted	non-adapted
Roselle (Hibiscus sabdariffa)	adapted	marginally adapted
Spinach (Spinacia oleracea)	marginally adapted	non-adapted
Squash (Cucurbita pepo)	adapted	marginally adapted
Sweet potato (Ipomea batatas L.	adapted	marginally adapted
Tomato (Lycopersicon esculentum)	adapted	non-adapted
Turnip (Brassica campestris, var. rapa)	adapted	non-adapted
Watermelon (Citrullus vulgaris)	adapted	non-adapted

FIGURE 2-2A

Monthly Rainfall Averages for Nouakchott, Rosso, and Kiffa

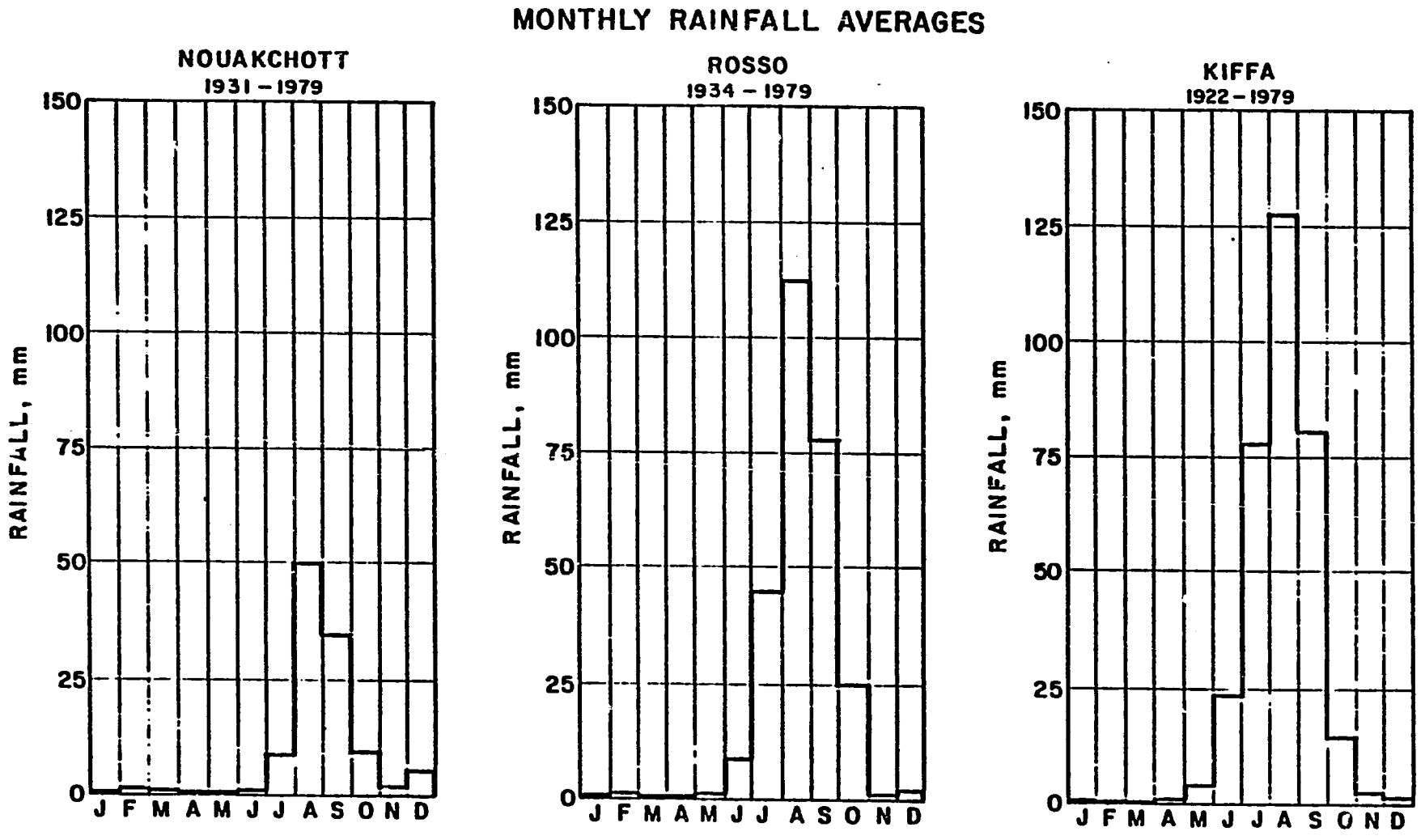
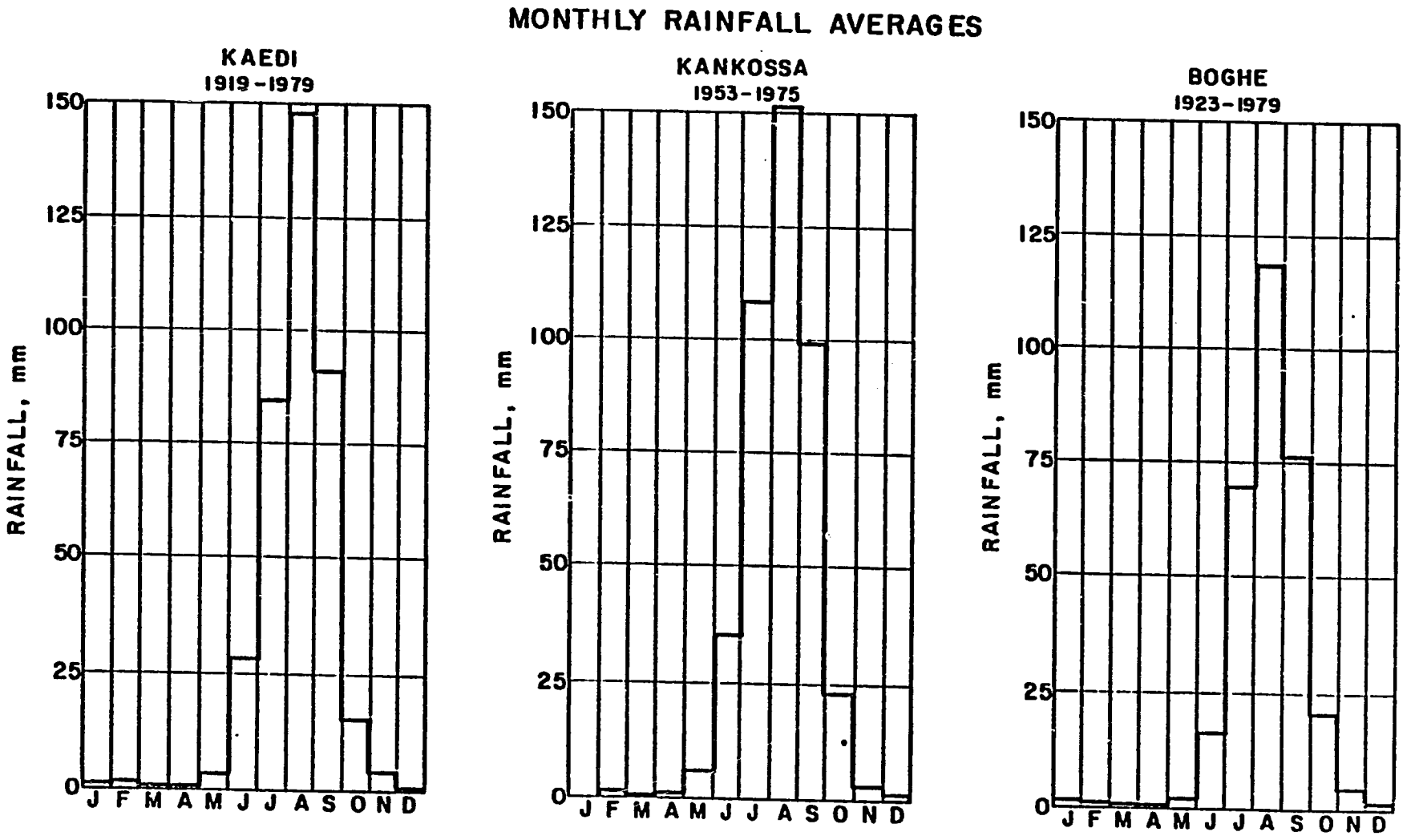


FIGURE 2-2B

Monthly Rainfall Averages for Kaedi, Kankossa, and Boghe



example, during 1970-75, average rainfall dropped to less than 20 mm per year in the Saharan and Coastal zones and to less than 30 percent of yearly averages for the Sahelian and Senegal River Valley zones.

Winds and Humidity

The hot dry winds common to Mauritania are also an important climatic factor. The prevailing winds from the north often reach velocities high enough to move sand and dust affecting seedling emergence and injuring leaves and fruits. Desert winds are extremely dry and can cause rapid plant desiccation. Low humidity conditions coupled with hot dry winds make evaporative demand very high. Most vegetable crops are extremely sensitive to high wind speeds, especially when evapotranspiration rates are greater than ten mm per day which is common to many of the vegetable production regions in Mauritania. In general, low humidity conditions prevail for most of Mauritania (Figure 2-3). Humidity is inversely related to potential evapotranspiration, i.e., low humidity contributes to high crop water demand.

To counteract detrimental wind effects of plant desiccation, sand blast, and high evaporative demand, windbreaks may be considered. Windbreaks can provide shading, which lowers soil and leaf temperatures thereby reducing evapotranspiration. Further, crops are protected from sand blast. Windbreaks offer an additional advantage in that they are used as by-products such as fuel wood. Windbreak disadvantages are that plantings take up land and use water that would otherwise go for production. In oases, date palms are a natural association with vegetable plantings because they provide shade. Windbreak plantings for flood recession and rainfed vegetable production may be an important consideration but the advantages might not be significant enough, especially since establishment under Mauritanian conditions are difficult. For irrigated perimeters, windbreaks can benefit production, but the costs of additional land, water, and fencing protection costs must be carefully considered.

Variety Selection

With the exception of limited preliminary vegetable production studies from the National Center for Agronomic Research and Agricultural Development initiated at Kaedi in 1974, no vegetable research program aimed at screening and selecting improved cultivars has been established in Mauritania. Project variety evaluation trials were conducted during the 1980-82 growing seasons in three project regions to evaluate seed varieties obtained from seed companies and experimental seed sources from international vegetable research institutes in other major production areas. The objective was to provide vegetable growers with improved varieties adapted to Mauritanian climatic conditions. Variety evaluation results for the October to April winter season are presented in Table 2-4. Overall performance is based on yield results, and each variety tested was classified into one of three categories: superior, acceptable, or unsatisfactory. Variety trials conducted during the April to September summer months gave unacceptable yield results, mostly because of extreme temperatures and insufficient soil moisture. Few cultivars were sufficiently heat tolerant and drought resistant for adaptation during these months.

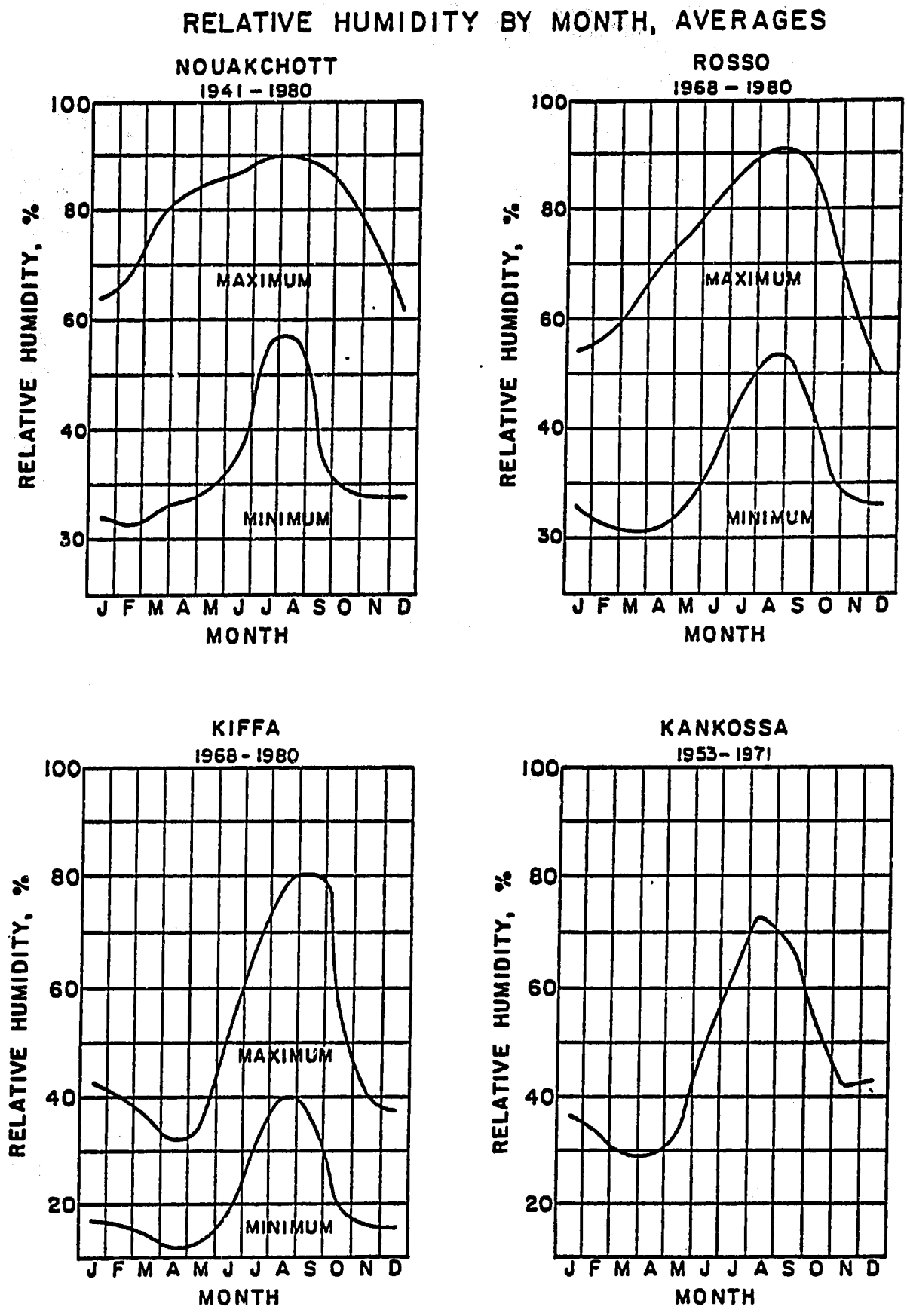


FIGURE 2-3

Monthly Minimum and Maximum Relative Humidity Averages for Nouakchott, Rosso, Kiffa, and Kankossa

TABLE 2-4

RATING OF VEGETABLE CULTIVARS
FOR THE OCTOBER-APRIL WARM GROWING SEASON

BEETS (Beta vulgaris)

Superior:	Rouge cylindra, Red Ball, Crosbys Egyptian,
Acceptable:	Detroit Dark Red, Red Globe, Early Wonder, Lutz Green Leaf

New crop to the area. Good yields. Relatively free from insects and diseases. Late season plantings in January and February are less productive. Market price high.

BROCCOLI (Brassica oleracea, var. italica)

Superior:	Italian Green Sprouting
Acceptable:	De Cicco, Waltham 29

New crop. Relatively unknown. Yield rates low. Usually slow growing and not well adapted to Mauritanian climates. Early plantings during October and November are most productive.

CABBAGE (Brassica oleracea L., var. Capitala)

Superior:	Golden Acre, Copenhagen Market, Couer de Boeuf, King Cole, Green Express, Harvest Queen, Early Marvel
Acceptable:	Fabula, June Star, Mascotte, Acre d'or, Emerald Cross, Early Greenball, Emerald Acre, Stonehead
Unsatisfactory:	Sri Gowa, All Season Wisconsin, Jumbo, N. S. Cross, Kentucky Cross, Rouge Gros

Very popular. Most varieties susceptible to head cracking, especially late in the season (March) when high night temperatures occur. Insect problems--cabbage worm and looper. Copenhagen market variety preferred. Market price high.

CARROTS (Dancus carota, var. sativa)

Superior:	Royal Chantanay, Red Cored Chantanay, Touchon Nantais-Touchon, Carenton
Acceptable:	Nantes Coreless, Denvers Half Long, Spartan Bonus, Scarla, Nantais ameliorie, Nantais Tantol, Little Finger, Nantes Half Long, De la Halle, Chantanay r. Bolex
Unsatisfactory:	Coreless Amsterdam, Ultra pack, Tabor, Sytan, Primenantes

Very popular. Chantenay varieties very productive. Seed germination is a problem for some varieties. Optimum production period is from November to December. Market price high.

TABLE 2-4 - Continued

CAULIFLOWER (Brassica oleracea L., var. Botrytis)

Acceptable: Snowball x, Snowball y, Monarch
Unsatisfactory: Early Snowball

New crop. Can be grown only during cooler months of December/January.

CELERY (Apium graveolens, var. dulce)

Unsatisfactory: Giant pascal, Golden Self Blanching

Varieties tested not adapted. Seedling growth very slow. Very temperature sensitive.

COLLARDS (Brassica oleracea, var. acephala)

Superior: Georgia
Acceptable: Carolina

Very popular. Growth rates good. Not adapted during hot season.

COWPEAS (Vigna sinensis)

Unsatisfactory: Purple hull, Blue Goose

American varieties tested not adapted. Photo-period sensitive. Produced only vegetative growth. However, local varieties productive, interplanted with corn and sorghum. Nitrogen fixation properties need further exploration. Both leaves and seed are eaten. Recommend testing IITA varieties.

EGGPLANT (Solanum melongen L.)

Superior: Black Beauty, Long Violette, Violette de Barbentane
Unsatisfactory: Burpee hybrid, Dusky, French Imperial, Jersey King, Black Nite, Black Bell, Early Beauty

Very popular. Yield rates good. Most varieties susceptible to nematodes. Several insects attack fruits. Can withstand high temperatures. Yield difference among varieties small. Fruit color and shape were important marketing criteria. Black Beauty variety exhibited longer shelf life in markets.

TABLE 2-4 - Continued

FENNEL (Foeniculum vulgare Mill)

Unsatisfactory: Mammoth

Variety tested not adapted. Seedling growth very slow. Temperature sensitive.

KALE (Brassica oleracea, var. acephala)

Acceptable: Georgia, Vates

Popular. Growth rates good.

KOHLRABI (Brassica oleracea, var. gongylodes)

Acceptable: White Vienna

New crop. Prepared with local dishes. Yield rate low. Higher yield during cooler season.

LETTUCE (Lactuca sativa)

Superior:	Black Seeded Simpson, Royal Oak Leaf, Iceberg, Early Curled Simpson
Acceptable:	Salad Bowl, Great Lakes, Green Ice, Minilake, Green Mignonette
Unsatisfactory:	Cos Romain, Parris White, Red Salad Bowl, Slobolt, Barcarolle Romaine, Bibb

Not too popular. Most varieties susceptible to premature seeding (bolting). Oak Leaf and Simpson Curled Leaf moderately resistant to bolting. Yield rates good during cooler season. Planting susceptible to nematodes.

MUSTARD (Brassica juncea)

Acceptable:	Florida Broadleaf
Unsatisfactory:	Green Wave

Not eaten by villagers. Growth rate good during cool season. Warm temperatures induce premature seeding.

TABLE 2-4 - Continued

OKRA (*Hibiscus esculentus*)

Superior:	Clemson Spineless, Dwarf Long Pod, Perkins Spineless, Emerald, Long Vert
Acceptable:	Lee, White Velvet, Green Velvet, Pop 12, Dwarf 210, Perkins Dwarf, Mammoth Long Pod
Unsatisfactory:	CDH 223, Red, Candalabra, Ark Turque

Very popular. Yields good. Eaten fresh or processed by drying. Withstands high temperatures. Cooler temperatures affect seed germination, plant stands, and seedling emergence. Market price high. Some varieties photo-sensitive.

ONION (*Allium cepa*)

Superior:	Texas Yellow Grano, Early Texas Grano 504, IRAT, Violette de Galmi, Yellow Granex, White Grano, Crystal White Wax
Acceptable:	Yellow Bermuda, Crystal Wax, Red Hamburger, Crystal White Wax, New Mexico y Grano, Tropic Ace, Beit Alpha, Red Creole
Unsatisfactory:	Southport y Globe, Southport Red Globe, Spano, Ebenezer, Early y Globe, White Portugal, Fiesta, Early Harvest, Stuttgarter, Red Burgundy, Gandialais, Jaune Espagnol, Ben Shemen

Very popular. Yield rates low. Most varieties had a tendency for premature seed head formation. Keeping quality of bulb a problem. Keeping quality related to varieties with high pungent flavor such as Red Creole. Market price high. Most of crop is harvested as green top. Bulbing photo-period and temperature sensitive.

PARSLEY (*Petroselinum crispum*)

Superior:	Moss Curled
Acceptable:	Dark Green Italian

Very popular. Difficult to grow during hot season.

PEAS (*Pisum sativum*)

Unsatisfactory: Alaska, Little Marvel, Progress

Variety tested unsatisfactory. Yield rates low and sensitive to temperatures and day length.

TABLE 2-4 - Continued

PEPPER, HOT (Capsicum frutescens)

Superior:	Cayenne, Long Slim Cayenne, Red Cherry Large, Rouge Long, Jalapeno
Acceptable:	Fresno Chilli Grande, Hungarian Hot Wax, Red Cherry Small, Red Chilli, Jalapeno, Anaheim

Popular. Yield rates good. Susceptible to nematodes.

PEPPER, SWEET (Capsicum annum)

Superior:	California Wonder, Cubanelle, Mercury, Yolo Wonder
Acceptable:	Keystone Resistant Giant, Hungarian Yellow Wax, Toledo, Turque, Narval, Cabanelle, Midway, Golden Calwonder
Unsatisfactory:	Serramp Chilli

Popular. Yield results vary widely. Plant susceptible to nematodes and fruit sun scale damage.

POTATO (Solanum tuberosum)

Acceptable:	Spunta, Radosa, Sakel, Desiree, Bintge, Claudia
Unsatisfactory:	Ajax, Alpha, Cardinale Holland, Cardinale Dakar, Claustar, Dramant, Eureka, Vekaro, Troubadour, Nicola, Podzola, Univers, Romano, Patronesse

Very popular. Yield rates moderate--13 tons per hectare; above African yield averages. Obtaining seed tubers difficult--must be purchased from Europe. Further variety evaluation needed. Market price high.

POTATO, SWEET (Ipomea batatas L.)

Superior:	Travis, Jusper
Acceptable:	Jewell, Centennial, LO-4-100, LO-0-100

Very popular. Local varieties susceptible to nematodes. Introduced varieties nematode resistant. Yield rate low. Good market price.

RADISH (Raphanus sativus)

Superior:	White Icicle
Acceptable:	Cherry Belle, Early Scarlet Globe, French Breakfast

Not popular. Rapid growth rate. Good yield. Production best during cool season.

TABLE 2-4 - Continued

SNAP BEAN (*Phaseolus vulgaris*)

Unsatisfactory: Tendergreen, Tendercrop

Not very popular. Yield rates low. Varieties susceptible to nematodes. Poor fruit set due to unfavorable high temperature. Sensitive to saline conditions.

SQUASH (*Cucurbita pepo*)

Superior: Yellow Crookneck, Grey Zuccini
Acceptable: Gold Zuccini, Butter Bush, Bush Acorn, Early White Bush, White Patty Pan, Patty Green Tint

Popular. Yield rates good. Developing fruit susceptible to fruit flies. Nematode sensitive.

TOMATO (*Lycopersicon esculentum*)

Superior: Peto 98, Peto 94, Moneymaker, Red Cherry Large, Tarzol, Rossol, UN-H-53, UN-H-65, Kosei, Master Z, Veeset
Acceptable: Roma-VR, Manulucie, Floramerica, Marglobe, Starfire, Supersteak, Earlymech, Peto 81, Heinz 1370, H63-3F_1, Hopse No. 1 VF, Piersol VFN, Castleprize VFN
Unsatisfactory: Tropic, Bonus, Terrific, Whopper, Beefmaster, Better Boy, Vine Ripe, Enorma Boy, Big Boy, San Mazarno, Ace 55, Large Red, Beefsteak, Spring Giant, Early Girl, Big Girl, Early Sunrise, Jumbo, Red Chief, Ultraboy, Venezuela, Yuma, Choto, Mecheast, Longkeeper, St. Pierre, Peto 95, Peto 86, Quatuor

Very popular. Many varieties tested. Good yield--20 tons/hectare. Blossom end rot serious. High temperatures inhibit fruit set. Susceptible to nematodes and fruit worms, also leaf blight. Local market preferred large fruit and shape not an important consideration. Both processing and large fresh market types acceptable on open market. Surplus production during peak season. Fruit drying introduced and powdered dry fruit well accepted.

TURNIP (*Brassica campestris*, var. rapa)

Superior: Des Vertus Marteau
Acceptable: Nantais r. Candia, Purple Top

Very popular. Yield rates good, especially during cool season. Good market price.

Seed Production

Local seed production and/or coordinated seed purchases of superior varieties identified in variety trials are needed. At present, much of the vegetable seed planted in Mauritania is imported by the Ministry of Rural Development from Senegal or overseas. Growers have complained of shortages and difficulty in obtaining vegetable seed to meet scheduled plantings, although some use their own farm-produced seed. Many open-pollinated vegetable crops can be produced from seeds which are harvested and saved, including bean, cowpea, eggplant, lettuce, okra, pepper (hot and sweet), and tomato. Sweet potato varieties can be reproduced from cuttings. Irish potato seed tubers cannot be produced in Mauritan. and would require cold storage facilities that are not available or economical in Mauritania. West Africa has similar Irish potato seed production and availability problems. Tubers are imported from Europe. Transport, storage, and distribution are production constraints at the village level. Low temperature requirements are a seed production constraint for several cool season vegetables (see Table 2-5). These crops are biennial, requiring two complete seasons for seed production. They represent 20 to 25 percent of vegetables with potential in Mauritania. A chilling period of 3° to 5°C for four to eight weeks is required for flowering and seed production. Minimum temperatures in Mauritania are approximately 10°C higher than those required for seed production of these crops. The low temperature constraint only affects seed production and not production of the harvestable produce.

TABLE 2-5

VEGETABLE CROPS REQUIRING LOW MINIMUM TEMPERATURES TO PRODUCE SEED STALKS

Beet	Kohlrabi
Cabbage	Onion
Carrots	Parsley
Celery	Radish, winter type
Chard, Swiss	Turnips
Collard	Fennel

Inputs

Fertilizers

Rainfed and oases cropping systems are practiced on sandy desert soils that are low in organic matter and fertility. Likewise, recessional agriculture, practiced in the vicinity of marigots is generally done on rather infertile soils. Long distances from supply channels generally preclude use of purchased fertilizers under these three cropping systems. Even if distances were not so great, farmers engaged in these production systems are not reliant on any form of purchased inputs. They do, however, use manures. Soil

improving crops used as green manure are not used because of water cost and other competing uses such as animal feed.

Flood recession and irrigated perimeter farming occur adjacent to the Senegal River where native soil fertility is relatively better than for the sandy soils which dominate most of Mauritania. Even in locations where native soil fertility is considered adequate, under continuous cultivation, crops remove significant quantities of nutrients that must be replenished annually if yields are to be maintained. Table 2-6 lists quantities of N, P, K, Ca, Mg, and S extracted by a vegetable crop producing at the yield level indicated.

The strategy in irrigated rice perimeters managed by SONADER is to provide chemical fertilizer and, in fact Mauritania imports are estimated at 1,000 metric tons annually.[3/] Similarly irrigated, perimeter-type vegetable production will require additional fertilizer importations. Since we expect the major portion of the vegetable-producing perimeters to be located near Rosso, supply distribution to perimeters will not be an insurmountable problem. If an estimated 1,000 ha of vegetables will be grown in irrigated perimeters near Rosso to meet demand in Nouakchott and Rosso, estimated fertilizer importations should be on the order of 500 to 1,000 metric tons annually.

TABLE 2-6

APPROXIMATE AMOUNTS OF NUTRIENTS REMOVED BY VARIOUS VEGETABLE CROPS UNDER MAURITANIAN PRODUCTION

Crop	Metric Tons/Ha	Kg/Ha					
	Yield	N	P_2O_5	K_2O	Mg	Ca	S
Beets	10	85	20	15	17	30	15
Cabbage	6	40	15	50	6	14	13
Lettuce	6	40	15	60	42	17	5
Potatoes	13	145	65	200	19	40	14
Sweet Potatoes	5	50	20	100	10	6	8
Tomatoes	20	140	45	230	24	44	28
Turnips	7	90	20	100	7	38	13
Onions	6	35	15	30	4	9	14

3/ West Africa Fertilizer Study, Volume 8: Mauritania AID/Afr-c-1176. International Fertilizer Development Center.

Pesticides

Mauritanian vegetable growers experience major losses due to pests. Insect and disease control are extremely difficult to achieve. Conventional control involves expensive chemical pesticide usage that is generally not available in the rural areas on a regular basis, and usage is limited by growers' knowledge of pest management practices. However, some growers have experienced success using pesticides and indicate it is cost effective. Growers without access to pesticides have experienced heavy yield losses ranging from 50 percent to complete crop failure. Some of the most serious insect pests are fruit borers (*Heliothis armigera*) on tomato, larva worms (*Plutella xylostella*, *Hellula undalis*) on cabbage, and fruit flies (*Dacus* sp.) on melons and squash. Most crops are affected by aphids (*Aphis* sp.), white flies (*Bemisia* sp.), mites (*Tetranychus* sp.), and grasshoppers (*Chrotogomus senegalensis*).

Diseases are less serious than insects due in part to low humidity. The most serious disease infestation common to all production areas includes early blight (*Alternaria solani*) on tomato, powdery mildew (*Pseudoperonospora* sp.) on melons and squash, and root rot (*Rhizoctonia*) on okra and beans. Nematodes (*Meloidogyne* sp. *incognita*, *javanica*) attack most vegetable crops, especially in the sandy soils of the Assaba and Trarza regions.

Mauritania imports small quantities of pesticides and additional importations will be required to support expanded production. A well-organized extension service effort can provide distribution of recommended chemicals and farmer training in pest control management. Non-chemical alternative management practices such as crop rotation, biological control, and varietal resistance can provide control results at reduced cost. For example, breeding programs sponsored by various international research centers have developed cultivars that are resistant to various nematode species. Table 2-7 lists tomato cultivars with nematode resistance that are adapted to Mauritanian production. The leaves and fruits of Neem trees (*Azardirochta indica*), often planted as windbreaks in vegetable plots, contain a natural repellent that provides insect protection. Initial studies from the International Rice Research Institute in the Philippines suggests ways in which Neem trees can be used to provide biologic control for soil insects and nematodes.[4/] Soil incorporation of Neem tree leaves in small plots under oases, flood recession, and small scale irrigated cropping systems merits investigation.

4/ *The International Rice Research Institute Reporter*. 2:1982.

TABLE 2-7

TOMATO CULTIVARS RESISTANT TO NEMATODES (*Meloidogyne* spp.)[a]

Meloidogyne arenaria:	Atkinson, Hawaii 5229, Manalucie, Nematex, VFN-8, 66N, 569 N - 10
M. acrita:	Gawaher (Giza 1), Hawaii 5229
M. hapla:	P.I. 270435 *L. peruvianum*
M. incognita:	Anahu, Anahu R, Atkinson, Beefeater, Beefmaster, Betterboy, Big Seven, Bigset (H), Bonus (H), Bw-21-F1, Calmart, Coldset, Florida-Hawaii Cross, Gawaher (Giza-1), Gilestar, Hawaii 7322, Hawaii 5229, Hawaii 7746, Hawaii 7747, Hawaii 55, Healani, Kalohi, Kewalo, Kolea, Manalucie, Merbein Canner, Merbein Early, Merbein Mid-season, Merbein Monarch, Monte Carlo, Nematex, N-52 (H), Nemared, Pelican, Peto 662VFN, Puunui, Red Glow (H), Ronita, Rodeplaat Albesto, Rossol, Small Fry, Sunburst, Terrific (H) Tuckercross K, Vine Ripe, VFN Bush, VNF-8, VNF368, PI 270435 *L. peruvianum*, 66 N, 569 N - 10
M. javanica:	Anahu, Atkinson, Gawaher (Giza-1), Hawaii 5229, Healani, Kalohi, Nematex, VFN-8, Manalucie, 66 N, 569 N - 10, *L. peruvianum* strains LP_1, LP_2, LP_3

Weed Control

Vegetable yield losses due to weeds for the four cropping systems, i.e., rainfed, flood recession, oasis, and irrigated perimeters, are generally small. Infestation depends in large part on the availability of soil moisture. Most production systems practice intense cultivation and production plots are kept fairly weed free using hand tools. Chemical weed control has not been introduced or attempted in Mauritania and may not be used even under an expanded production program. The most common weed species found in vegetable plots are presented in Table 2-8. The most serious are *Cyperus rotundus*, *Portulacca oleraceae*, and *Cancrus bifloris*.

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[a] R. B. Valdez: Proceedings, International Symposium on Tropical Tomato. 1:142.

TABLE 2-8

COMMON WEEDS IDENTIFIED IN MAURITANIAN VEGETABLE GARDEN PLOTS

Amaranthus iridus	Cucumis melo
Ammania senegalensis	Cynodon dactylon
Bergia ammanoides	Dactylotenium aegyptium
Boehavia repens	Dorstenia preussi
Cancrus bifloris	Eragrostis perbella
Chenopodium paniculatum	Indigofera senegalensis
Convulvulus microphyllus	Portulacca oleracea

Tools

Vegetable production tools used in Mauritania are relatively simple. With the exception of the large scale irrigated perimeters that use motor pumps and tractors, simple hand tools are used for soil preparation and planting for rainfed, flood recessional, oasis, and small scale irrigated perimeter cropping systems. Small plots are irrigated with watering cans and buckets used to convey water from wells, marigots, and the river. Tools are in short supply and can be purchased only from Nouakchott and Rosso. Tool costs could probably be reduced if tools were manufactured locally. Recent government programs have distributed imported tools at subsidized prices directly to growers. Expanded production will require larger tool imports unless local manufacture can be stimulated. The type and average price of tools used is presented in Table 4-6 of Chapter 4.

Summary

To summarize the principal points of this chapter, listed below are the major agronomic constraints to expanding vegetable production in Mauritania.

- Lack of sufficient water for irrigation and associated high water resource development costs.
- Difficulty in obtaining purchased inputs, i.e., seeds, tools, irrigation equipment, fencing, fertilizers, pesticides.
- Lack of heat-tolerant varieties to support year-round production.
- No domestic seed industry for multiplication, processing, and distribution of selected cultivars.
- Lack of protection from animals.
- Difficulty in controlling pests and diseases.

- Lack of sufficiently trained extension and research staff to conduct trials and extension activities to extend information to vegetable farmers and village gardeners.

CHAPTER 3

IRRIGATION

Introduction

Low rainfall and high evaporative demand make Mauritania an extremely difficult environment in which to produce crops.[5] Given an environment in which water deficits are naturally occurring, the importance in Mauritania of water for irrigation is readily recognized. The USAID Project Paper states: "Water is the limiting factor, as much so because of the arduousness in transporting it to the garden, as because of its relative scarcity in areas away from the river."[6]

This chapter deals with water sources and delivery systems, water quality, water requirements, and water constraints to vegetable production.

Present Situation

Water Sources

Wells -- Among the small cooperative gardens, wells supply the majority of the water. Relatively shallow groundwater seems to be plentiful at many locations in Southern Mauritania. Over much of the Assaba Region the water table varies from 0-30 m from the surface. In the oases the water table is at a depth of 0-4 m throughout the year. At one location north of Kiffa, farmers report that water is never deeper than 7 m.

Farmers in the Trarza Region report that the depth to water is about 6 m in Keur Massene and Dara during the dry season. However, in the dry season, waters at those locations evidenced salt water intrusion. Degradation of water quality limits vegetable production to a single planting between July and December. It is reported that in some areas, Boutilimit and Mederdra for example, deep wells are used for vegetable irrigation.

Further east along the Senegal River in the Brakna Region, the groundwater level is reported to be at about 15 m during the dry season. Depth to water is related to the distance between the well and the river.

The most widely used type of well is of large diameter and unlined. These wells are hand dug and shallow, only penetrating the surface of the aquifer. Typically the depth of water in the well is less than one meter. As the dry season progresses the water table drops and the wells are deepened. This process is repeated until well collapse occurs. Generally, the well is dug in gravelly or sandy material, neither of which has much vertical stability. As the well is deepened, the saturated material slumps. Over time, i.e., after

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5/ Data on climatic conditions are presented in Chapter 2.
6/ USAID Project Paper, Mauritania Vegetable Production Project, p. 18.

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repeated deepenings of the well, enough of the aquifer material has been removed to cause a cave in of the soil overburden. If the well has not collapsed due to aquifer slumping during deepening, the first rains saturate the soil causing the sides of the well to give way.

To illustrate the magnitude of the problem, one garden in Kiffa (1981) of less than one-half hectare in size had 12 operating and 12 collapsed, abandoned wells. Abandoned wells occupied about 25 percent of the garden area. Each time a well is dug and subsequently deepened, significant amounts of coarse-textured material, low in organic matter, is brought to the surface and spread over the garden area. Such material has a detrimental effect upon soil fertility and water holding capacity.

Alternative types of wells, suitable for or used in Mauritania are:

(1) Hand dug wells - either lined or unlined. Suitable for hand or windmill pumps, or for hand drawing using a bucket and rope.

(2) Drilled wells (tube wells) - lined. Suitable for hand or windmill pumps.

Installation of small diameter tube wells with hand pumps are considered to be most suitable for the following reasons:

(1) Wells can be drilled at any time of the year when access is possible;

(2) Time and labor requirements for well drilling are less than for a large diameter well;

(3) Wells are deep and penetrate the aquifer generally permitting: (a) a supply of water over a longer season of the year (even when water tables drop); (b) higher flow rates from wells due to the fact that several water bearing strata have been perforated;

(4) Wells have a considerably longer useful life than the traditionally-dug wells;

(5) Hand pumps are an intermediate technology between traditional and motor-driven pumps. In comparison to the bucket method, drawing water is made easier. In comparison to motor-driven pumps, hand pumps require less maintenance and no reliance on imported fuels, which at times are in short supply.

Under project-generated technical assistance, well drilling and lining equipment were purchased. In sandy strata, we estimate that a well with a four-inch (10 cm) casing can be installed in two days using a three-person team. Wells are fitted with Dempster hand-type pumps. Installation of an improved well, deepened and lined, offers a perennial water supply which can lead to a lengthening of the vegetable production season. It also can lead to increases in the area under production.

Marigots/Lakes -- A marigot is a small seasonal body of water. It is generally filled during rainfall and subsequent runoff and dries out in the

dry season. Marigots are used for crop production at many locations near the river. Planting is done on the banks and follows the receding shoreline of the marigot. Water is taken from the decreasing pool to irrigate the crops. When surface water is gone, shallow holes are often dug into the lake bed to extract additional water. Crop production does not continue for very long after the marigot dries (January to February). The heavy soils of the marigot bed are often used for cereal production with vegetables planted in the lighter soils of the shoreline.

Lakes offer opportunities for production which presently are underexploited. Lake Kankossa, a fresh-water lake covering an area of 150 ha and having a storage capacity estimated at three million cubic meters, is little used for irrigation. One reason is the isolation of the Kankossa area from any sizeable market. Crops recommended for production in the area would have to be nonperishable and ones which could withstand rough handling.

Senegal River -- Gardens drawing water from the Senegal River have access to water throughout the year. However, as the river water stage falls in the period February through June, water quality becomes poorer in the lower reaches of the River as a result of salt water intrusion.

Due to the steepness of the river bank, most commercial gardens, whether cooperative or private, use motor-driven pumps to lift water to gardens. The usual array of problems with use of motor-driven pumps include: shortages of spare parts, few well-trained repair/maintenance personnel, and intermittent shortages of fuel.

Delivery Systems

Traditional -- Typically, water is drawn from wells with a bucket constructed from a used truck inner tube and a rope. Gardeners, generally women, then deliver water to each individual bed in the garden with a watering can or other carrying utensil. Watering cans are in short supply and highly valued. In the case of marigots/lakes or the Senegal River the carrying container is filled by dipping into the water. A few of the gardens have water delivered to the garden via offtakes from rice perimeter canals or motor pumps drawing from the Senegal River. Watering cans are dipped into the delivery canals and the water carried to the beds.

Generally 10 or 20 liters of water is applied to each garden bed of about 3 square meters at each irrigation. Beds are irrigated twice each day, morning and evening. A 20-liter irrigation application on a 3 m^2 bed twice a day is equivalent to a 13 mm depth of water which slightly exceeds the April evapotranspiration demand of 10.5 mm per day for Kiffa. (See "Crop Water Requirements" section of this chapter.)

Improved -- In areas not subject to flooding which have fine textured soils, unlined canals can be used to transport water from the river bank to the gardens. Canals require regular maintenance and silt removal which is often inadequate. At Tieneel for example, Project staff helped repair sections of a broken canal and helped lay out new sections of a canal. With repairs made and conveyance losses reduced, villagers were amazed to observe that pumping

for irrigation could be carried out in half the previous time. When passing through sandy soil, new canals can be excavated at a rapid rate. In Sani, ten workers excavated 60 meters of canal in about three hours. The final shaping of the sides and leveling the bottom to grade takes considerably longer. Pipes can also be used to transport water to strategically located basins within the garden. Watering cans can be filled at each basin for delivery to the beds. The use of basins requires an investment in the pipe and basins. However, this will save considerable labor and, for that reason, may permit an expansion in garden size.

Where water is of poor quality and/or limited in supply, drip irrigation may be appropriate. Correctly managed drip systems maintain soil salinity levels no greater than salinity concentrations in the irrigation water. Moreover, the efficiency of application of drip is generally better than for other irrigation methods, thus permitting irrigation of a larger area with a scarce water supply. In drip irrigation, only a portion of the bed is wetted, reducing evaporative losses. Therefore, drip irrigation is most feasible for widely-spaced plants. For high density plantings of crops such as carrots, drip would offer little advantage over other methods of water application in terms of reducing irrigation requirements, since for a crop like carrots the entire surface of the bed would need to be wetted. Project staff installed demonstration drip systems in Nouakchott and in Ferrellah. Information about drip system installation is provided in Section 3 of this report.

As described earlier, lifting water from the small diameter tube wells with hand pumps would be a marked improvement over traditional systems. Motor-driven pumps are not recommended because of the problems of spare parts, maintenance, and the potentially unrealiable fuel supply. (These small diameter wells require the use of pumps since the well diameter is too small to allow the use of a rope and container.)

Water Quality

The objective of the Project was to determine the feasibility of expanded vegetable production in Mauritania, with production in large part dependent upon irrigation. Thus, the feasibility determination rests in part upon water supply adequacy and upon a determination of the quality of that water for irrigation purposes. Reported herein are results of water quality analyses for Southern Mauritania.

Water Samples

A total of 50 samples were obtained for analyses. The total includes 27 water samples collected by Project staff in May of 1981 which covered some of the oases in the Assaba region where agricultural development efforts are in progress. The majority of the 27 samples are from locations known to have good quality waters. Thus, the sample selection should not be viewed as representative of waters in Southern Mauritania. Figure 3-1 shows known locations where samples were collected. In addition, data are included for 23 other sites which were collected by others and submitted to the SONADER laboratory for analyses. Sampling dates for these are unknown.

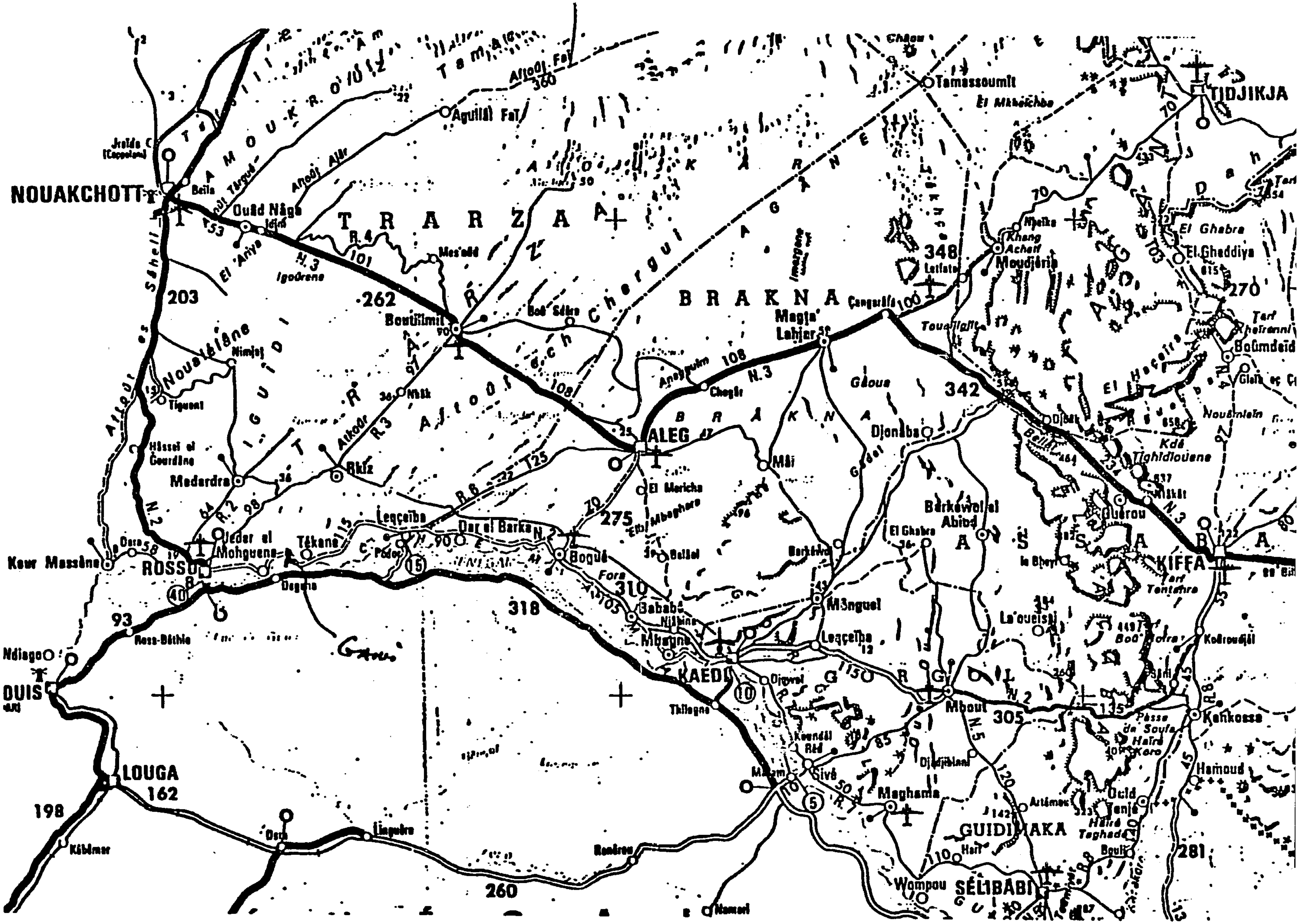


FIGURE 3-1

Location of Some Water Sampling Sites

Sample Analyses and Data Interpretation

Table 3-1 presents chemical analyses data for the 50 water samples from several regions of Mauritania. Analyses were performed in the SONADER laboratory, Nouakchott.

Two texts were followed for data interpretation:

- -- FAO Irrigation and Drainage Paper 29, Water Quality for Agriculture.
- -- USDA Handbook 60, Diagnosis and Improvement of Saline and Alkali Soils.

Tables 3-2 and 3-3 present guidelines for interpretation of water quality for irrigation following the FAO and USDA systems, respectively. These guidelines have been used to classify the 50 samples analyzed. Interpretations are presented in Table 3-4. Data results are plotted in Figure 3-2.

Conclusions Regarding Water Quality

Waters tested were generally of good quality for irrigation of vegetable crops and, if applied, would neither irrevocably damage the soil nor detrimentally affect crop yields. However, it must be borne in mind that almost half the sample sites were selected on the basis of previous testing or crop production, evidence of good quality waters. Thus, before recommendations can be made for crop production in an oasis, or use of wells or river waters for new irrigated developments, waters must be properly sampled and analyzed. Specific conclusions follow.

(1) Based upon electrical conductivity (ECw) criteria, 80% of the samples tested are classified as "no problem" waters, generally corresponding to C1 or C2 waters in the USDA system. Under conditions of good drainage (generally common in coarse-textured Mauritanian soils), these waters may be used on all but the most salt sensitive crops without special practices for salinity control. Application of these waters is not likely to lead to soil salinization.

(2) Fourteen percent (14%) of the waters tested showed an "increasing" degree of problems with salinity (corresponding to a C3 water in the USDA system). Given proper crop selection, good management practices, and adequate drainage, these waters can be used for vegetable production.

(3) Three waters tested (6%), showed salinity levels which were not suitable for irrigated vegetable production. However, they could be suitable for production of salt tolerant crops (such as date palms), where good drainage can be obtained and where excess irrigation water is applied for leaching. These three samples were from Keur Massene, N'Taket #2, and the River.

(4) There is recognition that from February to June salinity levels in the lower reaches of the Sènegal River are too high to support vegetable

TABLE 3-[illegible]

CHEMICAL ANALYSES OF WATER SAMPLES FROM MAURITANIA

Sample	pH	mmhos/cm ECw	milliequivalents per liter (meq/l) Na	Ca	Mg	K	Cl	SO_4	CO_3	HCO_3	SAR
Keur Massene	8.6	7.77	61.50	7.20	16.40	2.00	62.60	19.60	0.90	3.65	17.9
N'Taket #1*	6.5	0.41	0.80	1.40	0.80	0.35	1.20	0.49	0.00	1.20	0.8
N'Taket #2*	7.6	21.65	210.00	37.50	32.50	3.12	158.00	98.00	0.00	6.80	35.5
N'Taket #3*	7.0	0.17	0.62	0.60	0.64	0.14	0.60	0.16	0.00	1.30	0.8
N'Taket #4*	7.4	0.31	0.94	1.20	1.00	0.25	1.10	1.90	0.00	1.10	0.9
Teinteina #1*	7.1	0.28	0.73	1.30	0.70	0.33	0.50	0.20	0.00	2.40	0.7
Teinteina #2*	7.2	0.23	0.80	1.40	0.60	0.18	0.50	0.40	0.00	2.30	0.8
N'Douda #1*	7.4	0.31	1.34	0.80	0.50	0.23	1.20	0.48	0.00	1.50	1.7
N'Douda #2*	6.5	0.24	0.65	1.10	0.20	0.31	0.50	0.00	0.00	1.80	0.8
N'Douda #3*	6.6	0.19	0.28	0.48	0.28	0.64	0.80	0.44	0.00	1.00	0.5
Bethelli*	7.6	1.84	5.25	10.20	7.10	0.53	1.30	18.20	0.00	4.10	1.8
Owje #1*	7.7	0.23	0.53	1.10	0.60	0.16	0.40	0.80	0.00	1.40	0.6
Owje #2*	7.5	0.18	0.58	0.90	0.20	0.19	0.40	0.30	0.00	1.40	0.8
Bou Effra*	7.1	0.11	0.34	0.40	0.20	0.18	0.40	0.10	0.00	1.10	0.6
N'Tarhad El Ouassa #1*	6.5	0.08	0.16	0.28	0.16	0.08	0.30	0.28	0.00	0.70	0.3
N'Tarhad El Ouassa #2*	6.8	0.10	0.27	0.46	0.28	0.14	0.40	0.24	2.00	1.20	0.4
N'Tarhad El Ouassa #3*	7.2	0.81	1.60	1.48	1.60	0.37	5.50	1.68	0.00	1.00	1.3
Billaour #1*	8.0	1.72	2.00	1.20	2.00	0.74	8.60	3.50	0.70	7.10	1.6
Billaour #2*	6.9	0.28	0.60	1.16	0.72	0.18	0.70	0.24	0.00	0.70	0.6
Samoga #1*	7.2	0.09	0.16	0.40	0.16	0.13	0.20	0.28	0.00	0.70	0.3
Samoga #2*	7.4	0.53	0.48	2.48	1.56	0.95	1.90	0.00	0.00	4.50	0.3
Bou Gara #1*	7.1	1.49	3.90	6.20	4.06	0.68	3.68	1.30	0.00	1.30	1.7
Bou Gara #2*	7.0	0.53	1.40	2.00	1.30	0.18	1.24	0.36	0.00	0.90	1.1
El Grahan #1*	6.7	0.31	0.75	0.64	0.60	0.21	1.30	0.12	0.00	0.90	1.0
El Grahan #2*	6.9	0.31	0.50	0.90	0.44	0.20	0.50	0.16	0.00	1.10	0.6
Serumell #1*	6.7	0.14	0.50	0.36	0.28	0.10	0.40	0.12	0.00	0.40	0.9
Serumell #2*	6.6	0.14	0.40	0.36	0.20	0.11	0.50	0.16	0.00	0.60	0.8
Serumell #3*	6.8	0.16	0.69	0.40	0.30	0.14	0.40	0.30	0.00	0.70	1.2
Ouadane #1	7.9	0.26	0.62	1.24	0.72	0.07	0.80	0.00	0.00	2.05	0.6
Ouadane #2	8.0	1.33	4.58	6.00	4.12	0.24	3.36	7.00	0.00	4.50	2.0
Atar	7.9	1.89	4.60	5.12	2.00	0.12	6.75	3.02	0.00	1.70	2.4
Chinguetti	7.8	0.41	1.05	2.00	0.84	0.26	1.08	0.69	0.00	2.32	0.9
Tamourt En Naaj #1	6.7	0.29	0.90	1.30	0.70	0.23	1.00	0.50	-	1.80	0.9
Tamourt En Naaj #2	8.0	0.44	1.25	1.00	1.40	1.10	0.60	0.30	0.20	3.80	1.1
Tamourt En Naaj #3	7.5	0.47	0.40	3.60	0.80	0.10	0.30	0.20	-	4.50	0.3
Tamourt En Naaj #4	7.9	0.29	0.44	0.70	0.9	0.90	0.30	0.10	0.10	2.80	0.5
Tamourt En Naaj #5	6.9	0.13	0.26	0.60	0.20	0.18	0.20	0.10	-	1.20	0.4
Tamourt En Naaj #6	7.5	0.57	1.60	3.10	0.80	0.28	1.50	0.40	-	4.00	1.1
Tamourt En Naaj #7	7.2	0.23	0.58	0.90	0.40	0.04	1.00	0.30	-	0.80	0.7
N'Seffenm #1	7.1	0.17	0.62	0.40	0.56	0.12	0.48	0.22	-	1.05	0.9
N'Seffenm #2	7.1	0.18	0.62	0.44	0.52	0.12	0.48	0.22	-	1.05	0.9
Tamourt En Naaj Forage 1	6.7	0.46	0.69	2.32	1.56	0.50	0.76	3.52	-	4.10	0.5
Tamourt En Naaj Forage 3	7.2	0.49	1.16	2.16	1.48	0.43	0.88	0.45	-	4.20	0.9
Tamourt En Naaj Forage 4	6.5	0.29	0.31	1.21	1.10	0.34	0.48	0.12	-	2.35	0.3
Tawaz #1	8.0	0.52	2.60	1.12	1.60	0.09	1.92	0.00	0.00	3.40	2.2
Tawaz #2	8.1	0.70	0.63	3.60	2.72	0.24	2.76	0.26	0.00	4.10	0.4
Rodha	8.3	1.33	9.80	1.55	2.65	0.24	5.60	1.20	0.00	7.60	6.8
Lampsar Debi	6.8	0.10	0.57	0.04	0.20	0.15	0.56	0.16	-	0.40	1.6
Fleuve[a]	7.6	5.55	42.00	2.48	9.76	1.45	50.70	4.00	0.00	0.80	17.0
Tamchaket/SAFA	7.5	2.16	1.15	0.60	0.44	0.11	1.06	0.60	-	0.63	1.6

*Sample taken in May of 1981

[a] No location given but judging from high salt levels, sampling likely was near mouth of River.

TABLE 3-2

GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

FAO SYSTEM

Irrigation Problem	Degree of Problem		
	None	Increasing	Severe
Salinity ECw (mmhos/cm)	< 0.75**	0.75 - 3	> 3***
Permeability			
Salinity ECw (mmhos/cm)	> 0.5	0.5 - 0.2	< 0.2
Sodium SAR*	<10	10 - 22	>22
Bicarbonate (meq/l)	< 2	2 - 3	> 3
Toxicity			
Sodium SAR	< 3	3 - 9	> 9
Chloride (meq/l)	< 4	4 - 10	>10
Boron (mg/l)	< 0.75	0.75 - 2	> 2

* SAR is the Sodium Adsorption Ratio
** < means less than
*** > means more than

Ayers, R. S. and D. W. Westcot. Water Quality for Agriculture. Rome: FAO, Irrigation and Drainage Paper 29, (1976), page 7.

Note:

Problem definition into "No Problem," "Increasing Problem" and "Severe Problem" is somewhat arbitrary since changes occur gradually and there is no clear-cut breaking point. Changes of 10 to 20% above or below the guideline values may have little significance if considered in proper perspective with other factors affecting yield.

TABLE 3-3

GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

USDA SYSTEM

	EC: Millimhos/cm (EC x 10^3)
Conductivity	
Low-salinity water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.	less than 0.250
Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.	0.250-0.750
High-salinity water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.	0.750-2.250
Very high salinity water (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.	greater than 2.250
Sodium	
The classification of irrigation waters with respect to SAR is based primarily on the effect of exchangeable sodium on the physical condition of the soil. Sodium-sensitive plants may, however, suffer injury as a result of sodium accumulation in plant tissues when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of the soil.	See Figure 2
Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.	
Medium-sodium water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.	
High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management—good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.	
Very High sodium water (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.	

Source: USDA Handbook 60, Diagnosis and Improvement of Saline and Alkali Soils.

TABLE 3-4

INTERPRETATION OF CHEMICAL ANALYSES OF WATER SAMPLES FROM MAURITANIA

	FAO Classification						USDA
	Salinity	Permeability			Toxicity		
Sample	ECw	ECw	SAR	HCO_3	SAR	Cl	Water Classification
Keur Massene	S*	N	I	S	S	S	C4-S4
N'Taket #1	N	I	N	N	N	N	C2-S1
N'Taket #2	S	N	S	S	S	S	C4-S4
N'Taket #3	N	S	N	N	N	N	C1-S1
N'Taket #4	N	I	N	N	N	N	C2-S1
Teinteina #1	N	I	N	I	N	N	C2-S1
Teinteina #2	N	I	N	I	N	N	C1-S1
N'Douda #1	N	I	N	N	N	N	C2-S1
N'Douda #2	N	I	N	N	N	N	C1-S1
N'Douda #3	N	S	N	N	N	N	C1-S1
Betheili	I	N	N	S	N	N	C3-S1
Owje #1	N	I	N	N	N	N	C1-S1
Owje #2	N	S	N	N	N	N	C1-S1
Bou Effra	N	S	N	N	N	N	C1-S1
N'Tarhad El Ouassa #1	N	S	N	N	N	N	C1-S1
N'Tarhad El Ouassa #2	N	S	N	N	N	N	C1-S1
N'Tarhad El Ouassa #3	N	N	N	N	N	I	C3-S1
Billaour #1	I	N	N	S	N	I	C3-S1
Billaour #2	N	I	N	N	N	N	C2-S1
Samoga #1	N	S	N	N	N	N	C1-S1
Samoga #2	N	N	N	S	N	N	C2-S1
Bou Gara #1	I	N	N	N	N	N	C3-S1
Bou Gara #2	N	N	N	N	N	N	C2-S1
El Grahan #1	N	I	N	N	N	N	C2-S1
El Grahan #2	N	I	N	N	N	N	C2-S1
Serumell #1	N	S	N	N	N	N	C1-S1
Serumell #2	N	S	N	N	N	N	C1-S1
Serumell #3	N	S	N	N	N	N	C1-S1
Ouadane #1	N	I	N	I	N	N	C2-S1
Ouadane #2	I	N	N	S	N	N	C3-S1
Atar	I	N	N	N	N	I	C3-S1
Chinguetti	N	I	N	I	N	N	C2-S1
Tamourt En Naaj #1	N	I	N	N	N	N	C2-S1
Tamourt En Naaj #2	N	I	N	S	N	N	C2-S1
Tamourt En Naaj #3	N	I	N	S	N	N	C2-S1
Tamourt En Naaj #4	N	I	N	I	N	N	C2-S1
Tamourt En Naaj #5	N	S	N	N	N	N	C2-S1
Tamourt En Naaj #6	N	N	N	S	N	N	C2-S1
Tamourt En Naaj #7	N	I	N	N	N	N	C2-S1
N'Seffenm #1	N	S	N	N	N	N	C1-S1
N'Seffenm #2	N	S	N	N	N	N	C1-S1
Tamourt En Naaj Forage 1	N	I	N	S	N	N	C2-S1
Tamourt En Naaj Forage 3	N	I	N	S	N	N	C2-S1
Tamourt En Naaj Forage 4	N	I	N	I	N	N	C2-S1
Tawaz #1	N	N	N	S	N	N	C2-S1
Tawaz #2	N	N	N	S	N	N	C2-S1
Rodha	I	N	N	S	I	I	C3-S2
Lampsar Debi	N	S	N	N	N	N	C1-S1
Fleuve[a]	S	N	I	N	S	S	C4-S4
Tamchaket/SAFA	I	N	N	N	N	N	C3-S1

* S = Severe problem potential, I = Increasing problem potential, N = no problem potential.

[a] No location given, but judging from analysis, sampling must have been near mouth of River.

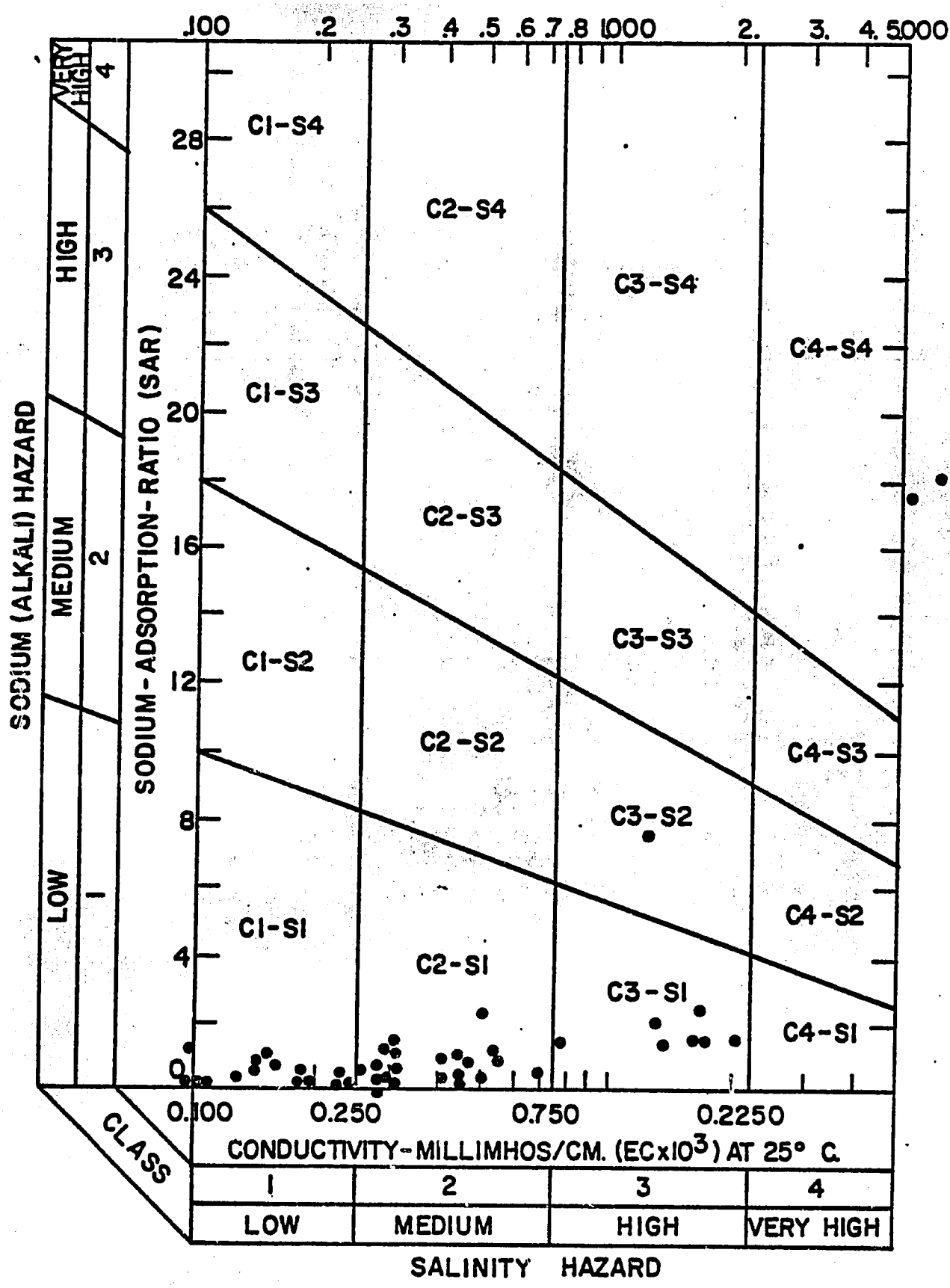


DIAGRAM FOR THE CLASSIFICATION OF IRRIGATION WATERS.
AGRICULTURE HANDBOOK 60, U.S. DEPT. OF AGRICULTURE.

FIGURE 3-2

production. Farmers as far east as Dar el Barka recognize high salinity levels, which together with low water stage in the river, influences their decisions not to pump after the month of February. Planners and engineers have also acknowledged the problem and planning is underway for construction of a salt water intrusion barrier (Diama Dam) near St. Louis. With construction of that barrier, salinity levels in the river will be reduced such that even in the Trarza region, river water can be used for irrigated vegetable production. Upon completion of the dam and an improvement in water quality, the Rosso area will have the potential for significant expansion of vegetable production. Given the good highway linkage between Rosso and Nouakchott, producers in this area will then have an additional competitive advantage in the Nouakchott market over producers in more remote areas.

(5) Ninety-four percent (94%) of the samples had Sodium Absorption Ratios which may be classified as "no problem." In other words, application of these waters will not likely lead to soil permeability problems, nor would sodium toxicity problems be induced in crops grown using these waters.

(6) Twenty-eight percent (28%) of the samples tested had very low salinity levels. If sodium was present in these waters, their application could lead to a soil permeability problem, particularly on very fine soils. However, given the sandy nature of most soils in Mauritania, there is but remote chance that application of these waters would result in a permeability problem.

(7) Eighty-six percent (86%) of the samples evidenced very low levels of chloride; applications of these waters would not cause chloride toxicity problems. However, six percent of the samples indicated high levels of chlorides, toxic to most vegetable crops. These samples indicated severe salinity problems as well.

Water Requirements

Crop Water Requirements

Crop water requirements were calculated using the modified-Penman method described in FAO Handbook 24, Crop Water Requirements. Climatic data for Nouakchott, Rosso, and Kiffa were taken from the RAMS report and used to calculate potential evapotranspiration (ET). (See Table 3-5). These data are plotted in Figure 3-3.

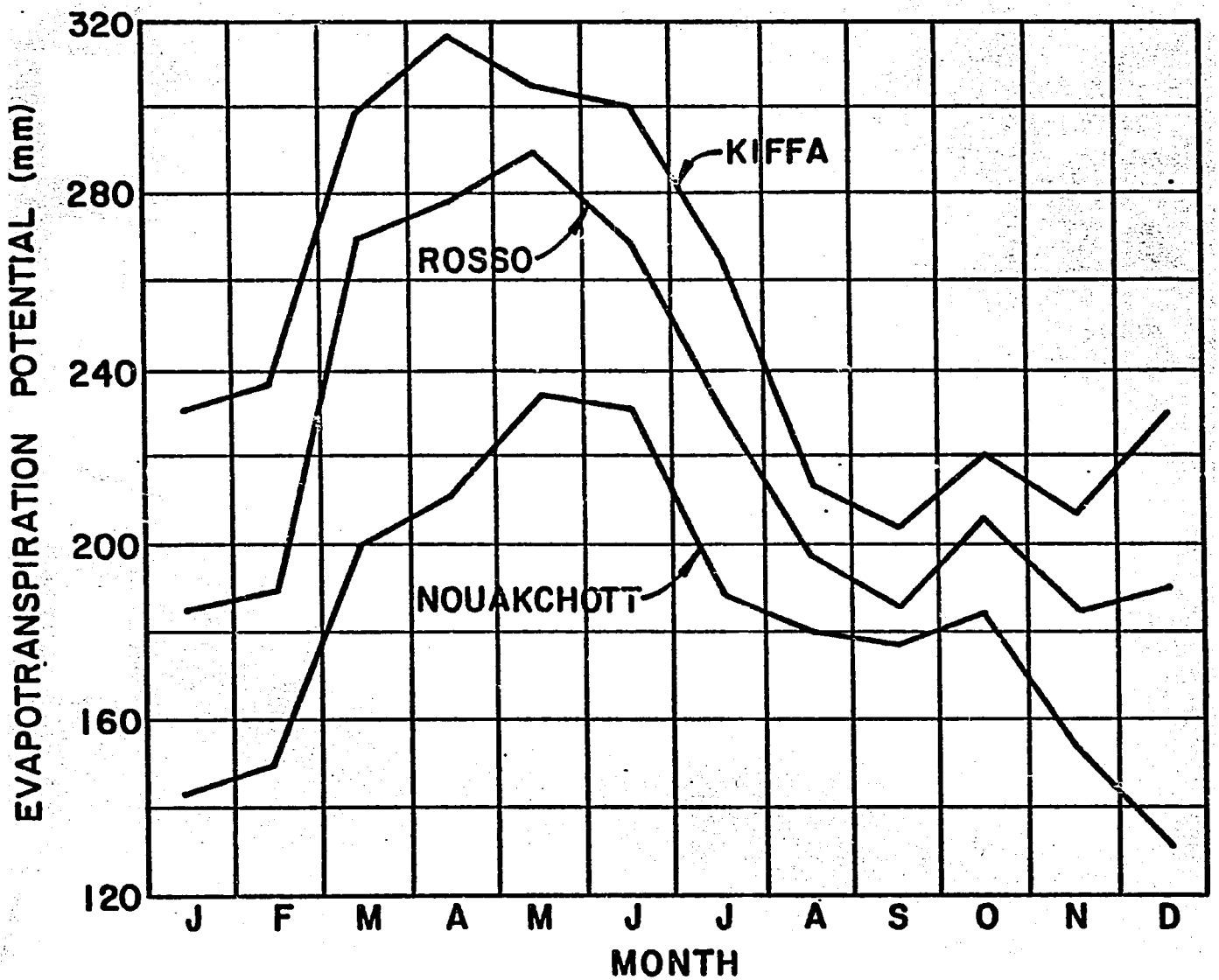
Season crop water use is dependent upon the crop (particularly the duration of the growing season), location and date of planting. Crop water requirements of onions, tomatoes, carrots, and potatoes at Nouakchott, Rosso, and Kiffa for various dates of planting are furnished in Table 3-6.

TABLE 3-5

POTENTIAL EVAPOTRANSPIRATION (ET)
(mm/day)
FOR MAURITANIA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Nouakchott	4.6	5.3	6.5	7.0	7.5	7.5	6.2	5.8	5.9	5.8	4.9	4.3
Rosso	5.9	6.7	8.6	9.3	9.5	8.9	7.4	6.3	6.2	6.6	5.9	5.9
Kiffa	7.4	8.4	9.6	10.5	9.8	10.0	8.5	6.8	6.8	7.1	6.8	7.4

Data from RAMS report and based on modified-Penman calculations.



MONTHLY EVAPOTRANSPIRATION POTENTIAL (PENMAN)*

FIGURE 3-3

*RAMS, ASI, Agro-Ecological Zones of Mauritania, p. 12

TABLE 3-6

SEASONAL CROP WATER REQUIREMENTS

(mm)

	Date of Planting			
	SEP	OCT	NOV	
Onions (Dry) (180 Day Crop)				
Nouakchott	800		870	
Rosso	985		1,135	
Kiffa	1,165		1,340	
Tomatoes (135 Day Crop)				
Nouakchott	580		570	72
Rosso	700		735	94
Kiffa	820		845	1,08
Carrots (110 Day Crop)				
Nouakchott	505		455	56
Rosso	595		585	73
Kiffa	675		720	86
Potatoes (110 Day Crop)				
Nouakchott		430		
Rosso		540		
Kiffa		645		

The ranges of crop water requirements are summarized below:

	Seasonal Crop Water Requirement (mm)
Onions (dry) (180-day crop)	800-1340
Tomatoes (135-day crop)	570-1080
Carrots (110-day crop)	455- 865
Potatoes (110-day crop)	430- 645

The following conclusions can be drawn from an analysis of crop water requirements.

(1) Water requirements for onions are 40-50% more than for tomatoes, which are 15-30% more than for carrots, which are 10% greater than for potatoes. That is:

Potatoes		Carrots		Tomatoes		Onions
	<	10% greater	<<	15-30% greater	<<<	40-50% greater

Differences in water requirements among crops are primarily due to the length of the respective growth periods. In Mauritania, most onion varieties require 180 days to maturity, whereas for tomatoes, carrots, and potatoes, the numbers are 135, 110, and 110 days, respectively. Varieties which require fewer days to maturity than others would similarly use less water and therefore be preferred, other factors being equal.

(2) Water requirements in Kiffa, representative of an interior desert climate, are 40-50% greater than for Nouakchott (where temperatures are moderated by the ocean), and 15-20% greater than for Rosso.

(3) Onions planted in November require 10-15% more water than onions planted in September. Carrots and tomatoes planted in September or November use approximately the same amount of water. However, those same crops planted in January require 20-30% more water than a September or November planting. From a water conservation standpoint, earlier planting dates (September to November) are recommended over January dates since an earlier planting during the cool period uses the least amount of water. However, in determining planting dates, yield potential and market demand also need to be considered.

Irrigation Water Requirements

Irrigation water requirements are the summation of all water demand components, i.e., crop water requirements plus on-farm water losses primarily to deep percolation, plus system losses in conveyance and distribution (seepage in canals, leaks at pipe joints, evaporation, operating problems, etc.). It is common to combine on-farm and system losses into an efficiency percentage and to divide crop water requirements by that percentage to estimate overall irrigation water requirements. For gravity (surface) irrigation methods, an overall efficiency of 30-50% is common. For sprinkler

irrigation, an efficiency of 50-70% is common. For drip irrigation, efficiencies may approach 85%. In Mauritanian vegetable gardens, water is applied by bucket, and water losses are due mainly to deep percolation beyond the root zone. If an irrigation efficiency factor of 50% is applied, seasonal irrigation water requirements are twice the crop water requirements shown in Table 3-6.

Irrigation systems are designed to meet peak irrigation water requirements. For the crops analyzed, peak crop water requirements occurred in April and were 7.7, 10.2, and 11.5 mm/day respectively for Nouakchott, Rosso, and Kiffa. Using these peak crop water requirements, an overall irrigation efficiency of 50%, and assuming continuous 24-hour water deliveries, flow rates on the order to 1.78, 2.36, and 2.66 l/sec/ha would be required for system design in those three locations, respectively.

Water Constraints to Vegetable Production

Water Quality and Vegetable Production

Crops differ in their sensitivities to salinity. For vegetable crops commonly grown in Mauritania, beets, tomatoes, okra, melons, and cabbage are the most salt tolerant, with onions, carrots, and beans the most sensitive. Table 3-7 shows estimates of the salinity effect upon yield of certain vegetable crops. Figure 3-4 graphs estimated yield decrements versus salinity of the irrigation water for certain of the crops shown in Table 3-7. For example, use of N'Taket #2 (ECw = 21.65 mmhos/cm) or Keur Massene (ECw = 7.77 mmhos/cm) water would result in yield decrements exceeding 50% for all crops. For illustration purposes, use of Atar water, tested at an ECw of 1.89 mmhos/cm (a C3 classification), would result in the following salinity-induced yield decrements:

Beets (Beta vulgaris)	None
Tomato (Lycopersicon esculentum)	0-10%
Cantaloupe (Cucumis melo)	0-10%
Spinach (Spinacia oleracea)	0-10%
Cabbage (Brassica oleracea capitata)	10%
Potato (Solanum tuberosum)	10-25%
Sweet corn (Zea mays)	10-25%
Sweet potato (Ipomea batatas)	10-25%
Pepper (Capsicum frutescens)	10-25%
Lettuce (Latuca sativa)	10-25%
Radish (Raphanus sativas)	10-25%
Onion (Allium cepa)	25-50%
Carrot (Daucus carota)	25%
Beans (Phaseolus vulgaris)	25-50%

Seventy-six percent (76%) of the waters tested had ECws of 0.7 mmhos/cm or less. No yield decrements would be anticipated with use of these waters for vegetable production. Yields of beets, tomatoes, melons, and cabbage would not be affected by use of waters with ECws of 1.8 mmhos/cm or less. Therefore, these crops may be produced without yield decrement at all but six of the sites where waters were tested. At three sites, yield decrements from

TABLE 3-7
YIELD DECREMENT TO BE EXPECTED FOR CERTAIN VEGETABLE CROPS
DUE TO SALINITY OF IRRIGATION WATER
WHEN COMMON SURFACE IRRIGATION METHODS ARE USED

Crop	0%		10%		25%		50%		Maximum
	ECe*	ECw*	ECe	ECw	ECe	ECw	ECe	ECw	ECe
Beets[a] (Beta vulgaris)	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15
Broccoli (Brassica italica)	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	13.5
Tomato (Lycopersicon esculentum)	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	12.5
Cucumber (Cucumis sativus)	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10
Cantaloupe (Cucummis melo)	2.2	1.5	3.6	2.4	5.7	3.8	9.1	6.1	16
Spinach (Spinacia oleracea)	2.0	1.3	3.3	2.2	5.3	3.5	8.6	5.7	15
Cabbage (Brassica oleracea capitata)	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12
Potato (Solanum tuberosum)	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10
Sweet corn (Zea mays)	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10
Sweet potato (Ipomea batatas)	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	10.5
Pepper (Capsicum frutescens)	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.5
Lettuce (Lactuca sativa)	1.3	0.9	2.1	1.4	3.2	2.1	5.2	3.4	9
Radish (Raphanus sativas)	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	9
Onion (Allium cepa)	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.5
Carrot (Daucus carota)	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.1	8
Beans (Phaseolus vulgaris)	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.5

a/ Sensitive during germination. ECe should not exceed 3 millimhos per centimeter (mmhos/cm) for garden beets and sugar beets.

* Electrical conductivity given in mmhos/cm where ECe is the conductivity of the soil saturation extract and ECw is the conductivity of the irrigation water.

Source: FAO Irrigation and Drainage Paper 29, Water Quality for Agriculture.

VEGETABLE CROP TOLERANCE TO SALINITY

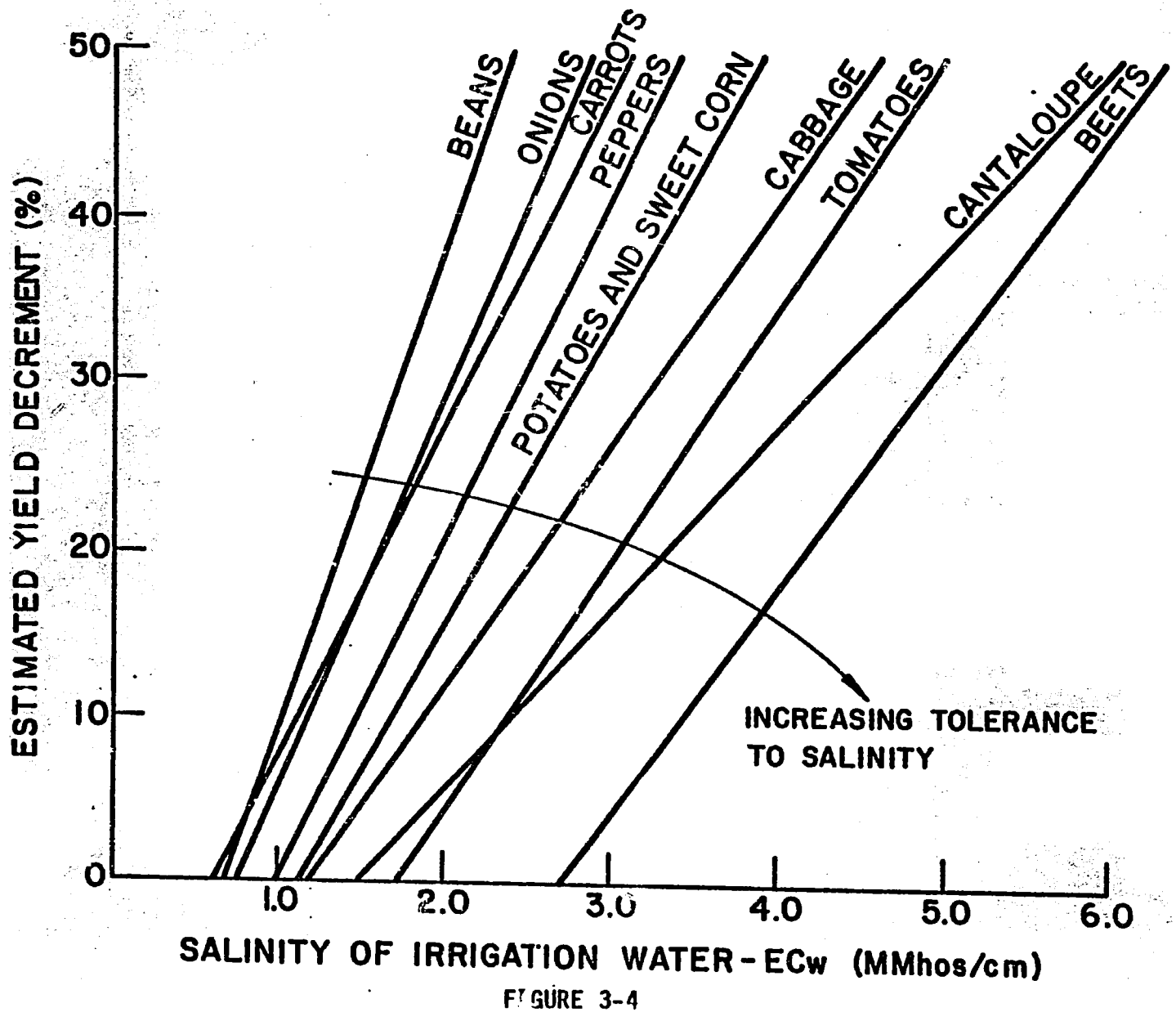


FIGURE 3-4

salinity could be expected to be on the order of 10% and only at three sites would decrements exceed 10%.

More generally, cultural practices may present greater constraints to yield than water quality. In effect the salinity-induced decrements may never be apparent.

The potential exists in several sites for permeability problems to develop. However, most gardening is on well-drained, sandier soils which are less likely to give problems. In the heavy clays along the Senegal River and near marigots, permeability problems are more likely. On those soils, permeability problems could affect vegetable production by causing surface water ponding and drowning of the plants. By decreasing the amount of water passing through the soil, toxicity problems might then also occur.

Water Management Alternatives for Vegetable Production

A salinity problem occurs and yields are affected if salts from the applied irrigation water accumulate in the crop root zone. Salt accumulations can be removed by allowing excess deep percolation through the root zone (leaching). This is effected by over irrigating. Rainfall may naturally leach salts. Although it is doubtful that there is enough rainfall in Mauritania to accomplish much leaching, over-irrigation is common practice.

If the potential for a salinity problem exists, farmers can adopt certain practices that may help prevent or mitigate the problem. Some of the management practices include:

- irrigate frequently to maintain an adequate soil water supply to the crop (this is common practice in Mauritania because soils tend to be sandy and crops evidence wilting if not frequently irrigated);
- routinely use 10 to 20 percent extra water to satisfy the leaching requirement (this is likely commonly done when farmers over irrigate);
- change the method of irrigation to one that will both apply water frequently and give better salt control, for example, drip irrigation;
- plant crops/varieties that are salt tolerant (see Table 3-7).

Obtaining satisfactory germination of vegetable seeds on saline soils or when using poorer quality water can be a particularly serious problem. Mauritanian farmers sometimes compensate by planting two or three times as much seed as normally required. Adjustments in planting procedures can be made to reduce salinity in the soil area around the germinating seeds. This can be done by selecting suitable planting practices, bed shapes and irrigation management.

Planting seeds in the center of a single-row raised bed will place the seed exactly in the area where salts are expected to concentrate (Figure 3-5a). By comparison, a double-row raised planting bed may offer an advantage (Figure 3-5d). The two rows are placed so that each is near a shoulder of the raised bed, thus placing the seed away from the area of greatest salt accumulation. By this method higher soil and water salinities can be tolerated than with the single-row plantings because the water moves the salts through the seed area to the center of the bed.

Alternate furrow irrigation may also offer advantages. If the beds are wetted from both sides, the salt accumulates in the top and center of the bed (Figures 3-5a and 3-5d) but if alternate furrows are irrigated, the salt can be moved beyond the single seed row (Figure 3-5b). The salts may still accumulate but salinity effects will be reduced. Off-center, single-row plantings on the shoulder of the bed closest to the watered furrow (Figure 3-5e) has also been used and may permit germination as saline conditions are in effect reduced.

With either single or double-row planting, if salts are expected to be a problem, increasing the depth of water in the furrow can also be an aid to improved germination (Figures 3-5c and 3-5f). Salinity control can be achieved by planting the seed row (or transplants) just above the water line (Figure 3-6). This technique has been observed in use on tomatoes at Baghdad, Trarza.

Crusting and a lack of water penetration has been observed at the Serumeli oasis in the Assaba Region. Data indicates that whereas sodium hazard from use of this water is low, salinity concentration (ECw = 0.11 mmhos/cm) is also low. Poor water penetration can be attributed to removal of soluble salts from the soil, dispersion of the finer soil particles and surface sealing. Management options are to break the crust through cultivation and to introduce crop residues and manures into the soil. However, in Mauritania, the use of crop residues for soil improvement is only practical if residues are not used for animal feed.

Evidence of sodium saturation (soil dispersion, poor water penetration, and soil crusting) was observed along canal banks and in the rice perimeters near Rosso. The sodium problem will be alleviated in part with the proposed salt-water intrusion barrier (dam). However, if these soils are to be used for production of crops other than rice, sodium should be removed. This reclamation process would involve application of calcium or magnesium salts. In the western USA, this is customarily done through application of gypsum to the land. Another alternative, practical in western Trarza, is to apply and incorporate finely ground-up sea shells.

A toxicity problem is different from a salinity or permeability problem in that toxicity occurs as a result of crop uptake and accumulation of certain constituents, especially sodium, chloride, or boron. These can reduce yields and cause crop failure. Not all crops are equally sensitive but most perennial crops generally are. Toxicity problems of sodium and chloride, however, can occur with almost any crop if concentrations are high enough. Toxicity problems often accompany and are a complicating part of a salinity or

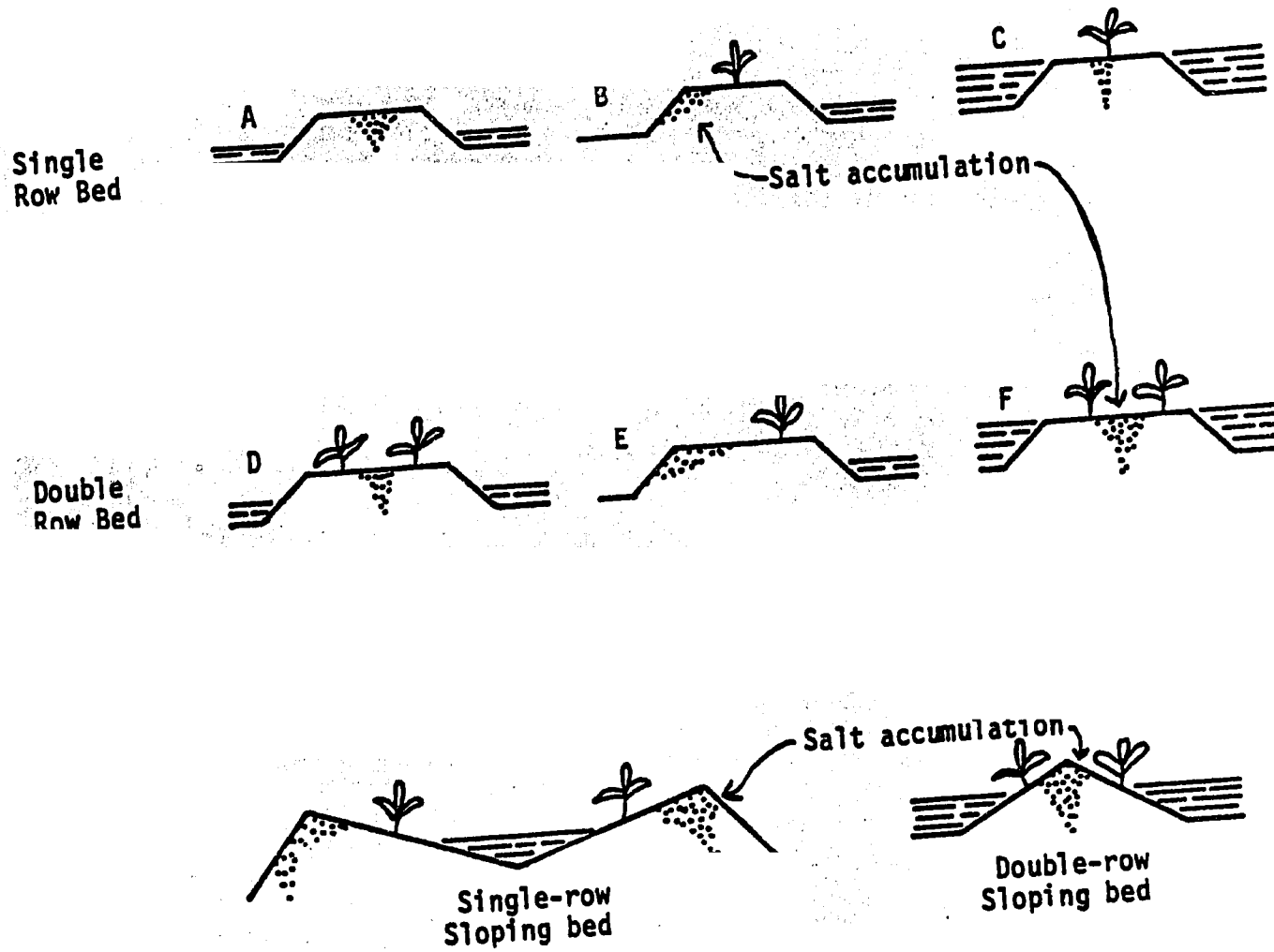


FIGURE 3-6
Salinity with Sloping Beds

permeability problem. Tables 1, 2, and 3 in Section 3 of this report give the tolerances of various crops to exchangeable sodium, chloride, and boron. Several of the sample sites, Rodha, Billaour #1, and Atar have chloride levels in the toxic range.

If sensitive vegetable crops such as beans or onions are to be grown, certain management practices may be needed which either reduce the effective concentration of the toxic elements or make adjustments that improve production under existing concentrations. Practices to reduce the effective concentratons of toxic constituents include:

- o change or blend water supplies with good quality waters;
- o in the case of sodium toxicity, use an amendment, such as gypsum or sulphuric acid which adds calcium and reduces the percentage of sodium;
- o plant crops which are tolerant.

Water Supply

With completion of the Manantali reservoir, a regulated river flow of 300 m^3/s will be released. If 1 m^3/s of this flow was to be used for vegetable production in perimeters nearby to Rosso, about 400 ha could be cropped. This assumes a vegetable crop with a peak evapotranspiration of 11 mm/day and an overall irrigation efficiency of 50%.

Thus, in the near future, both quality and quantity of water available for irrigation will be adequate to support a significant expansion in irrigated vegetable production. The constraints to significant expansion will then be those of water access structures (wells), lifting devices, and a cadre of staff to maintain and to operate the water pumping facilities.

CHAPTER 4

THE ECONOMICS OF VEGETABLE PRODUCTION

Introduction

Most vegetable production in Mauritania is characterized by small scale, labor-intensive garden plots. Production technology is rudimentary, with little use of mechanized power, chemical fertilizers, or pesticides and herbicides. Production costs are dominated by water-related investments: a hand-dug, short-lived well, and manual irrigation with watering cans. Public and private infrastructure for supporting vegetable production are minimal; there are no formal agricultural credit institutions, few extension personnel, and limited distribution of production inputs. Most production tools and materials are supplied by the government at subsidized prices.

In the western Trarza region from Rosso to Nouakchott there are some gardens of "commercial" size which use mechanized power for soil tillage and water pumping--particularly in tomato production. Some of these gardens are cooperatives and some are individually owned, but the essential characteristics are a relatively more modern production technology made economically feasible by access to large urban markets.

As described elsewhere in this report, there are four principal vegetable production systems in Mauritania which are defined primarily by water source--rainfed, flood recession, oasis, and irrigated perimeter. Production survey and cost data in this chapter reflect the two most important systems in terms of current and potential total production--flood recession and irrigated perimeter. However, certain programs for improvement of rainfed and oasis vegetable production are suggested in the concluding chapter because there will continue to be some production using those systems.

This chapter includes a description of the results of a regional survey of vegetable production, estimation of the costs and returns of vegetable production, and conclusions and recommendations about augmenting production. Some recommendations are contingent upon analysis of marketing, which appears elsewhere in this report.

Vegetable Production Survey

Two survey methods were employed to obtain agricultural production information--a questionnaire answered by regional Sector Chiefs pertaining to aggregate production and yield estimates, and a producer-level questionnaire pertaining to production costs and returns. Numerous difficulties arose in both approaches, ranging from no response to implausible results. Nevertheless, the owners or managers of 38 gardens distributed among nine regions of Mauritania were able to provide usable information.

As shown in Table 4-1, the producer-level survey included at least 15 vegetable crops on 51 hectares of land distributed among 38 gardens. Yield estimates are crude because nearly one year had elapsed since the most recent harvest, and because some of the crops were planted in small quantities or

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TABLE 4-1
VEGETABLE YIELDS IN MAURITANIA, 1980-81

Crop	Mauritania Area Sampled (Hectares)	Average Yields in Metric Tons/Hectare		
		Mauritania Survey[a]	Africa[b]	World[c]
Beets	0.67	10	--	11.6
Cabbage	8.70	6	24.5	20.2
Carrots	5.00	11	11.6	22.0
Chili Pepper	0.08	4	7.0	8.1
Eggplant	0.42	10	14.4	13.1
Green Pepper	0.01	4	--	6.8
Lettuce	0.42	6	--	14.1
Okra	0.17	2	--	11.0
Onions	10.60	6	10.9	11.7
Parsley	0.24	3	--	--
Potatoes	3.40	13	8.7	15.0
Radish	0.01	6	--	--
Sweet Potato	0.04	5	6.2	8.4
Tomatoes	17.20	20	11.7	19.9
Turnips	4.00	7	--	11.0
Total	50.96			

a/ Source: Survey of 38 gardens in nine regions of Mauritania, including Trarza, Guidimaka, Gorgol, Brakna, Assaba, Inchiri, Adrar, and the Hodhs

b/ Source: FAO Production Yearbook, 1978.

c/ Source: FAO Production Yearbook, 1978. Yields for beets, green pepper, lettuce, okra and turnips are for the USA only, obtained from the Handbo for Vegetable Growers by J. E. Knott, 1965.

interspersed with other crops such that identification of yields, revenues, or production costs for a single crop was impossible. Furthermore, linear expansion of yield from something like a four-square-meter plot to one hectare (10,000 square meters) is at best a dubious procedure, but nevertheless a necessary one to compare productivity to internationally-recognized standards.

In most cases Mauritanian vegetable yields are below African and world averages, a notable exception being tomatoes--the most popular vegetable in Mauritania. The average tomato yield of 20 tons/hectare is the same as the world average, and 8 tons higher than the Africa average. In descending order of area devoted to specific crops in the gardens surveyed, the crops are tomatoes (33 percent), onions (20 percent), cabbage (17 percent), carrots (9 percent), turnips (8 percent), and potatoes (5 percent). The order of importance varies substantially among regions; for example, 80 percent of the area surveyed in Brakna was devoted to potatoes. Annual variations in crop mix proportions are strongly influenced by seed availability, hence it is not known if the relative proportions of crops reported herein are typical of other years.

Vegetable Costs and Returns

The principal vehicle for exhibiting and analyzing production costs and returns is the enterprise budget.[7] An enterprise budget is a statement of the particular set of physical and financial inputs required to obtain a specified quantity of production. It also includes the expected revenues and expenses associated with production. Enterprise budgets provide the basic information required for economic analyses such as estimation of farmers' cash needs to purchase inputs, determination of the profitability of investments in different production technologies, and estimation of the impacts of input and product price changes on profits.

Budget Preparation Methodology

Enterprise budget information was obtained by interviewing the farmers associated with 38 gardens at various locations, as previously described. Production cost interviews were conducted by Mauritanian research assistants in the presence of the project economist. Farmers were selected on the basis of personal references by local government administrators who considered farmers' cooperativeness, ability to recall the information sought, "typicalness" with respect to production technology, and accessibility.

Enterprise budgets have been generated for seven crops; reliable estimates for others could not be obtained from the survey sample because of insignificant quantities grown or inability to separate intermingled crops. The seven crops are beets, cabbage, carrots, chili pepper, onions, potatoes, and tomatoes.

7/ An "enterprise" pertains to one particular product (e.g., tomatoes) or a combination of products which are impractical to separate in cost accounting (e.g., milk and calf production).

Numbers contained in the budgets are synthesized "best estimates" of input quantities and costs considering all areas and farmers interviewed, plus secondary and primary data obtained from other sources; no specific averaging method was used. Definitions, measurement, and methodological approaches are described below.

Crop Yields and Revenues

Yields are expressed in kilograms per 100 square meters (one "are") of planted area within a 1,000 square meter fenced garden containing a well, pathways, and 650 square meters of planted area. This planted area is the maximum amount that can be irrigated from one hand-dug well using traditional irrigation technology (i.e., no motor pump). Yields are those reported in the survey, and therefore reflect typical plant densities and field losses. Reported yields are the quantities available before home consumption, sale, retention for seed or other uses in a "normal yield" year.

Gross revenue is yield multiplied by the typical product price received by farmers during the peak harvest period, which is near the low end of the seasonal price range. The gross revenue figure assumes that all of the product is sold, without reduction for storage losses or home consumption.

Net revenue is the difference between gross revenue and all production costs except payments to management and land. Technically, "net revenue" as defined herein is "returns to land and management." Land ownership and rental costs are excluded because no instances of rental or sale could be found. Most gardens are backyard plots or village cooperatives which do not enter the sale or rental market.

Labor

Inquiries revealed that vegetable gardening is done primarily with unpaid family labor, most of which consists of women and children. Vegetables can therefore be an important source of income and nutrition for women and children living without the men, who often seek salaried employment elsewhere. However, limited evidence of contracting labor by task was found which permits calculation of an implicit market wage rate for hired labor and unpaid family labor. Division of the cost per task by the number of hours required for completion it results in a typical wage rate of 16 UM per hour. For purposes of standardization and comparison, the budgets are calculated on the assumption that all labor is valued at 16 UM per hour, whether it be the cash cost of hired labor or the opportunity cost of family labor.

Labor activities described in the production budgets are unaccompanied by the use of machine or animal power; only hand tools are used. The greatest labor expense is irrigation, which is accomplished by manually lifting well water and transporting it in watering cans. The cost of irrigation labor ranges from approximately 27 percent of total production cost (beets) to 50 percent (chili peppers). Most crops are irrigated twice a day, with application of three to five cans of water (10 liter capacity) each irrigation.

Seed

The supply and price of vegetable seeds are severe problems. Many farmers depend upon the Direction of Agriculture for free or subsidized seeds, but shortages and late delivery are common. The consequences of dependence on government have been failure to plant, late planting, and volatile residual demand for seed from the private sector. The quantities and proportions of vegetable crop production are reputed to be erratic due to seed supply, but confirmation was not obtained.

Seed prices in the private sector reflect substantial quantity discounts, dealer markups between wholesale and retail, and rural distribution charges. Selected seed prices are shown in Table 4-2. Although urban wholesale-retail markups were not obtained for Mauritania, the markup in Dakar, Senegal, might be similar to that in Mauritania. Seed price differences in the private sector between urban and rural areas could not be obtained in most instances because of no supply or because the government handled all distribution.

Retail seed prices (imported) in the private sector have increased since 1977 at the rates shown in Table 4-3. The only price decrease has been in potato seed (-23.7 percent/year), and other price increases have ranged from 3.0 percent (beets) to 38.8 percent (eggplant). Although seed cost is a low proportion of total production cost, it could be an obstacle to cash-deficient producers.

A particularly difficult seed management problem exists for potatoes, which are highly susceptible to disease in the Mauritanian climate. Without cold storage Mauritania will continue to be dependent upon potato seed imports and a deficient seed marketing system.

Containers

The three principal containers used to transport fresh vegetables are nylon sack, jute sack and plastic case. Considering sack capacity and re-use, the cost per kilogram per use of sacks is approximately half that of plastic cases (Table 4-4). Nylon sacks are in widespread use because the initial outlay is only 20 UM each, even though the cost per kilogram per use is approximately equal that of jute sacks. Nylon sack costs are used in the production budgets with the exception of tomatoes, which are usually packed in molded plastic containers to protect against damage. Sack costs (3.3 UM each) reflect re-use six times.

Well

Wells are typically dug by hand, unlined or lined. Unlined wells have a short useful life because of wall deterioration and cave-ins. The average life of a typical well in the Assaba region is one to three years, depending on soil conditions, water table, and maintenance. In this study, a well is assumed to last two years with annual maintenance cost equal to 10 percent of the initial total investment. Total labor cost for digging a shallow well of less than eight meters is estimated to be 4,200 UM, and depreciation is calculated using

TABLE 4-2

VEGETABLE SEED PRICES IN SELECTED MARKETS, 198

Prices in UM per gram

Crop	Dakar, Senegal Wholesale[a]	Dakar, Senegal Retail[b]	Nouakchott Retail[b]	Rural Mauritania Retail[b]
Beets	0.6	6.0	2.5	--
Carrots	0.8	5.0	5.0	8.0[c]
Cabbage	0.7	10.0	6.7	--
Chili pepper	3.1	--	8.0	--
Eggplant	2.4	15.0	8.0	--
Lettuce	1.2	--	4.4	--
Okra	0.5	--	--	0.3[d]
Onions	1.7	5.0	4.0	7.5[e], 16.0[f]
Parsley	0.6	6.0	4.0	--
Tomatoes (Roma)	1.7	20.0	10.0	22.5[e]
Tomatoes (Round)	2.2	--	10.0	40.0[f]
Turnips	0.2	3.8	4.0	--

a/ Based on the price per kilogram in bulk.
b/ Based on the price for purchases of 2 to 5 grams.
c/ Price in Robinet.
d/ Price of locally-produced seed in Kobenni.
e/ Price in Aioun.
f/ Price in Nema.

TABLE 4-3

IMPORTED VEGETABLE SEED PRICES: NOUAKCHOT
BULK RATES, 1977-8

UM per kilogram

Crop	1977	1979	1981	Average Annual Percent Change[a]
Beets	--	660	700	+ 3.0
Cabbage	581	740	1,200	+26.6
Carrots	684	900	1,000	+11.5
Eggplant	1,897	3,080	4,840	+38.8
Onions	1,487	1,840	2,000	+ 8.6
Parsley	752	--	900	+ 4.9
Potatoes	--	38	20	-23.7
Tomatoes	1,864	2,560	3,680	+24.3
Turnips	--	220	320	+11.4

[a] Average annual percent change is expressed as total percent change between 1981 and the earliest reported price (1977 or 1979) divided by the number of years elapsed.

TABLE 4-4

VEGETABLE CONTAINER COSTS, 1982

	Nylon Sack	Jute Sack	Plastic Case
Container capacity	50 kg	80 kg	25 kg
Unit cost	20 UM	40 UM	200 UM
Number of uses	6	8	64
Cost per use	3.3 UM	5.0 UM	3.1 UM
Cost per kg. per use	0.07 UM	0.06 UM	0.12 UM

the straight-line method with no salvage value (2,100 UM per year). Annual interest on the average investment is assumed to be 12 per cent of 2,100 UM.

Fence

Garden fencing is one of the greatest cost and most important production inputs because of the need to protect crops from roaming animals. Numerous types of fencing are used in Mauritania, as shown in Table 4-5. The type of fence selected for inclusion in the production budgets is wooden stakes, gathered and placed with hand labor at a cost of 34 UM per linear meter. The area enclosed is assumed to be 1,000 square meters. Rates of depreciation, maintenance and interest are identical to those assumed for the well.

The "real cost" of fencing depends not only upon initial maintenance, depreciation and interest, but on effectiveness in protecting the crop and access to capital to make the initial investment. These dimensions of cost were not investigated.

Tools

The seven most common tools used in vegetable gardening according to the farmer survey are listed in Table 4-6. Prices of imported tools are higher than domestically manufactured tools, but the useful lives of the former are usually greater. Assuming an inventory of one tool of each kind for 650 square meters of planted area, the annual cost of imported tools is 2,168 UM and the cost of domestic tools is 819 UM. Although domestic tools are less expensive, many farmers prefer imported tools--especially when they are provided by the government. As with seed, tools are distributed by the Directorate of Agriculture at highly subsidized cost. Tool supplies and distribution are chronically deficient.

The "Missing" Inputs

Chemical fertilizers, insecticides and herbicides are distributed in limited quantities by the government, but are not commonly used in vegetable production. The fertilizer application listed in the production budgets consists of animal manure.

There is no formal institution for disbursing agricultural production credit in Mauritania, and even if there were it is unlikely that the majority of vegetable producers could qualify for loans. The two most important reasons why they would not qualify are lack of collateral (not even a storable crop) and small farm size. However, informal lending occurs among family members, and sometimes shop owners lend to farmers.

Summary of Costs and Returns

Considering the great variations in product prices over time and space, variations in crop yields and production costs, and high post-harvest product losses, it is somewhat illusory to draw general conclusions about profitability from individual, static enterprise budgets. A slight decrease in yield or product price could drive returns to land and management negative,

TABLE 4-5
GARDEN FENCE TYPES

Sample Area	Fence Description	Average Life (Years)
Tintane	Mud brick wall, 2 meters high	5
Chivaa	Palm tree stumps	5
Aioun	Euphorbia, cardboard, and metal packing strips	5
Aioun	Wooden stakes	3
Aioun	Rock wall	20
Abdel Bagarou	Wooden stakes, sacking	3
Taghilalit	Barbed wire and metal stakes	5
Robinet	"Grillage" and metal stakes	5
Diaguili	Brambles and wooden stakes	3
Louebda	Chain-link storm fencing, metal stakes	7
Assaba oases	Wooden stakes, woven palm fronds	2
M'Leigat	Peripheral canal	10

TABLE 4-6

GARDEN TOOL COSTS, 1982[a]

Tool	Life (Years)	Values in UM: Price	Annual[b] Depreciation	Interest[c] @ 12%	Total Cost/Year
Imported					
Shovel	3	387	129	23	152
Watering can	1	857	857	51	908
Pick axe	10	613	61	37	98
Rake	1	435	435	26	461
Hoe	5	580	116	35	151
Weeder	3	204	68	12	80
Bucket	1	300	300	18	318
TOTAL		3,376	1,966	202	2,168
Domestic					
Shovel	2	150	75	9	84
Watering can	1	200	200	24	224
Pick axe	3	60	20	4	24
Rake	1	150	150	18	168
Hoe	3	100	33	6	39
Weeder	2	100	50	6	56
Bucket	1	200	200	24	224
TOTAL		1,060	728	91	819

a/ Costs and useful lives pertain to a garden with 650 square meters of planted area. In the enterprise budgets these costs are allocated to a 100-square-meter area.

b/ Depreciation is calculated using the straight-line method assuming zero salvage value.

c/ Interest is calculated on the average investment amount, or one-half the initial price.

just as high profits could result if the producer sells when prices are high. Nevertheless, a conservative accounting of costs and revenues suggests that vegetable production can be a profitable, viable activity for small-farmers.

Enterprise budgets for seven crops are shown in Tables 4-7 through 4-13, and a financial summary appears in Table 4-14. Production costs consist almost entirely of manual labor; even the "fixed" costs of depreciation and interest pertain primarily to the labor activities of well digging and fence construction, which last only two years. The image derived from these costs is one of rudimentary technology, insufficient capital for investment in improved technology, and continuation of moderate but unstable income from vegetable production.

Examination of the production budgets reveals that soil preparation, fertilization and cultivation, post-harvest clearing, and sacking and transport are nearly identical for all crops. This result is partly due to the similarity of these tasks for all vegetables, and partly due to inaccuracy in measuring or reporting time utilization on such small plots. The fixed costs of a well, fence and tools are assumed to be identical for all crops.

As summarized in Table 4-14, estimated net revenues range from approximately 600 UM for cabbage to 4,500 UM for beets. This calculation assumes that all inputs are purchased, but in fact labor is usually unpaid family members and materials are often provided virtually gratis by the government. In spite of assuming conservative yield and price figures, all of the crops show positive net revenues, suggesting that producers should have sufficient incentive to grow vegetables.

Individual enterprise budgets exclude consideration of the farmer's strategy of crop diversification to mitigate physical and market risk. "Physical risk" pertains to yield reduction due to pests, weather, or plant diseases; "market risk" pertains primarily to market price fluctuations. Farmers also diversify to even out demands on their labor time, thus avoiding hired labor. In essence, vegetable farmers follow a "garden strategy" of spreading risk over crops and, if possible, over time by staggering planting dates. Unavailability of seeds also forces diversification. For these reasons the potential profits from vegetable production are not readily obvious from examination of the enterprise budgets. Crop combinations were not investigated in this study, but warrant further research.

If the farmer can produce a marketable surplus, production strategy necessarily includes consideration of marketing strategy, which takes into account product prices, post-harvest product losses, access to markets, transport cost and availability, and consumer demand. Considering the market characteristics of great seasonal price variation and costly transport, it therefore appears rational for the small-farmer to produce a variety of crops for local markets, and to extend the growing season to capture high product prices.

TABLE 4-7

BEET PRODUCTION BUDGET, 1982

Yield:	100 kilograms on 100 square meters cultivated
Gross revenue:	7,000 UM @ 70 UM/kg
Total production cost:	2,465 UM
Net revenue:	4,535 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Soil preparation	3	16	48
Planting and thinning	3	16	48
Cultivation and fertilization	4	16	64
Irrigation	42	16	672
Harvesting	3	16	48
Post-harvest clearing	2	16	32
Sack and transport	1	16	16
TOTAL	58		928

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	100 grams	2.50	250
Sacks	3	3.33	10
TOTAL			260

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools	—	302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE 4-8

CABBAGE PRODUCTION BUDGET, 1982

Yield:	60 kilograms from 100 square meters cultivated
Gross revenue:	3,000 UM @ 50 UM/kg
Total production cost:	2,435 UM
Net revenue:	565 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Soil preparation	3	16	48
Planting	2	16	32
Cultivation and fertilization	4	16	64
Irrigation	48	16	768
Harvesting	3	16	48
Post-harvest clearing	2	16	32
Sack and transport	1	16	16
TOTAL	63		1,008

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	20 grams	7.00	140
Sacks	13	3.33	10
TOTAL			150

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools		302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE 4-9

CARROT PRODUCTION BUDGET, 198

Yield:	110 kilograms from 100 square meters cultivated
Gross revenue:	3,300 UM @ 30 UM/kg
Total production cost:	2,266 UM
Net revenue:	1,034 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Soil preparation	3	16	48
Planting and thinning	2	16	32
Cultivation and fertilization	4	16	64
Irrigation	42	16	672
Harvesting	3	16	48
Post-harvest clearing	2	16	32
Sack and transport	1	16	16
TOTAL	57		912

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	30 grams	2.22	67
Sacks	3	3.33	10
TOTAL			77

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools	—	302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE 4-10

CHILI PEPPER PRODUCTION BUDGET, 1982

Yield:	38 kilograms per 100 square meters cultivated
Gross revenue:	5,700 UM @ 150 UM/kg
Total production cost:	3,520 UM
Net revenue:	2,180 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Soil preparation	3	16	48
Planting	3	16	48
Cultivation and fertilization	4	16	64
Irrigation	110	16	1,760
Harvesting (15 times)	3	16	48
Post-harvest clearing	1	16	16
Sack and transport	1	16	16
TOTAL	125		2,000

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	30 grams	8.00	240
Sacks	1	3.33	3
TOTAL			243

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools		302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE 4-11

ONION PRODUCTION BUDGET, 1982

Yield:	60 kilograms of bulbs on 100 square meters cultivated
	30 kilograms of leaves
Gross revenue:	1,800 UM @ 30 UM/kg for bulbs
	3,000 UM @ 100 UM/kg for leaves
	4,800 UM Total
Total production cost:	2,700 UM
Net revenue:	2,100 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Soil preparation	3	16	48
Seed bed cultivation	4	16	64
Transplanting	2	16	32
Cultivation and fertilization	4	16	64
Irrigation	55	16	880
Harvesting	5	16	80
Post-harvest clearing	2	16	32
Sack and transport	1	16	16
TOTAL	76		1,216

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	40 grams	5.00	200
Sacks	3	3.33	10
TOTAL			210

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools		302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE 4-12

POTATO PRODUCTION BUDGET, 1982

Yield:	130 kilograms on 100 square meters cultivated
Gross revenue:	5,200 UM @ 40 UM/kg
Total production cost:	2,725 UM
Net revenue:	2,475 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Soil preparation	3	16	48
Planting	2	16	32
Cultivation and fertilization	4	16	64
Irrigation	55	16	880
Harvesting	4	16	64
Post-harvest clearing	2	16	32
Sack and transport	1	16	16
TOTAL	71		1,136

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	15 kg	20.20	393
Sacks	3	3.33	10
TOTAL			313

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools		302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE 4-13

TOMATO PRODUCTION BUDGET, 1982

Yield:	200 kilograms on 100 square meters cultivated
Gross revenue:	6,000 UM @ 30 UM/kg
Total production cost:	2,620 UM
Net revenue:	3,380 UM

Labor Activities	Hours	Imputed Cost/Hour (UM)	Total (UM)
Seed bed cultivation	4	16	64
Soil preparation and fertilization	3	16	48
Transplanting	2	16	32
Cultivation and fertilization	4	16	64
Irrigation	55	16	880
Harvesting	4	16	64
Post-harvest clearing	2	16	32
Pack and transport	1	16	16
TOTAL	75		1,200

Materials	Quantity	Unit Cost (UM)	Total (UM)
Seed	10 grams	10.00	100
Packing Crates	8	5.00	40
TOTAL			140

Other Costs[a]	(UM) Maintenance	Depreciation	Interest	Total
Well	65	323	39	427
Fence (130 meters)	136	340	41	517
Tools	—	302	31	333
TOTAL	201	965	111	1,277

[a] These costs correspond to 1,000 square meters fenced, within which includes the well and 650 square meters of cultivated garden. The 100 square meters of this crop is allocated 100/650 or 15.4% of total annual fixed costs.

TABLE

FINANCIAL SUMMARY OF VEGETABLE PRODUCTION BUDGETS[a]

(Thousand UM)

Crop	Production Costs				Gross Revenue	Net Revenue
	Labor	Materials	Other	Total[b]		
Beets	0.9	0.3	1.3	2.5	7.0	4.5
Cabbage	1.0	0.2	1.3	2.4	3.0	0.6
Carrots	0.9	0.1	1.3	2.3	3.3	1.0
Chili Pepper	2.0	0.2	1.3	3.5	5.7	2.2
Onions	1.2	0.2	1.3	2.7	4.8	2.1
Potatoes	1.1	0.3	1.3	2.7	5.2	2.5
Tomatoes	1.2	0.1	1.3	2.6	6.0	3.4

a/ Estimates correspond to a planted area of 100 square meters within a tota garden area of 650 square meters cultivated. Costs and revenues correspond to the year 1982.

b/ Numbers might not sum correctly due to rounding.

Conclusions

1. Estimated average vegetable crop yields are lower than average world yields in all instances except for tomatoes, and lower than African average yields except for tomatoes and potatoes.

2. Survey results suggest that the most commonly grown vegetables are tomatoes, onions, cabbage, carrots, turnips, and potatoes. Vegetable production occurs primarily on small plots under four cropping systems--oasis, irrigated perimeter, flood recession, and rainfed.

3. Vegetable production technology is rudimentary, labor intensive, and stagnant due to lack of investment capital, technical expertise, supplies of both modern and traditional inputs, and research and extension services.

4. Subsidy of production inputs, principally seeds, tools and fertilizer, has encouraged dependence by farmers on the government, but the government has demonstrated only mediocre performance in ability to deliver sufficient quantities on time.

5. The supply and price of vegetable seeds are major problems due to high import costs, lack of participation by the private sector, and periodic failure of the government to deliver seeds at the times and in the quantities needed.

6. Produce packing is often inadequate to protect against bruising, sand, and sun damage. Nylon sacks are the most common packing container because of low initial cost. All materials are in short supply.

7. Shallow wells are hand-dug, costly, and short-lived due to cave-in of the unlined walls. The costs of well depreciation, interest, and maintenance amount to nearly 2,800 UM per year for a typical garden of 650 square meters planted, which represents approximately 20 percent of total production cost.

8. Fencing to protect crops is necessary but expensive, the cost varying a great deal depending upon materials used. The least expensive fence for 1,000 square meters enclosed represents approximately 20 percent of total production cost on an annual basis.

9. Imported tools are preferred because of quality and because the government subsidizes them, but domestic tools are less expensive considering full market prices. Annual tool costs represent 10 to 15 percent of total production cost.

10. Labor consists almost entirely of unpaid family members--mostly women and children. The imputed wage rate is approximately 16 UM per hour, but cash payments for labor are uncommon.

11. Few chemical fertilizers, pesticides, or herbicides are used, and there is no formal agricultural credit institution. Animal manure is available in moderate supply and its use is encouraged.

12. Vegetable production can be risky but profitable, depending upon yields and product prices at the time of sale.

13. Farmers diversify crop mix to provide themselves with dietal variety and to mitigate physical and market risks.

14. Great potential for increased profits exists in off-season production to capture high market prices. The technology required includes protection of crops from heat and an assured water supply.

CHAPTER 5

VEGETABLE MARKETING

Introduction

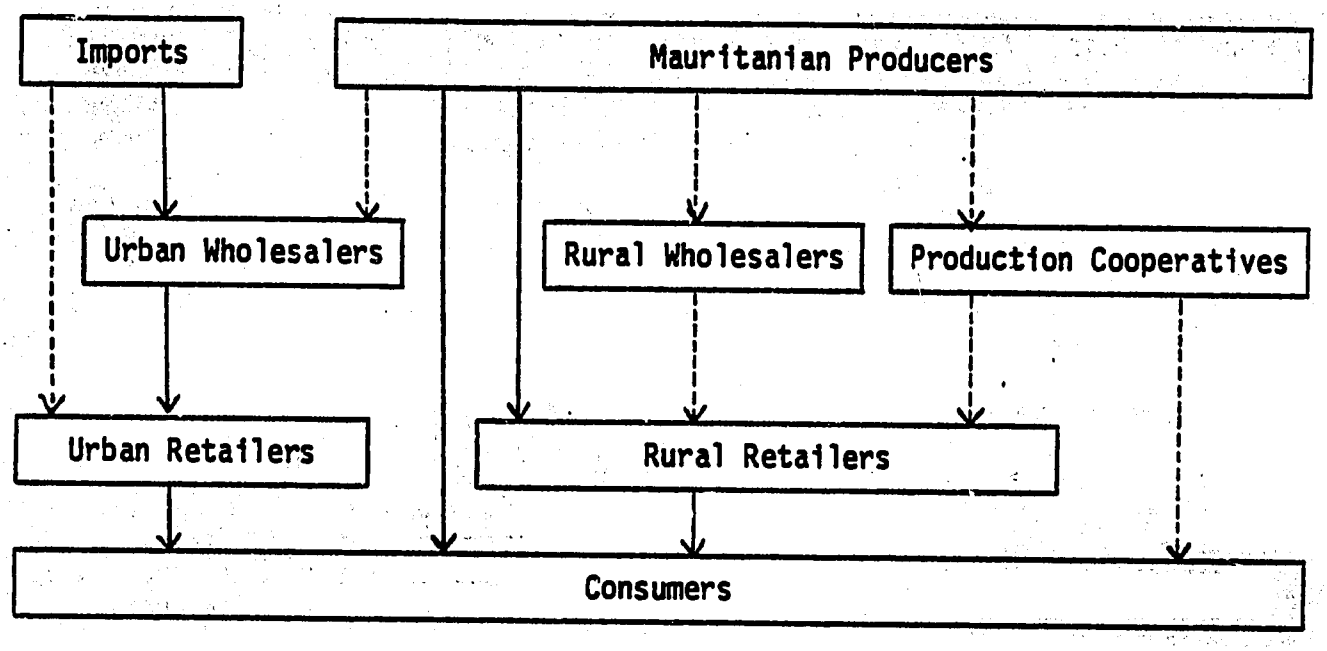
Vegetable marketing in Mauritania is in transition from a traditional subsistence economy to a market-oriented agricultural economy. As population and urbanization increase it becomes increasingly necessary to transport fresh produce greater distances with greater speed, but the infrastructure of storage, transportation and markets is inadequate to support replacement of imports with domestic production. The obstacles to fresh vegetable marketing are formidable: hot weather and lack of cold storage result in rapid spoilage; poor roads increase transport time and costs, and contribute to damaged products; lack of market information can be risky to the producer or trader who ships from rural to urban areas on the expectation of obtaining a buyer and a satisfactory price. In essence, it is an imperfect and risky market which could result in high profits or losses to the producer or trader.

In terms of market sophistication, Mauritania can be separated into Nouakchott and everything else. In Nouakchott there are bulkers, wholesalers, cold storage, price information, and some quality control. Demand created by the population and income of Nouakchott has been exploited primarily by the Senegalese and secondarily by local producers. It is difficult to compete with the Senegalese because of their lower production and transport costs, and because of their control of wholesale vegetable markets in Nouakchott.

Outside of Nouakchott the principal product flows are from producers to retailers, and from producers directly to consumers in local markets. Producers also sell small amounts to rural wholesalers and independent truckers. A few producer cooperatives have tried to sell to urban wholesalers or retailers, but without much success because of irregular quantity and quality of produce. The primary and secondary flows of fresh vegetables through the Mauritanian marketing network are depicted in Figure 5-1.

FIGURE 5-1

FLOW OF FRESH VEGETABLES THROUGH THE MAURITANIAN MARKETING NETWORK



Primary trade channels ⟶

Secondary trade channels - - - ⟶

This chapter is organized in terms of marketing functions, which are identified as follows:[8]

Physical Functions:	Transportation and handling Storage Processing Grading and standardizing
Exchange Functions:	Buying Selling Pricing
Facilitating Functions:	Financing and risk bearing Marketing information Demand creation Research

Following description of the existing situation, recommendations are made for mitigation of the constraints consistent with producers' needs, available funds, and implementation feasibility. Since facilitating functions are virtually nonexistent, they are discussed only in the conclusions section.

Transportation and Handling

The principal method of transporting vegetables into and within Mauritania is motor truck, with minor amounts transported by boat on the Senegal River, and imported by sea and airfreight into Nouakchott. Truck transportation is expensive in Mauritania relative to Senegal because of poor roads, high vehicle import tariffs (100% duty), great distances between population centers, underutilization of backhaul capacity, and high costs of fuel, insurance and spare parts. Intrusion of Senegalese truckers into the Mauritanian market caused such tension that an agreement was signed in 1977 (now expired) which regulated the amount of trucking in each other's territory. This competition has contributed to underutilization of Mauritanian-owned trucks in the private sector. The private sector must also compete with government enterprises such as SONIMEX and Aide Alimentaire, which have captured much of the transport business in commodities once handled by the private sector. These commodities--primarily cereals, tea and sugar--comprise between 60 percent and 80 percent of all truck freight. The government also regulates freight and passenger tariffs, thus squeezing truckers' profits and inducing illegal methods of generating greater revenue.

8/ Foreign Economic Development Service, U.S. Department of Agriculture cooperating with the U.S. Agency for International Development. Improving Marketing Systems in Developing Countries: An Approach to Identifying Problems and Strengthening Technical Assistance, February 1972.

Truck Operating Costs

Typical operating costs of a 10- to 12-ton capacity truck in Mauritania are shown in Table 5-1. The total estimated operating cost per kilometer is nearly 44 UM on paved surfaces, approximately 40 percent of which consists of fixed costs (amortization, fees, insurance, taxes and overhead).[9]

Operating costs per kilometer increase as road conditions worsen. The results of applying "cost multipliers" to compensate for road conditions are shown in Table 5-2. Total cost per kilometer and per-ton-per-kilometer more than doubles when operating on unimproved dirt roads.

Additional costs excluded from the preceding figures include loading and unloading charges usually provided by the trucker, and time the truck is idle waiting for spare parts or a backhaul load. Information was not obtained on gross or net revenues generated by a truck, hence the impact of these cost items on the profitability of truck transportation is unknown.

Regulated Freight Tariffs

The government sets freight and passenger tariffs. Passenger tariffs are an important cost item in vegetable marketing because most producers market small quantities frequently, taking several bags of produce to the market personally. Typical passenger and freight tariffs are shown in Tables 5-3 and 5-4, respectively.

Official tariffs are periodically revised, but not necessarily in accordance with changes in vehicle operating costs. Official tariffs in 1982 were as much as eight percent less than actual costs for truck shipments originating in Nouakchott (Table 5-5), with only one destination (Atar) showing a positive net revenue. Truckers and passenger vehicles make up revenue deficiencies by carrying passengers on routes even where prohibited, charging extra fees for hand luggage, overloading, and numerous other ways.

Vegetable producers who market their produce locally can rent animal carts for 150-200 UM per half-day, take a Peugeot taxi, or transport bags on donkeys or camels. The difficulty and cost of hiring a truck is often too great for small producers, thus forcing them to sell in local markets for whatever price they can get before the product spoils.

Packing and Handling

Most fresh vegetables are hauled in bags because of apparent low cost, but the lack of protection against bruising on rough roads might result in an increased real cost relative to molded plastic containers. Additional hazards are heat, sand and sunlight which cause rapid deterioration when produce is

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9/ Some fees such as parking and road tolls are variable costs, but no breakdown is available.

TABLE 5-1

TRUCK OPERATING COSTS BY EXPENDITURE CATEGORY, 1982[a]

Cost Category	UM/Kilometer	Percent
Amortization	13.18	30.0%
Fees	1.06	2.4
Insurance	1.03	2.3
Maintenance and repair	7.30	16.7
Tires	0.35	0.8
Salaries	8.50	19.4
Fuel	9.30	21.2
Taxes and overhead	3.15	7.2
Total	43.87	100.0%

[a] Source: BCEOM study Entretiens Routier en Mauritanie, 1978. Costs have been updated at a rate of 10 percent per year. Costs are for a truck of 10-12 tons capacity.

TABLE 5-2

TRUCK OPERATING COSTS BY ROAD SURFACE, 1982[a/]

Road Surface	Cost Multiplier	UM/km	UM/ton/km
Paved	1.00	43.90	4.4
Unpaved, improved	1.32	57.95	5.8
Unpaved, mediocre	1.95	85.6	8.6
Unpaved, unimproved	2.38	104.5	10.4

a/ Source: BCEOM study Entretiens Routier en Mauritanie, 1978. Costs pertain to a truck of 10-12 tons capacity, updated to 1982 at a rate of 10 percent annually.

TABLE 5-3

OFFICIAL PASSENGER TARIFF, 1980

Itinerary		Km	Class[a]	Tariff/Person	Tariff/Km
Nouakchott	- Rosso	203	1e	355 UM	1.75 UM
			2e	250	1.23
"	- Akjoujt	256	1e	440	1.72
			2e	310	1.21
"	- Kiffa	604	1e	1045	1.73
			2e	725	1.20
Akjoujt	- Atar	195	1e	495	2.54
			2e	385	1.97
Rosso	- Boghe	215	1e	630	2.93
			2e	510	2.37
"	- R'Kiz	90	1e	220	2.44
			2e	140	1.55
"	- Boutilimit	200	1e	400	2.00
			2e	275	1.37
Boghe	- Kaedi	110	1e	330	3.00
			2e	265	2.40
Kiffa	- Nema	535	1e	1045	1.95
			2e	880	1.64
"	- Selibaby	240	1e	690	2.87
			2e	535	2.23
Kaedi	- Selibaby	227	1e	495	2.18
			2e	330	1.45

[a] 1e class -- refers to 504 Peugeot - bush taxi or the front cabin of a 404 pick-up.

2e class -- refers to the back of a 404 Peugeot pick-up.

Source: 1980 Official Transport Tariffs -- Direction du Transport.

TABLE 5-4

OFFICIAL MERCHANDISE TARIFF, JULY 1979

Itinerary	Distance (km)	Tariff/ton/km	Tariff/10T Truck[a]
Nouakchott - Boutilimit	154	4.2 UM	6,776 UM
Nouakchott - Aleg	262	4.2	11,044
Nouakchott - Boghe	332	4.7	15,674
Nouakchott - Kaedi	437	5.3	23,297
Nouakchott - Kiffa	604	4.2	25,368
Nouakchott - Aioun[b]	819	4.2	34,398
Nouakchott - Nema[b]	1099	4.5	49,568
Nouakchott - Akjoujt	256	4.2	10,752
Nouakchott - Rosso	203	4.2	8,526
Nouakchott - Atar	451	5.3	23,752
Rosso - R'Kiz - Boutilimit	195	7.7	15,015
Rosso - Boghe	205	7.5	15,375
Rosso - Aleg	303	7.5	22,725
Rosso - Keur Macene	58	7.3	4,234
Rosso - Mederdra	64	7.7	4,928
Kaedi - Maghama - Selibaby	230	7.7	17,710
Kiffa - M'Bout - Kaedi	305	7.7	23,485
Akjoujt - Atar	195	6.67	13,000
Aleg - Boghe	70	6.67	4,670
Boghe - Kaedi	105	7.26	7,623
Kiffa - Kankossa - Selibaby - Gouraye	280	7.17	20,080
Aioun - Kobenni	115	8.5	9,775
Nema - Abdel Bagarou	135	8.0	10,800

a/ The capacity of the trucks for which these rates apply are not specified by the law set out in the official Journal.

b/ These rates were calculated using the paved road formula for the distances then paved.

Source: Journal Officiel de la Republique Islamique de Mauritanie, 29 Aout, 1979, p. 436 arrete no. R - 122.

TABLE 5-5

TRUCK TRANSPORT COSTS COMPARED TO REGULATED FREIGHT TARIFFS, 1982[a]

From Nouakchott to:	Actual Trip Cost (UM)	Regulated Tariff (UM)	Percent Difference From Actual
Akjoujt	11,264	10,752	-4.5%
Atar	22,574	23,752	+5.2
Kiffa	26,576	25,368	-4.5
Rosso	8,932	8,526	-4.5
Nema	52,932	49,568	-6.3
Kiffa/Selibaby	49,006	45,108	-7.9
Boutilimit	6,780	6,776	0.0
Aleg	11,528	11,004	-4.5
Boghe	15,890	15,674	-1.3
Kaedi	24,880	23,297	-0.6

[a] Costs and revenues pertain to a ten-ton capacity truck.

inadequately protected. The economic benefits and costs associated with alternative packing and handling methods have not been examined, but current losses warrant investigation.

An additional problem is that vegetable producers are numerous, with small average total production. It is difficult and uneconomic to coordinate their activities to achieve greater economies in handling and transportation.

Storage

Fresh vegetable storage occurs on the farm and in the control of traders, but by necessity the time periods involved are short. There is virtually no cold storage outside of Nouakchott, so the rate of produce spoilage over time is probably high. One study shows regional post-harvest losses of 16 to 62 percent depending on the vegetable, but no studies could be found specific to Mauritania.[10/] Some general recommendations for reducing losses are discussed subsequently in this report.

Processing

Some fresh vegetables can be preserved by drying, pickling or salting. Drying is already practiced for certain vegetables, notably okra, onion leaves, and sometimes cabbage leaves. Dried tomato slices have been powdered and sold during the off-season with some success. No studies of vegetable processing were found specific to Mauritania, nor was an investigation of the economics of vegetable processing carried out. In general, preservation by drying appears to offer good prospects for producers, traders and consumers because it would mitigate peak-season supply gluts and off-season scarcity while moderating market price fluctuations.

Grading and Standardization

Outside of Nouakchott there is little grading or standardization of a formal nature. Standards exist or do not exist as local market customs dictate, and price discounts or premiums often serve as the only indication of quality. This lack of formal standards is detrimental to marketing in the more sophisticated markets such as Rosso and Nouakchott, which often prefer imports to local products because of quality.

Exchange Functions: Buying, Selling and Pricing

Vegetable producers who do not sell directly to consumers sometimes face an entrenched wholesaling or retailing network which effectively excludes entry, minimizes competition, and puts downward pressure on prices received by producers. This situation has not been substantiated, but its presence is detected in conversations with producers and traders. The time, capital, and

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10/ National Academy of Science, Post Harvest Food Losses in Developing Countries, Washington, D.C., 1978.

sophistication required to circumvent this obstacle are beyond the means of all but a few vegetable producers.

Fresh vegetable retailing varies in scale and sophistication from the producer himself in an outdoor village market to small supermarkets in Nouakchott which cater to an international clientele. Marketing margins--defined as the difference between producer and retailer prices--vary a great deal among regions and marketing channels, thus emphasizing the presence of market imperfection and market stratification.

The Nouakchott Market

Although urban Nouakchott is a unique market in Mauritania, vegetable price and marketing margin differences exemplify the existence of market stratification and market imperfections. A four-day vegetable price survey of eight outdoor markets was conducted between February 1 and 4, 1982, the results of which are shown in Table 5-6. Comparison of retail prices among markets reveals that retail prices are similar in all markets for some vegetables (e.g., manioc and potatoes), but significant differences occur for others (e.g., tomatoes). Retail prices in some markets are sometimes double those of other markets, reflecting differences in purchasing power and preferences of the clientele.

A second comparison pertains to the wholesale-retail price spread. In general, retailers obtain approximately 10-20 UM per kilo markup on all vegetables. This appears to be a rational pricing policy considering that overhead expenditures (except for produce spoilage) should differ little among products. Average markups reflect the risk of spoilage losses, from a high of 21 UM/kg for tomatoes to a low of 9 UM/kg for onions. On a percentage basis, markups range from 23 percent on onions to 73 percent on eggplant. However, percentage markup is merely the result of applying the absolute markup of 10-20 UM/kg on different wholesale price levels, and does not appear to be the important decision variable.

Except for the 1er and Kebba 1er markets, retailers pay similar prices for produce. It is not known if this similarity is due to competition or lack of it among buyers. Some wholesale and retail prices differ because of product quality, but quality evaluation was not considered in the survey. A notable example of consumer and trader concern with quality is that many refuse to purchase locally grown vegetables which are irrigated with untreated sewage water.

The Trarza Region

The Trarza region produces vegetables for the Rosso and Nouakchott markets. Due to relatively good roads, climate, and urban incomes this region is one of the oldest and most important vegetable producing areas in Mauritania. Commercial production of tomatoes and onions in the environs of Rosso contribute much of the supply to Rosso and Nouakchott.

Annual retail price ranges for six vegetable crops are shown in Table 5-7 for selected markets in the Trarza region. In general, prices are much lower in

TABLE 5-6

WHOLESALE AND RETAIL VEGETABLE PRICES IN NOUAKCHOTT MARKETS, FEBRUARY 1-4, 1982
UM/Kilogram

Market	Cabbage		Carrots		Manioc		Onions		Potatoes		Sweet Potatoes		Tomatoes		Eggplant	
	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
Ksar	35	50	28	44	45	60	39	50	30	40	29	37	29	35	15	40
Capitale	35	47	35	45	32	42	36	45	28	42	25	32	31	63	35	45
SOCIM	35	60	33	45	37	57	38	52	28	40	40	55	35	70	35	43
5eme	35	50	20	40	47	62	37	40	28	40	32	45	40	60	17	42
6eme	35	50	20	38	45	60	37	40	28	40	32	45	30	60	17	42
1er	70	105	30	42	38	60	50	60	34	40	30	45	48	57	40	45
Kebba 1e	--	--	80	90	--	--	34	50	35	42	40	60	100	120	40	50
Kebba 5eme	55	80	30	40	--	--	36	45	28	40	45	50	35	60	27	37
Range of Markup (UM)	12 - 35		10 - 20		10 - 22		3 - 16		6 - 14		5 - 20		6 - 35		5 - 25	
Average Markup (UM)	20		12		16		9		11		12		21		15	
Average % Markup	43%		50%		40%		23%		40%		16%		60%		73%	

TABLE 5-7

ANNUAL RETAIL PRICE RANGES FOR VEGETABLES IN SELECTED MARKETS, 1981-82[a]
UM/Kg

Market	Cabbage	Carrots	Onions	Potatoes	Tomatoes	Turnips
Trarza						
Rosso	20-40	30- 50	20-40	35-40	7- 90	30- 45
Tekane	30-	27- 40	40-60	-60	8- 23	
Boutillimit		60-120	30-50		40- 80	50- 70
Gany	15-	30-	30-		10-	20-
Mederdra			40-	-50	- 80	
Brakna						
Aleg	100-	90-	50-60	40-55	100-	50-
Boghe	20-	15- 20	30-	35-	15-	
M'Bagne	40-	20-		60-	30-	15-
Assaba						
Kiffa	37-59	50-100	30-40	35-40	15-150	63- 96
Hodh El Charki						
Tintane	20-35	35- 90	40-60	35-60	20- 40	
Nema	22-30	40- 70	40-60	35-60	30- 60	
Inchiri/Adrar						
Akjoujt	20-70	10- 30	40-50	40-60	30-200[b]	30-200
Atar	30-50	10- 60	30-50		20-160[b]	20-160
Guidimaka & Gorgol [c]						
Matam	30	60	39	26	6	
Kaedi	50	50	24	39	30	
M'Bout	60		60	34	40	
Selibaby	43		43	34	20	
Bakel (Senegal)	40		47	34	15	

[a] Prices were obtained by interviews on an ad hoc basis. Price ranges were not obtained for all crops and locations, as designated by absence of an entry.

[b] Extraordinarily high prices represent sales to local mining companies, which are up to triple the local market prices.

[c] Price ranges were not obtained for Guidimaka and Gorgol. The single prices reported represent typical peak-season prices, which would be near the low end of the price range. Bakel (Senegal) is the market for Gouraye, Mauritania.

producing areas such as Tekane and Gany than in importing areas such as Boutilimit, reflecting transportation costs. Prices commonly double for most crops between peak season production and early or late production, and tomatoes--the most perishable of crops reported--manifest a price difference of 13 times the low price in Rosso. Rosso is a tomato production center, hence the peak season glut forces the price down to very low levels.

The Brakna Region

Vegetable production in the Brakna region is increasing, but local demand is weak and export potential suffers from poor roads. If the Boghe-Aleg road is paved as planned, Boghe will be only a four-hour drive from Nouakchott. Given its location near the Senegal River above the saltwater intrusion zone, Boghe could expand vegetable production given better access to markets.

Few vegetables are sold in Aleg, which is probably due in part to the absence of any large-scale gardening in the area. Typical retail price ranges for vegetables in the markets of Aleg, Boghe and M'Bagne are shown in Table 5-7, once again reflecting the price differentials resulting from transportation costs. Seasonal price variations were not obtained for most crops because of the unrealiable and minor amount of information available.

Assaba

Assaba is an oasis-pastoral area which produces few vegetables. However, production has expanded rapidly in the wake of the Sahelian drought of the early 1970's--especially around Kiffa. Supply and demand imbalances have resulted in periodic gluts of tomatoes on the market in the peak production season, but equilibrium can be expected to prevail because there is little import or export activity to disrupt local markets. High transportation costs and product losses are the principal reasons for minimal import and export activity.

Reported vegetable price ranges in Kiffa are shown in Table 5-7. The ranges are quite large due to dependence on local, seasonal supply. Farmers who can market their produce early or late in the season stand to profit greatly from the high price extremes. Seasonal price differences of one-third are commonplace, and the high price of tomatoes is ten times the low price in Kiffa.

The Western and Eastern Hodhs

The Western Hodh region (Hodh El Gharbi) in which Aioun is the principal town, and the Eastern Hodh (Hodh El Charki) whose capitol is Nema, have longer histories of vegetable gardening than Assaba. Production is due in part to influence from Mali, which has a stronger tradition of vegetable production than Mauritania. The Western Hodh region is characterized by relative isolation, self sufficiency, and supply-demand equilibrium at a relatively high price level. This area might represent a desirable long-term model for other areas in Mauritania. Unlike producers in Trarza and Inchiri, producers in the Hodhs have never attempted large scale production for export. Annual price ranges for locally produced vegetables in Tintane and Nema are shown in

Table 5-7. Prices of imports during the local off-season were not obtained, but they would be much higher than those indicated. Seasonal price variations of 100 percent are commonplace in this region.

Inchiri and Adrar

Vegetable production in Inchiri and Adrar was originally induced by demand generated from European mining communities and a French military base. Indigenous people gradually acquired a taste for the vegetables which were initially produced only for the expatriate community. When most of the foreigners departed production was necessarily reduced to a lower equilibrium level. However, some produce--especially carrots--is exported by train or truck at low backhaul rates. Annual price ranges in Atar and Akjoujt are shown in Table 5-7. Seasonal prices change by multiples of three to eight, indicating again the large potential gains to producers who can sell early or late in the season.

Guidimaka and Gorgol

Production of non-traditional vegetables is relatively new in these regions, but enterprising people--particularly the Sarakholle--promptly began producing seed for resale and set up a vegetable wholesaling network. In the Guidimaka, which joins eastern Senegal and western Mali, some women have organized wholesale trading as an extension of their vegetable production enterprises. Several producers in the vicinity of Matam-Cive have attempted hot season production to capture high off-season prices. Spot prices for vegetables in-season are shown in Table 5-7.

Summary and Conclusions

The principal characteristics of fresh vegetable marketing in Mauritania are summarized as follows.

1. The principal trade channels for domestically-produced vegetables are from producers to consumer direct, or via rural retailers. Outside of the Rosso-Nouakchott strip most vegetables are grown for home consumption.

2. The Nouakchott vegetable market is unique and atypical of the rest of Mauritania in terms of clientele and marketing infrastructure. Nouakchott depends heavily on vegetable imports from Senegal and abroad.

3. Transportation is expensive and slow due to high vehicle operating costs and poor roads.

4. Government regulation of freight and passenger tariffs, plus lower-priced competition from Mauritanian government enterprises and Senegalese truckers, have probably been detrimental to private-sector motor vehicle operators. Since vegetable hauling alone cannot support the private sector, vegetable marketing suffers from the restricted service and higher costs resulting from the vehicle operators' predicament.

5. Post-harvest vegetable losses on the farm and in transit are suspected to be high, but no firm evidence is available. The principal reasons for losses are high temperatures, dryness, sun and sand damage, and bruising during transport on rough roads.

6. Vegetable preservation by drying appears to hold promise for some crops. This would mitigate seasonal product supply gluts and shortages, as well as their consequent price variations.

7. There is no formal vegetable grading or standardization program in Mauritania outside of Nouakchott.

8. Nouakchott vegetable markets exhibit marked stratification by clientele, as exhibited by retail price differences. Wholesale-retail price markups appear to be set in accordance with marketing costs, varying from 10-20 UM per kilogram.

9. Regional vegetable markets differ considerably, but most are characterized by short seasons, relatively few imports and exports, and large retail price variations over time. Prices at the beginning or end of the production season range from two to ten times those of peak-season prices. Price multiples tend to be greatest for the more perishable products such as tomatoes.

10. Except for Nouakchott, there is almost a complete absence of "facilitating functions" in vegetable marketing--financing, marketing information, demand creation, and research.

Apart from the Rosso-Nouakchott strip, the most viable marketing development strategy in the short run appears to be promotion of regional and local independence. The objective would be to produce sufficient quantities and varieties of fresh vegetables to satisfy local demand, thereby mitigating the costs and difficulties associated with transportation. This strategy necessarily includes a production strategy intended to foster vegetable supply and price equilibrium levels which provide incentive for producers to produce and consumers to purchase. The conditions necessary to provide this incentive include moderated price levels and variations, improved product quality, producers' access to markets, and reliable and affordable transportation from farm to market. These are discussed in turn.

Price Levels and Variations

In a competitive market, prices reflect the forces of supply and demand. Assuming short-run income and population stability in a given market, vegetable price volatility is primarily the result of supply variations. Alternating periods of product scarcity and abundance can be mitigated at the production level by staggering planting times, improving off-season production technology, and changing the relative quantities of vegetables produced to achieve a better balance in the market. At the marketing level some vegetables can be preserved by drying or cold storage. Local supplies can sometimes be augmented or disposed of by importing and exporting.

Product Quality

Vegetable quality is a function of size, flavor and condition at the point of sale. At the production level producers can improve quality through selection of improved plant varieties, application of water and fertilizer, and protection of produce from pests. At the marketing level producers can improve produce quality through prompt transport and sale, greater protection in transport and handling, and removal of inferior products from the marketed selection.

Producers' Access to Markets

Entrenched or exclusionary wholesale and retail trade networks can operate to deny producers access to markets, or to deny them a fair price for their produce. Producers' alternatives are often nonexistent when they arrive at the market with fresh produce; they are forced to accept the offered price.

It is unrealistic to expect buyers to take all that producers want to sell at a price that yields them a profit because market forces must be allowed to work. However, it might be feasible to organize a "producers market" in which they are guaranteed access to try to sell their own produce. Regulation of wholesalers and retailers would probably prove undesirable and futile.

Transportation

Regional and local independence in vegetable production would reduce but not eliminate dependence on truck transport. Traditional reliance of producers on local taxis, small trucks and animals is expected to continue with little prospect for constructive intervention by government. One potential means of improving transport accessibility for vegetable producers is the purchase of a vehicle by a producers' cooperative, but in most cases this will require government assistance in the form of credit or loan guarantees. Furthermore, organization of small-farmers to supply capital, management, and vehicle scheduling might be impractical, but the concept warrants further investigation.

Facilitating Functions

Prospects for improving the facilitating functions of marketing appear to be very limited given the lack of basic infrastructure. One possibility, however, would be radio programs for agriculturalists, which would broadcast weather forecasts, market prices, and other pertinent information. This could help producers decide when to harvest, which market is paying the best price, and which crops to plant.

The Rosso-Nouakchott Area

Due to the greater sophistication of markets and competition from Senegal it will be difficult for Mauritanian producers to entirely replace imports. The development strategy in this area should be gradual improvement of produce quality and supply regularity to increase the foothold in the Nouakchott

market. It is possible that government intervention to help domestic producers gain access to Nouakchott markets will be necessary.

In conclusion, vegetable marketing in Mauritania is hindered by lack of infrastructure, high transportation costs, and heavy post harvest losses. A short-run development strategy emphasizing many local supply and demand equilibriums would mitigate these costs and supply the growing demand for vegetables until such time as transportation and storage infrastructure are improved enough to permit economical shipment. In the meantime, small farmers will earn incomes and improve production methods so that some will eventually be able to exploit export possibilities.

CHAPTER 6

AGGREGATE VEGETABLE SUPPLY AND DEMAND

Introduction

Determination of aggregate supply and demand for vegetables in Mauritania is little better than a guess due to lack of information. Production sites are small, dispersed, and intended primarily for growing family food supplies. There are no records of shipments or sales except for imports. A few consumption surveys have been undertaken, but they were limited in scope. In this Chapter a number of prior studies, secondary references and first-hand observations have been used to synthesize crude estimates of past and future supply and demand for fresh vegetables in Mauritania.

Demand

Aggregate demand for vegetables is theoretically a function of unit prices, incomes, population and tastes and preferences. In the absence of reliable data to estimate demand statistically, per capita consumption figures are used as the measure of demand. A major weakness of using per capita consumption figures in Mauritania is that consumption is severely constrained by absence of supply for over half the year. Even with income, population, and other traditional explanatory variables held at constant levels, the quantity consumed would increase dramatically if produce were available.

Supply

Supply is composed of domestic production plus imports, most of which come from Senegal and Europe. Essentially all imports go to Nouakchott and Rosso. Import figures are difficult to interpret for some crop categories, and do not include produce which moves across the Senegal River except for the Dakar-Rosso highway.

As mentioned previously, domestic production is difficult to determine. Recent estimates are in the range of 600 to 1,000 cultivated hectares at average yields of 2 to 20 tons per hectare, depending on the crop (Chapter 4). Secondary references used to help synthesize production estimates are listed at the end of this chapter.

The Balance Sheet

The balance sheet of supply and demand is shown in Table 6-1. Aggregate population estimates from the 1977 census are increased at the rate of 2.7 percent per year for the nation, corresponding to official estimates. The estimated populations of Nouakchott and Rosso are known for 1977 and 1982, and the intervening years are estimated using the average annual growth rate between 1977 and 1982. Since the rate of growth for those cities is expected to slow down (they nearly doubled population in 5 years), a doubling of population is assumed from 1982 to 2000.

Per capita consumption is calculated as a residual by dividing total estimated supply by population. All imports are assigned to the Nouakchott/Rosso populations, and all domestic production is assigned to the rest of the country. The resulting per capita consumption figures correspond remarkably well to a 1976 study done in Senegal which indicated per capita vegetable consumption of 41.7 kg among urban dwellers and 8.2 kg among rural populations.[11] As a point of reference, the same study indicated that per capita consumption of vegetables by foreigners in Senegal was 150 kg.

The per capita consumption figures in Table 6-1 appear somewhat erratic between 1977 and 1980 because of inconsistencies in reported production, but some conclusions can be drawn. First, urban per capita consumption is four to five times that of the rural population, which consists partly of nomads who are unaccustomed to vegetables in their diets. Second, per capita consumption should be increasing secularly; the dip in 1980 is believed to be due to incomplete production statistics or insufficient supply due to drought.

Our projections for the year 2000 assume (1) a four-to-one ratio of urban to rural per capita consumption, (2) a doubling of rural per capita consumption, and (3) an increase of approximately 50 percent in urban per capita consumption relative to 1979-1982 trends. After multiplying through by the urban and rural population projections, it appears that total annual consumption will increase to 85,000 tons (more than three times current levels) if the produce is available. Due to urban growth the current 50/50 consumption balance between Nouakchott/Rosso and the rest of the country will change to approximately 60 percent for the former. Both urban and rural demand would triple by the year 2000.

Meeting Demand

Mauritania would have to triple domestic production in 17 years just to meet rural demand, and much more to substitute for imports. In terms of land devoted to vegetable production, total domestic production of 37,000 tons at the current average yield of approximately 10 tons would require 3,700 hectares, or at least triple the current planted area. Increasing yields would help to alleviate the pressure on scarce suitable land, as indicated in Table 6-2. Doubling of yield from 10 tons to 20 tons/hectare would require only 1,800 hectares to produce 37,000 tons.

11/ Louis Berger International, Etude de Commercialisation de Produits Maraichers en Basse Casamance, Preliminary Report, 1977.

TABLE 6-1

ESTIMATED VEGETABLE CONSUMPTION, PRODUCTION AND IMPORTS, IN MAURITANIA

Year/Location	Population X (Thousands)	Per Capita Consumption = (Kg)	Total Consumption (Tons)	
1977				
Nouakchott/Rosso	157	25	4,000	(all imports)
Other	1,183	5	6,100	(domestic production)
Total	1,340	8	10,100	
1978				
Nouakchott/Rosso	177	34	6,068	(all imports)
Other	1,199	8	9,760	(domestic production)
Total	1,376	12	15,828	
1979				
Nouakchott/Rosso	200	60	12,077	(all imports)
Other	1,213	9	10,550	(domestic production)
Total	1,413	16	22,627	
1980				
Nouakchott/Rosso	226	43	9,804	(all imports)
Other	1,225	6	7,300	(domestic production)
Total	1,451	12	17,104	
1982 (Assumed)				
Nouakchott/Rosso	290	50	14,500	(all imports - projected)
Other	1,240	10	12,400	(domestic production - projected)
Total	1,530	18	26,900	
2000 (Assumed)				
Nouakchott/Rosso	600	80	48,000	(all imports - projected)
Other	1,873	20	37,460	(domestic production - projected)
Total	2,473	35	85,460	

TABLE 6-2

COMBINATION OF VEGETABLE YIELD AND HECTARES OF LAND NECESSARY TO ACHIEVE PRODUCTION LEVELS

Grid entries are tons of vegetables

	Number of Cultivated Hectares						
Average Yield/Ha.	600	1,000	1,400	1,800	2,200	2,600	3,000
10	6,000	10,000	14,000	18,000	22,000	26,000	30,000
15	9,000	15,000	21,000	27,000	33,000	39,000	40,000
20	12,000	20,000	28,000	36,000	44,000	52,000	60,000

Given Mauritania's scarcity of good soil, it appears necessary to increase yields if increased demand is to be met. It is unlikely that Mauritania can produce enough to substitute for all the imports into Nouakchott, but there will be need to at least triple production outside the Nouakchott/Rosso strip, plus a large market for import substitutes.

Conclusions

1. Current per capita vegetable consumption in Mauritania is approximately 50 kg in Nouakchott and Rosso, 10 kg in other areas, and increasing.

2. Per capita vegetable consumption in 2000 could reach 80 kg in Nouakchott and 20 kg in other areas, thereby tripling total consumption.

3. Mauritania should strive to at least triple vegetable production to 37,000 tons by the year 2000 to supply areas other than Nouakchott/Rosso.

4. Vegetable imports are expected to triple to 48,000 tons by the year 2000 as Mauritania urbanizes unless Mauritanian producers can produce import substitutes.

5. Given Mauritania's scarcity of good soils, increased production should be sought by increasing yields.

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CHAPTER 7

STRATEGIES FOR INCREASING VEGETABLE PRODUCTION[12/]

Introduction

The potential benefits from increased vegetable production would accrue to consumers in the form of improved nutrition, to producers in the form of increased incomes, to people who gain employment from vegetable production or trade, and to the nation in the form of reduced expenditures for imports. Realization of these benefits is likely to occur in Mauritania only as a result of government support for programs designed to improve the technical and economic conditions associated with vegetable production and marketing. The objectives of this chapter are to identify and evaluate these programs and to suggest strategies for implementation.

Certain basic conditions and philosophies underlying formulation and evaluation of strategies must be stated at the outset. First, it is judged best that the essential characteristics of the four principal vegetable cropping systems described in this report be maintained and strengthened. The reason is that the systems are established and stable, thus providing a solid foundation upon which to build improvements. Second, it is important that production technology remain simple and low cost because of constraints on capital and technical capability. Third, it is believed that government intervention is necessary and desirable to stimulate vegetable production, but that private sector participation should be encouraged. A fourth condition is that transport of fresh vegetables (apart from the Rosso-Nouakchott strip) should be minimized given the high transport costs and product losses. Finally, it is assumed that vegetable production is the "highest and best crop use" of land with favorable soil and water resources, thus precluding the question of resource opportunity cost foregone.

Vegetable Development Programs

The essential characteristic of the proposed development programs is that they serve and reinforce the four cropping systems. Within each cropping system--previously defined as rainfed, flood recessional, oasis and irrigated perimeter--four development programs are envisaged:

1. Production extension services designed to improve farmers' production technology;

12/ In this report a strategy is a plan to allocate resources among alternative programs. A program is an ongoing development effort which, unlike a project, need not have a specific objective, activity, beginning, and end. For reference see J. Price Gittinger, Economic Analysis of Agricultural Projects, Second Edition, 1982, published by The Johns Hopkins University Press for The World Bank.

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2. Production infrastructure development designed to provide technical and financial assistance for investments in fixed structures such as water supply and fences;

3. Purchased input distribution designed to make seeds, fertilizers, chemicals, tools and other items available to farmers;

4. Product marketing designed to improve postharvest transportation, storage and handling, and processing (drying) of fresh vegetables.

The scope and nature of the components within these development programs may differ not only among cropping systems, but also within cropping systems. For example, irrigated perimeters vary greatly in size and the proportion of production marketed, thereby requiring different approaches to marketing. Development programs are described and evaluated in this chapter following specification of program objectives and evaluation criteria.

Program Objectives

The four development program categories envisaged for vegetable production in Mauritania have the following general objectives:

1. Improved nutrition. Consumers of fresh vegetables, including producers who grow vegetables only for family consumption, benefit from the vitamins and minerals which are deficient in traditional diets. Both the number of people consuming vegetables and per capita consumption by those who already eat vegetables can be expected to increase along with vegetable supply.

2. Increased income. Vegetable producers with access to markets can sell their surplus (in excess of family consumption). Producers who do not have marketable surplus benefit from increased production in terms of real income in the sense that they can spend their money on other foods and necessities in lieu of vegetables. Due to the small scale, family-oriented nature of vegetable production, it is believed to be particularly beneficial to rural, small-farmers. People involved in vegetable transportation and marketing also can generate higher incomes due to increased vegetable supply.

3. Increased employment. Given the high apparent rate of unemployment in Mauritania, employment is an important social objective. Vegetable production is labor intensive, thus requiring hiring of unskilled labor for large gardens. The irrigated perimeter system is the only one which can support significant amounts of hired labor, but vegetable production also provides unpaid employment for women and children who produce for family consumption. Employment would also result from a greater amount of produce moving through marketing channels.

4. Reduced balance of payments deficit. Mauritania runs a chronic balance of payments deficit, which is aggravated by vegetable imports into the Rosso and Nouakchott markets. Increased domestic production could mitigate increases or even reduce the balance of payments deficit. The potential

for accomplishing this objective is diminished somewhat by the need to import many production inputs such as fertilizer, chemicals, and implements.

Program Evaluation Criteria

Agricultural development programs are commonly evaluated in terms of technical, financial, and economic feasibility.[13] Technical feasibility means that something can be physically done--such as hot weather vegetable production--and that the technology can be managed by farmers. Financial feasibility means that the program or project is financially profitable and an improvement over existing income from the farm family's point of view. Economic feasibility means that the program or project generates positive net benefits from a national point of view. Economic feasibility differs from financial feasibility in its exclusion of transfer payments (e.g., the farmer's debt obligation) and its indifference to capital ownership. It includes consideration of national costs and benefits, however, such as employment and the balance of payments.

An additional criterion which should be considered is the ability of the Government to implement the programs, which vary a great deal with respect to complexity, the availability if expertise, and the availability of funding.

Program Evaluation Scheme

This Project is a first step toward establishing the feasibility of additional projects in vegetable production. Since information is very limited, and since no specific projects have been formulated, a combination of objective information and subjective judgment is employed to evaluate program alternatives. A subjective rating scheme is used based on numbers from zero through two; the higher the score the more favorable the program's contribution to national objectives or ability to meet the feasibility criteria. The numerical scores have the following interpretations:

Score	Interpretation (Objectives)
0	Negligible
1	Moderate Impact
2	Strong impact

	Interpretation (Feasibility)
0	Infeasible or inapplicable
1	Moderate feasibility
2	Strong feasibility

13/ Gittinger, op. cit.

Use of this subjective evaluation scheme without specifying the level of effort, the scope and character of the projects that would follow, or specific estimates of costs and benefits is highly tenuous. The scheme merely represents a subjective ranking of potential programs based on the experience of Project team members. Results of the subjective evaluation are shown in Tables 7-1 through 7-5.

Production Extension Services

This program focuses on major production practices for increasing crop yields including varietal and seed improvement, irrigation, cultural improvements, and crop protection. Trained vegetable crop specialists assigned to production regions would provide recommended practices, demonstrate improved production techniques, and organize farmer training programs. Variety trials on farm fields or government-owned lands would provide information on improved varieties which are more temperature and drought tolerant; disease, insect, and nematode resistant; earlier maturing; and have higher yield potential. Seed production and preservation techniques for major vegetable crops would be demonstrated providing recommended practices to farmers and the private sector for seed multiplication, processing, and distribution. Irrigation management practices to improve crop performance and methods to improve irrigation application effectiveness would be demonstrated. Recommended cultural practices such as optimum planting densities, planting dates, seed bed preparation, tillage practices, crop sequences, growth habits, irrigation requirements, manure and fertilizer use, wind protection measures, pest control, and intercropping and mixed cropping methods would be recommended. To enhance grower ability to adopt improved farming practices, appropriate extension publications and teaching modules must be developed. Visual aids such as slides and movies about recommended production activities are valuable extension training tools to convey technical information to farmers. A discussion of evaluation results for this extension program implemented under the various cropping systems follows.

A. Irrigated Perimeters--Large Scale (2-20 hectares)

Evaluation of the production extension program results on accomplishing the major production objectives and their feasibility as rated in Table 7-1 would provide a larger impact on increasing vegetable production than any of the other cropping systems. As a result of significant production increases, the major objectives of improved nutrition, increased income, increased employment, and reduced balance of payment deficits would be positively impacted. Produce from the large-scale irrigated perimeters, to be located primarily along the Senegal River in the vicinity of Rosso, is expected to help supply the Rosso and Nouakchott markets, thereby reducing costly imports. Technical, financial, and economic feasibilities are rated very strong because of high yield potential and large economic returns to farmers. Due to differences among the program components in the complexity of input use and crop management, the cultural improvements and crop protection components of the extension program will be somewhat more difficult to implement than the varietal, seed improvement, and irrigation components.

TABLE 7-1

EVALUATION OF ALTERNATIVES FOR INCREASING VEGETABLE PRODUCTION IN MAURITANIA

Cropping System: Irrigated Perimeters - Large Scale

Major Vegetable Crops: Tomato, Potatoes, Sweet Potatoes, Carrots, Cabbage, Peppers, Melons, Onions, Eggplant, Cowpeas

	OBJECTIVES[a]				FEASIBILITY[b]			
PROGRAMS	Improved Nutrition	Increased Income	Increased Employment	Reduced Balance of Payments Deficit	Technical	Financial	Economic	Implementation
Production Extension Services								
Varietal and Seed Improvement	2	2	2	2	2	2	2	2
Irrigation	2	2	2	2	2	2	2	2
Cultural Improvements	2	2	2	2	2	2	2	1
Crop Protection	2	2	2	2	2	2	2	1
Purchased Input Distribution	2	2	2	2	1	2	1	1
Production Infrastructure								
Water Supply	2	2	2	2	2	2	2	1
Fencing	1	1	1	1	0	0	0	0
Marketing								
Transportation	2	2	2	2	1	2	2	1
Storage and Handling	2	2	2	2	1	2	2	1
Processing (Drying)	1	1	1	1	1	1	1	1

a/ Key to "objectives" ranking: 0 = negligible impact, 1 = moderate impact, 2 = strong impact.

b/ Key to "feasibility" ranking: 0 = infeasible or inapplicable, 1 = moderate feasibility, 2 = strong feasibility.

TABLE 7-2

EVALUATION OF ALTERNATIVES FOR INCREASING VEGETABLE PRODUCTION IN MAURITANIA

Cropping System: Irrigated Perimeters - Co-op Garden - Small Private

Major Vegetable Crops: Tomatoes, Cowpeas, Eggplant, Onions, Sweet Potatoes, Potatoes, Lettuce Okra, Cabbage, Squash, Maize, Melons, Carrots, Peppers, Turnips, Beets

PROGRAMS	OBJECTIVES[a]				FEASIBILITY[b]			
	Improved Nutrition	Increased Income	Increased Employment	Reduced Balance of Payments Deficit	Technical	Financial	Economic	Implementation
Production Extension Services								
Varietal and Seed Improvement	2	2	1	1	2	2	2	2
Irrigation	2	2	1	1	1	2	1	1
Cultural Improvements	2	2	1	1	1	2	2	1
Crop Protection	2	2	1	1	1	2	1	1
Purchased Input Distribution	2	2	2	1	1	2	1	1
Production Infrastructure								
Water Supply	2	2	2	1	2	2	2	1
Fencing	2	2	2	1	2	2	1	1
Marketing								
Transportation	2	2	2	1	1	2	2	1
Storage and Handling	2	2	2	1	1	2	2	1
Processing (Drying)	2	2	2	1	2	2	2	2

[a] Key to "objectives" ranking: 0 = negligible impact, 1 = moderate impact, 2 = strong impact.

[b] Key to "feasibility" ranking: 0 = infeasible or inapplicable, 1 = moderate feasibility, 2 = strong feasibility.

TABLE 7-3

EVALUATION OF ALTERNATIVES FOR INCREASING VEGETABLE PRODUCTION IN MAURITANIA

Cropping System: Oasis

Major Vegetable Crops: Tomatoes, Cowpeas, Eggplant, Onions, Sweet Potatoes, Potatoes, Lettuce, Okra, Cabbage, Squash, Maize, Melons, Carrots, Peppers

	OBJECTIVES[a]				FEASIBILITY[b]			
PROGRAMS	Improved Nutrition	Increased Income	Increased Employment	Reduced Balance of Payments Deficit	Technical	Financial	Economic	Implementation
Production Extension Services								
Varietal and Seed Improvemen	2	2	1	0	2	2	1	1
Irrigation	2	1	1	0	1	1	1	1
Cultural Improvements	2	1	1	0	1	1	1	1
Crop Protection	2	1	1	0	1	1	1	1
Purchased Input Distribution	2	2	2	0	1	2	1	1
Production Infrastructure								
Water Supply	2	2	1	0	2	2	2	1
Fencing	2	2	2	0	2	2	2	1
Marketing								
Transportation	1	1	1	0	1	1	1	1
Storage and Handling	1	1	1	0	1	1	1	1
Processing (Drying)	2	2	2	0	2	2	2	1

a/ Key to "objectives" ranking: 0 = negligible impact, 1 = moderate impact, 2 = strong impact.

b/ Key to "feasibility" ranking: 0 = infeasible or inapplicable, 1 = moderate feasibility, 2 = strong feasibility.

TABLE 7-4

EVALUATION OF ALTERNATIVES FOR INCREASING VEGETABLE PRODUCTION IN MAURITANIA

Cropping System: Flood Recessional

Major Vegetable Crops: Tomatoes, Cowpeas, Eggplant, Onions, Sweet Potatoes Potatoes, Okra, Cabbage, Squash, Maize, Melons

PROGRAMS	OBJECTIVES[a]				FEASIBILITY[b]			
	Improved Nutrition	Increased Income	Increased Employment	Reduced Balance of Payments Deficit	Technical	Financial	Economic	Implementation
Production Extension Services								
Varietal and Seed Improvement	2	2	1	0	2	2	1	1
Irrigation	1	1	1	1	1	1	1	1
Cultural Improvements	1	1	1	0	1	1	1	1
Crop Protection	1	1	1	0	1	1	1	1
Purchased Input Distribution	2	2	2	0	1	2	1	1
Production Infrastructure								
Water Supply	0	0	0	0	0	0	0	0
Fencing	0	0	0	0	0	0	0	0
Marketing								
Transportation	1	1	1	0	1	1	1	1
Storage and Handling	1	1	1	0	1	1	1	1
Processing (Drying)	2	2	2	0	2	2	2	1

a/ Key to "objectives" ranking: 0 = negligible impact, 1 = moderate impact, 2 = strong impact.

b/ Key to "feasibility" ranking: 0 = infeasible or inapplicable, 1 = moderate feasibility, 2 = strong feasibility.

TABLE 7-5

EVALUATION OF ALTERNATIVES FOR INCREASING VEGETABLE PRODUCTION IN MAURITANIA

Cropping System: Rainfed

Major Vegetable Crops: Cowpeas, Melons

PROGRAMS	OBJECTIVES[a]				FEASIBILITY[b]			
	Improved Nutrition	Increased Incomes	Increased Employment	Reduced Balance of Payments Deficit	Technical	Financial	Economic	Implementation
Production Extension Services								
Varietal and Seed Improvement	1	1	1	0	1	1	1	1
Irrigation	0	0	0	0	0	0	0	0
Cultural Improvements	1	1	1	0	1	1	1	1
Crop Protection	0	0	0	0	0	0	0	0
Purchased Input Distribution	2	2	2	0	1	2	1	1
Production Infrastructure								
Water Supply	0	0	0	0	0	0	0	0
Fencing	0	0	0	0	0	0	0	0
Marketing								
Transportation	1	1	1	0	1	1	1	1
Storage and Handling	1	1	1	0	1	1	1	1
Processing (Drying)	0	0	0	0	0	0	0	0

a/ Key to "objectives" ranking: 0 = negligible impact, 1 = moderate impact, 2 = strong impact.

b/ Key to "feasibility" ranking: 0 = infeasible or inapplicable, 1 = moderate feasibility, 2 = strong feasibility.

B. Irrigated Perimeters--Co-op Gardens and Small Private Gardens

Evaluation results presented in Table 7-2 indicate that the proposed extension program for this cropping system would have a strong impact on the nutrition, income, and employment objectives, with a moderate effect on reduced balance of payment deficits. Some produce is expected to be sold in small regional markets, but most will be used for home consumption. The technical, financial, and economic feasibilities are considered moderate to strong. The varietal and seed improvement components of the program are expected to provide the greatest impact on production. Since many of the small scale irrigated perimeters are scattered throughout remote rural areas, implementation of a successful extension program will be difficult. This results from requirements for a greater number of or greater mobility for adequate farmer contacts.

C. Oasis Agriculture

Evaluation results presented in Table 7-3 indicate that the extension program would have a strong impact on the objectives of improved nutrition, a strong to moderate impact on increased income value and employment and a negligible impact on balance of payment deficits. Most produce would be grown for home consumption, significantly improving nutrition. The technical, economical, and financial feasibilities for the varietal and seed improvement components of the program are considered strong to moderate, whereas other aspects of the program, i.e., irrigation, cultural improvements, and crop protection are considered moderate. Most oases are located in remote rural areas and implementation of extension services with adequate farmer contacts will be difficult.

D. Flood Recessional

Evaluation results presented in Table 7-4 indicate that the extension program for flood recessional would have a strong impact on improved nutrition, a strong to moderate impact on increased real income and employment and a negligible impact on balance of payment deficits. More produce would be available for home consumption, significantly improving nutrition, thereby reducing other food intake costs. The technical, financial and economic feasibilities of the program are considered strong to moderate, whereas other components of the program, i.e., irrigation with small earth dams, cultural improvements, and crop protection are considered moderate. Most recessional flood farms are located next to the Senegal River or near lakes (marigots), and are difficult to reach during the early growing season due to flooding.

E. Rainfed

Evaluation results presented in Table 7-5 suggest that the extension program would have a moderate to negligible impact on major production objectives of improved nutrition, increased income and increased employment and a negligible effect on balance of payment deficits. The harvest produce is grown mainly for home consumption needs. Few crops are adapted to the cropping system; most production consists of melons and cowpeas. The technical, financial and economic feasibilities of the program for rainfed agriculture are considered

moderate for varietal and cultural improvements, whereas other components such as crop protection are considered negligible. Early maturing short-cycle varieties that are temperature and drought tolerant could significantly increase production. Rainfall frequency and intensity are highly variable in most regions, so production risks are high.

Purchased Input Distribution

Seeds, fertilizers, chemicals, tools, and farm equipment must be made available in the necessary quantities and times. Due to poor road conditions, lack of transportation facilities, and low availability of purchased inputs, private enterprise, government organization, and/or a combination to coordinate input purchases and distribution could significantly increase production. The tasks of the organization would be to purchase needed inputs in Nouakchott or import sources, deliver by truck to production regions, and distribute to farm organizations and individual farmers. Inputs could be sold at subsidized prices with capital provided in a "revolving fund" system. The organization would require trucks, trained management personnel with accounting expertise who could work directly with farmer organizations, and extension agents in production regions. Distribution of purchased inputs could be implemented by means of government-owned stores, by supporting or subsidizing private sector stores, or a combination of both depending on the input items. The evaluation of the program in the various cropping systems is discussed below.

A. Irrigated Perimeters--Large Scale

As presented in Table 7-1, input distribution would have a strong impact on increasing production objectives. Improved input distribution could reduce farmers' procurement costs, make possible the timely use of improved inputs, and encourage use of yield-increasing inputs. Poor road conditions, truck maintenance requirements, accounting difficulties, and problems involved in maintaining equitable distribution to farmers would make the feasibility of implementing the program somewhat difficult. However, since the large scale irrigated perimeters are located near Rosso close to major roads and distribution channels, farm input delivery and distribution would be less of an implementation problem compared to other cropping systems.

B. Irrigated Perimeters--Co-op Gardens and Small Private Gardens

Evaluation results indicate that purchased input distribution will have a strong impact on improved nutrition, increased income, and increased employment objectives and a moderate effect on reduced balance of payment deficits. Some produce is sold to local and regional markets. The financial feasibility of the program would be strong because it reduces production costs and makes possible the timely use of inputs, but the technical, economic, and implementation feasibilities are moderate because farm access to markets and distribution channels varies greatly.

C. Oasis Agriculture

Evaluation results for oasis agriculture indicate that input distribution will have a strong impact on three of the major production objectives, i.e., nutrition, income, and employment and a negligible effect on reduced balance of payment deficits. Input distribution would provide essential materials and stimulate production motivation for home consumption. The financial feasibility of input distribution is strong because producers could consume or sell their produce for profits. The technical, economical, and implementation feasibility is moderate because of great distances between distribution channels and farm locations under poor road conditions.

D. Flood Recessional

Evaluation results for a flood recessional input distribution program are similar to oasis agriculture. Providing inputs will stimulate production and, therefore nutrition, income, and employment. The effect on the balance of payments will be negligible because production is mainly for home consumption. The financial feasibility of the program should be strong because of yield and production increases. The technical, economic, and implementation feasibilities are moderate because of distances between distribution points, poor road conditions, and high transport costs.

E. Rainfed

Evaluation results for rainfed agriculture are similar to those for flood recessional and oasis agriculture. The distribution of improved seed varieties which are temperature and drought tolerant would stimulate production and reduce yield risks under marginal conditions.

Production Infrastructure

Technical and financial assistance are needed to develop on-farm infrastructure, principally water supply and fences. Water resources and fencing costs represent approximately 35-40% of the total vegetable production costs. Low rainfall and high evaporative demands make water supply the most limiting factor affecting vegetable production expansion in Mauritania. Water from the Senegal River and shallow wells are the principal water sources. Free-roaming animals--goats, camels, and cows--destroy planted crop areas if not protected. Farmers in the rural areas that do not construct fencing frequently lose a significant part of their production. Three major types of fencing materials are used in Mauritania: wooden stakes, barbed wire, and chain link or metal stakes.

To develop farm infrastructure, a government assistance program would be established to provide credit for purchasing fencing materials and water supply facilities. Well drilling and well lining services would be organized with a trained specialist team to provide technical assistance in well drilling. Drilled wells suitable for hand, windmill, and motor pumps would be developed for irrigated perimeters. The evaluation results of this proposed program for the various cropping systems are discussed below.

A. Irrigated Perimeters--Large Scale

Evaluation results for the production infrastructure assistance program to large scale irrigated perimeters indicate that production and farmer income would be significantly increased. Credit assistance for water supply development would have a strong impact on all four major production objectives. Increasing water supply would involve purchasing motor pumps for channeling water from the Senegal River and for well pumping. The preferred farm location near the Senegal River and the Rosso-Nouakchott highway makes investments for motor pumps for expanding production appear very profitable. The technical, financial, and economic feasibilities of the program are rated very strong. The feasibility of implementation is moderate given the managerial and organizational requirements of coordinating the farm credit system in rural areas.

The expected impact of credit assistance for fencing on the large scale irrigated perimeters is less than water supply development. Additional fencing protection would have a moderate effect on production-related objectives and economic, technical, and implementation feasibilities are negligible due to high costs and low potential animal damage on farms of this size.

B. Irrigated Perimeters--Co-op Gardens and Small Private Gardens

Evaluation results for an infrastructure development program for small irrigated perimeters indicate that credit assistance for developing water supplies and fencing will have a strong impact on improved nutrition, increased income, and increased employment objectives and a moderate effect on reduced balance of payment deficits. Some produce is sold to local and regional markets providing some farm capital, however, a large portion of the harvested produce is used for home consumption. Water from the Senegal River and shallow wells are the principal water resources requiring credit for development. Motor pumps, well drilling and well lining services are the major capital items. The technical and financial feasibility are rated strong because in most production regions water can be pumped from the Senegal River without excessive costs if good crop management practices are followed and wells can be constructed without serious difficulty due to a shallow water table in many production areas that provides high quality water. The economic and implementation feasibility are rated as moderate with some field problems with drilling equipment and program organization anticipated because of the diverse production site locations.

Similarly, evaluation results for financing credit for fencing indicate that it will have a strong impact on improved nutrition, increased income, and increased employment objectives and a moderate effect on reduced balance of payment deficits. Protecting production sites in rural areas where damage from roaming animals is high will significantly increase production and farmer income. Farm credit availability for fencing construction permits additional lands to be developed and its technical and financial feasibility are very strong. The economic and implementation feasibility are rated as moderate because of high on-farm cost and possible organizational difficulties for credit accounting and fencing distribution to farm sites.

C. Oasis Agriculture

Similar to irrigated perimeter development, evaluation results for an infrastructure development program for oasis agriculture indicate that farm credit assistance for developing water supplies will have a strong impact on improved nutrition, increased income, and increased employment objectives and a negligible impact on balance of payment deficits. Increased production will be used primarily for home consumption, although small quantities will be sold in local markets. Shallow wells will be the principal water resource requiring credit for development. Small motor pumps, hand pumps, and well drilling services and well lining equipment are the major capital items. The technical, financial, and economic feasibility for developing oasis water supplies for expanding vegetable production is rated very strong. Because of farm credit management difficulties for Mauritania in rural areas, its implementation feasibility is considered moderate.

Similarly, fencing credit assistance will also have a strong impact on nutrition, income, and employment objectives and a negligible impact on balance of payment deficits. Fencing will provide needed crop protection from animals and the technical, financial, and economic feasibility is rated strong with implementation feasibility rated as moderate due to possible organizational and distribution difficulties in rural areas that are difficult to reach.

D. Flood Recessional and
E. Rainfed

Evaluation results for the production infrastructure assistance program for vegetable production under flood recessional and rainfed cropping systems indicate that water supply development and fencing will have a negligible impact on production objectives. The technical, financial, economic, and implementation feasibility are very low and development is not cost effective. Such a program involves marginal production at high risk that is very difficult to implement due to dispersion of growers and the nature of the cropping which uses low production inputs.

Marketing

A. Irrigated Perimeters--Large Scale

The success of large irrigated perimeters depends upon ready access to the Rosso and Nouakchott markets. Truck transportation is a critical component of this enterprise because of the need to ship perishable vegetables immediately after harvesting, and because of the need to haul inputs such as fertilizer and pesticides from town to farm in time for application. Given the high costs and uncertainty of hiring transport in Mauritania, substantial savings could be realized from truck ownership. Since few vegetable producers could afford the capital investment, a government loan program is envisaged whereby qualified vegetable producers could purchase vehicles.

Even some "large scale" producers might be unable to generate the incomes necessary to qualify for truck loans, so cooperative or government ownership is an alternative. Cooperative ownership would require scheduling and cost-sharing among the users which could be difficult and prone to conflict. Government ownership and operation of a trucking service for vegetable producers might also be prone to operational difficulties, and private truckers might protest such competition.

The potential contribution of improved transportation to all four program objectives is judged to be very good. It would get more domestic produce to market in better condition, help to mitigate foreign imports, and reduce producers' costs. It should prove feasible both financially and economically. The principal constraints are the technical and implementation difficulties associated with truck maintenance, plus coordination and administrative difficulties.

Vegetable storage, packing and handling are important components of the large irrigated perimeter enterprise because of the relatively quality-sensitive Nouakchott market. A program is envisaged to teach better methods of pre-market storage, product appearance and grading, and packing to lessen damage from bruising, heat, and sand. Rankings for this program are identical to those for improved transportation.

Vegetable drying is not a principal activity of large irrigated perimeter enterprises because they can sell most of their fresh produce at good prices in Nouakchott and Rosso. However, some produce with poor appearance could be dried instead of marketed fresh, then sold in the off-season. This activity is judged to be helpful in meeting national objectives, but marginally profitable and feasible compared to the alternative of marketing fresh vegetables.

B. Irrigated Perimeters--Co-op Gardens and Small Private Gardens

Proliferation of small irrigated perimeters appears to be a very good way to increase the supply of vegetables to rural markets while augmenting small-farmer incomes. Small irrigated perimeters operated cooperatively or privately do not market proportionally as much of their produce as large irrigated perimeters. The marketing task is more difficult because there are numerous gardens in scattered locations producing relatively small amounts for sale. The principal means of transporting produce to market under this system is commercial transport; the quantity moving to market from one garden at one time is usually insufficient to warrant hiring a truck.

The potential gains from improved transport services at lower cost are substantial, both from the producer's and the nation's points of view.

The alternatives for improving transport services for vegetables are to improve commercial transport services in general, or to provide vegetable hauling services in areas where producers are numerous and concentrated enough to justify the program. In summary, this could be a very beneficial and profitable program, but under restricted conditions and areas. Considerable

difficulty is foreseen in implementing such a program because of the organization and coordination required.

A program to improve storage and handling of vegetables marketed from small, irrigated perimeters would be very beneficial because of the high postharvest losses that occur. Such a program would be very difficult to manage, however, because of the geographic dispersion of producers, erratic quantities of marketable surplus emanating from those farms, and producer dependence upon public transportation.

Vegetable drying appears to offer great gains. Drying reduces the urgency of getting fresh produce to market, requires simple technology, and could result in much better (off-season) product price. Furthermore, it lengthens the period of time during which consumers can obtain vegetable products. This appears to be one of the best alternatives for vegetable producers--particularly those who produce tomatoes. Tomatoes are amenable to drying, then powdering and mixing with water to make tomato paste.

C. Oasis Agriculture

Oases are relatively isolated, small communities which constitute a stable but limited market for vegetables. A goal of local market equilibrium appears to be desirable given the limited prospects for import or export of vegetables.

Given the small local distances and small quantities of produce to be moved, the potential gains from improvement of transportation, storage and handling are not great. It is believed that such programs would be moderately beneficial for both producers and consumers, that such programs would be both financially and economically feasible, but that technical development and implementation of improved methods would be difficult.

The greatest potential gains appear to be in sun-drying vegetables for off-season consumption. This activity would mitigate the large market price fluctuations caused by seasonal product gluts and shortages, while increasing the duration of product supply. Sun-drying requires a low level of technology, but implementation of a program would be difficult because of locational isolation, farmers' desire for quick sale, and satisfactory fresh vegetable prices during most of the season.

D. Flood Recessional

The flood recession cropping system is not a market-oriented system; produce is intended primarily for family consumption. Production sites are scattered and small, making any development program difficult to manage. While limited impact could be expected from programs to improve transportation, storage and handling, and although such programs could be expected to be moderately feasible, the overall contribution of these programs would not be great.

As in the oasis cropping system, the greatest potential for postharvest improvement would be drying vegetables to lengthen the consumption season, improve family nutrition, and obtain greater product prices for the small

amount of produce marketed. This program is ranked highly on all criteria except implementation feasibility and balance of payments reduction.

E. Rainfed

Rainfed vegetable production is almost entirely for family consumption, leaving little scope for development programs in marketing. Sun-drying of vegetables is impractical because the two principal crops--cowpeas and melons--are not amenable to drying. It is believed, however, that moderate improvements in the transportation, storage and handling of melons and cowpeas could be achieved in areas of traditional, concentrated production sites.

Recommended Development Strategies

Evaluation of development programs within each of the four principal cropping systems leads to identification of the potentially most effective programs, as indicated in Table 7-6. "Effectiveness" is subjectively rated in terms of the potential impact on four national objectives and four measures of feasibility.

A dual strategy of vegetable development is envisaged for Mauritania--one to supply the urban Nouakchott and Rosso markets, and one to supply other areas. The "urban strategy" must necessarily depend upon large irrigated perimeters because insufficient quantities can be supplied from other cropping systems. A "rural strategy" could simultaneously be followed which seeks to achieve local supply and demand equilibriums, thus minimizing transportation costs and postharvest losses.

The Urban Strategy (Nouakchott-Rosso)

Irrigated perimeters (2-20 hectares) should be developed near the Rosso-Nouakchott highway, preferably in the Trarza region near Rosso. Site feasibility studies would have to be conducted to determine the most favorable locations with respect to soil, water, climate, and access to roads.

Organizationally, the GIRM could develop irrigated perimeters owned and operated completely by the government, could develop the land and water resources and then lease to private parties, or merely provide loans for private development. Alternatively the GIRM could establish a state enterprise analagous to SONADER to guide development of irrigated perimeters.

Among the programs described herein and listed in Table 7-6, only fence construction and vegetable drying appear to be of low importance. Among all the cropping systems, the large irrigated perimeter is the only one which can hope to produce enough for import substitution. The balance of payments deficit would not be mitigated by the full value of vegetables produced, however, because of the high cost of imported materials necessary for production.

TABLE 7-6

SUMMARY OF THE POTENTIALLY MOST EFFECTIVE VEGETABLE DEVELOPMENT PROGRAMS

Programs	CROPPING SYSTEMS				
	Rainfed	Oasis	Flood Recession	Irrigated Perimeters Large	Irrigated Perimeters Co-op/Small
Production Extension Services					
Varietal and Seed Improvement	X	X	X	X	X
Irrigation				X	X
Cultural Improvements				X	X
Crop Protection				X	X
Purchased Input Distribution	X	X	X	X	X
Production Infrastructure					
Water Supply		X		X	X
Fencing		X			X
Marketing					
Transportation				X	X
Storage and Handling				X	X
Drying		X	X		X

The Rural Strategy

The principal impacts of the rural strategy would be increasing rural nutrition and incomes, but since imports barely penetrate rural areas there would be virtually no import substitution.

The most effective programs for increasing production in the four rural cropping systems are improvement of seeds and crop varieties, distribution of inputs, and drying (Table 7-6). Water supply and fencing are important for oasis cropping systems. Small irrigated perimeters would benefit a great deal from all programs.

As previously described, varietal and seed improvement would generate production and profit gains by increasing crop tolerance to heat and drought, while effectively lengthening the season during which crops can be produced. This results in marketing advantages because of end-of-season high prices.

Purchased input distribution could be implemented by means of government-owned stores, by supporting private-sector stores, or some combination. This program appears to be a currently important constraint on vegetable production; if inputs are not available, no amount of profit incentive can spur production.

Priorities

Allocation of scarce resources between the urban Nouakchott/Rosso strategy and the rural strategy is a matter of policy to be determined by the Government. If the overriding problem is perceived to be imports, then the urban strategy should take precedence. If the principal objective is perceived to be rural development as measured by income and nutrition, then the rural strategy should be emphasized. Given a choice of strategies, the most promising program components should be given priority within the appropriate cropping systems.

If sufficient funding is available, a balanced approach between urban-rural strategies and among cropping systems is recommended. The reasons are that (1) the current relative shares of vegetable production among cropping systems are roughly equal, (2) no segment of the population should be ignored, and (3) the risks associated with development programs should be spread over several alternatives in case some do not result favorable.

Project Approach

A pilot project involving one or two sites for each cropping system is recommended at the outset for each of the 9 agricultural regions. Not all cropping systems are practiced in all regions. A large irrigated perimeter near the Senegal River and Rosso would preferably be designed and constructed anew to assure proper irrigation design and field layout, but pilot projects within the other cropping systems should include improvement of existing sites. The logic of the latter approach is that people are likely to continue working existing gardens, and they should be encouraged to increase yields. Since they have already learned the rudiments of vegetable production it

should be less difficult and more cost-effective to improve their situation than to persuade adoption by new entrants into vegetable production.

A pilot project would enable participants to design and perfect production and marketing methodologies while training new extension personnel. For example, an input supply store might be established in three or four rural towns to learn the kinds and quantities of items to stock, the prices that can be charged, and the appropriate management form. Only after methodologies have been tested should they be expanded to new areas.

Conclusions

1. The benefits that would accrue to Mauritania from increased vegetable production include improved nutrition, higher income, increased employment and improved balance of payments.

2. The conditions and philosophies underlying a vegetable development strategy are that (a) the principal characteristics of the four cropping systems should be preserved and strengthened, (b) production technology should remain simple and low cost, (c) government intervention is necessary and desirable to stimulate vegetable production, and (d) transport of fresh vegetables should be minimized except for the Rosso-Nouakchott strip.

3. The four principal development program categories are (a) production extension services, (b) production infrastructure development, (c) purchased input distribution, and (d) product marketing.

4. The expected effectiveness of development programs and program components varies by cropping system, but in general the most promising are (a) varietal and seed improvement, (b) purchased input distribution, (c) water supply development, and (d) vegetable drying.

5. A dual strategy of vegetable development is envisaged for Mauritania--one to supply the urban Nouakchott/Rosso markets using high input technology on large irrigated perimeters, and the other to supply rural areas using lower input technology on all cropping systems. The rural strategy seeks to achieve local supply and demand equilibrium to minimize transportation costs and post-harvest product losses.

6. Allocation of scarce resources between the urban-rural strategies and among program alternatives is a matter of Government policy, but a balanced strategy is recommended which would involve all the alternatives on a limited basis.

APPENDIX 1
VEGETABLE ECONOMIC SURVEY QUESTIONNAIRE

QUESTIONNAIRE

I. Vegetable Production Questionnaire

Region_____ Date_____

Department_____ Name of Survey Taker:

Village_____ _____

	Small Garden	Collective	Industrial
1. Number of Gardens			
2. Number of Farmers			

3. Type and quantity of seeds distributed:

Tomato_____ Turnips_____

Potato_____ Beets_____

Onion_____ Lettuce_____

Carrot_____ Eggplant_____

Cabbage_____ Melon_____

Others_____ Others_____

4. Principal production problems:

5. Special observations:

N.B.: 1) Individual garden or modest family type.
2) Cooperative garden.
3) Modern garden.

VILLAGE_____

PCV QUESTIONNAIRE NAME OF PCV SURVEY TAKER_____

(This questionnaire is designed as an aide memoire only. It is completed by the volunteer as an when he has obtained relevant information in day-to-day meetings and conversations. It is an indicative questionnaire only.)

Vegetable Production - Part 1 - 1981-1982

1. Why do the farmers in your village grow vegetables? (Check the one that applies to the greatest number of farmers.)

For their own consumption	_____
To sell and make money	_____
To see what they are like	_____
Government subsidies	_____
Other (Specify)	_____

Comments:

2. Do most of the farmers you work with get free vegetable seed?

3. If yes, ask the farmers if they would be able to grow vegetables if they weren't given free seed and tools?

4. If yes, from where would they procure the seed?

5. a. If the farmers don't now get free seed, where do they get their seed from?

   b. If it is purchased, how much does it cost?

6. What inputs do the farmers use in their vegetable gardens?

A. Labor

1. Who does what task? Men, women, slaves.

2. How long does each task take for each bed: Leveling, bed preparation, planting, transplanting, weeding, watering, harvesting.

3. Are there other crops that conflict with time spent in the garden? (Sorgo, mil, riz, mais, niebe, etc.)

4. Do the farmers ever hire labor to perform certain tasks in the gardens? Which tasks? How much are they paid per task?* (e.g., well-digging, watering, weeding, etc.)

5. How much time do people spend guarding the gardens against animals, birds, and other pests?

*Often partial payment is made in food. If you can, try to estimate the quantity of food given per worker, per day.

B. Land

1. How big are the gardens in your area?

2. How many are worked individually?

   How many are worked cooperatively?

3. Are there any problems with land tenure claims and the use of land for gardens?

4. What was the land used for before the garden was put in?

C. Water

1. Where does the garden's water supply come from?

2. What are the problems with getting and distributing water from this source? (i.e., collapsing wells, salt, distance to marigot, etc.)

3. How much time is spent each day hualing water for a garden? (Please specify the approximate size of the garden.)

D. Capital

1. What inputs do the farmers use in gardening in your area?
   a. Type of fencing or enclosure?

   b. Tools and implements: hoses, hoes, rakes, watering cans, innertube buckets, shovels, etc.

   _____ _____
   _____ _____
   _____ _____
   _____ _____

   c. How were these tools obtained? If purchased, how much did they cost?

   d. Even if the farmers got their tools for free, can they be purchased locally? Which ones? How much?

   e. How long do the tools last? (You may not be able to answer this questions yet.)

   f. If they break, can they be repaired by a local forgeron?

   g. Do the farmers use fertilizers? If yes, what kinds on what crops and how much of each?

      Were these fertilizers purchased? If yes, how much do they cost per kilogram?

   h. Do the farmers use any kind of other chemicals? Herbicides, pesticides, fungicides?

      If yes, what kinds, how obtained, and at what price purchased?

i. Have you ever seen the farmers use local crops or preparations as pesticides?

If yes, what do they use and what is it good for?

j. Have you ever observed any informal credit network in your village?

- Borrowing funds or goods among family members _____
- Borrowing funds or goods from a local merchant _____
- Other (specify)_____

k. If yes, try to find out what "rate of interest" is charged, if any. Often a sack of grain will be borrowed and returned with an additional 1/2 sack of grain. If this exists, try also to determine the period of the loan (e.g., six months).

7. How long does it take for each of the major vegetables to grow in your region (from planting time until harvest)?

8. What is the approximate yield of each major vegetable per plant? Per bed of _____ plants?
(fill in)

a. Pick a "typical farmer" - how much did he/she produce this year of:

Carrots	_____
Cabbage	_____
Tomatoes	_____
Potatoes	_____
Eggplant	_____
Gumbo	_____
Lettuce	_____
Other (specify)	_____

Vegetable Marketing - Part 2

1. Do the farmers in your area try to sell their vegetables?

2. Which vegetables do they try to sell?.

3. Are there any vegetables that they grow but do not eat? Which ones? Are they able to sell these?

4. Are there any vegetables that they do not each and that don't sell? Why did they grow these crops? Will they plant them again next year?

5. Do your farmers know that vegetables are an important addition to their diets?

6. Do they sell or eat all they produce? If not, what do they do with the surplus?

7. What prices do farmers get for their vegetables at the beginning, middle and end of the growing season?

	Begin	Middle	End	UM/UNIT (specify kg or No.)
Tomatoes				
Carrots				
Eggplant				
Potatoes				
Onions				
Dried onion balls				
Cabbage				
Betts				
Lettuce				
Swiss chard				
Gumbo				
Other _____				

8. Ask the farmers if they would be able to grow vegetables if they were not given the seeds and tools?

   Where would they go to get seeds? Tools?

9. How do the farmers transport their produce to market?

   Head carry
   Donkey _____
   Oxcart _____
   Camel _____
   Truck _____
   Other _____
   Horse cart _____

10. Do they ever pay for this transport? If so, how much do they pay per kg/km?

11. Do the farmers ever sell their vegetables directly out of the fields to transporters, merchants, or middlemen (-women)?

12. Does anyone ever come from other towns or villages to buy vegetables from the farmers (like nomads, truckers, commercants, or other farmers)?

13. If yes, where do they come from?

14. Do farmers ever sell vegetables across the river to Senegal?

15. Do vegetables from Senegal appear in your local market? How often and what vegetables?

16. Do the farmers ever take their vegetables out of town to sell them?

17. How many people sell vegetables in the local market?

18. By how much does this number vary:

- week to week _____
- day to day _____
- month to month _____

19. In what months are there no fresh vegetables in the market in your area?

20. In what month(s) are there the most fresh vegetables in the local markets?

21. What is the highest price paid locally for: (UM/kg)

Tomatoes	_____
Carrots	_____
Potatoes	_____
Gumbo	_____
Lettuce	_____
Eggplant	_____
Beets	_____
Onions	_____
Cabbage	_____
Other	_____

22. When do these high prices occur?

23. What is the lowest price paid for: (UM/kg)

Tomatoes	_____
Carrots	_____
Potatoes	_____
Gumbo	_____
Lettuce	_____
Eggplant	_____
Beets	_____
Onions	_____
Cabbage	_____
Other	_____

24. When do these low prices occur?

25. How often do taxi-brousses come through your village weekly?

During the dry season _____
During the rainy season _____

26. How often do large trucks come through weekly?

Dry season _____
Rainy season _____

27. How much does it cost to send a 100 kg sack from your village to Nouakchott?

By large truck? _____
By taxi-brousse? _____

APPENDIX 2

VEGETABLE NUTRITION SURVEY QUESTIONNAIRE

Nutrition Survey

Vegetable Production Project

DATE_____

VILLAGE_____

ETHNIC GROUP_____

MEMBER OF A COOP? _____YES _____NO

HAVE FAMILY GARDEN _____YES _____NO

NUMBER OF PERSONS WHO ARE FED IN THE HOUSEHOLD: _____ADULTS _____CHILDREN UNDER 10

SOURCES OF INCOME: PRINCIPAL_____
SECONDARY_____

I. FOOD PURCHASING AND PLANNING

Who decides the composition of the meal?

When and how are meals planned?

What cooking fuel is used? Quantity per month and cost

Do you have a good budget for the family? Yes No

Who manages the food money and how is this determined?

Amount of money available per day or month:

How do you save up to buy a sheep/goat at Tabaski?

MARKETING

How do you supply yourself with the following food provisions:

		Source	Price	Quantity procured per ----	How long does the unit of purchase last?
Rice.....					
Sorghum (mil rouge)	(whole.....				
	(pounded.....				
	(flour.....				
	(couscous.....				
Millet (petit mil)	(whole.....				
	(pounded.....				
	(flour.....				
	(couscous.....				
Wheat	(whole.....				
	(flour.....				
	(bread.....				
	(couscous.....				
	(pasta.....				
Cow Peas.....					
Peanuts.....					
Melon seeds.....					
Water lily seeds.....					
Aaz (wild grain).....					
Oil	(peanut.....				
	(palm.....				
Fresh Butter.....					
Rendered Butter.....					
Milk	(fresh/what animal?).....				
	(powdered.....				
	(carton.....				
	(canned.....				
Eggs.....					
Sugar.....					
Tea.....					
Meat....beef....camel....goat.....					
Fish.....fresh.....dried.....					
Dried meat.....					
OTHER FOODS & CONDIMENTS					
Tamarind.....					
Hibiscus Flowers.....					
Dates.....					
Baobab fruit.....					
Tomato Concentrate.....					
Dried Cow Pea Leaves.....					

II. FOOD CONSUMPTION AND PREPARATION

A. What do you usually have for breakfast (this morning, for example)?

B. What do you usually have for the noon meal (today for example)?

C. What do you usually have for the evening meal (yesterday or tonight for example)?

D. VEGETABLES
   a. What are the vegetables you eat?
   b. When (at which meal and in what dish/recipe)?
   c. How often do you eat certain vegetables?
   d. Is _____ liked by everyone or by women/men/kids only?

(Ask the questions above to complete the chart.)

VEGETABLES EATEN	WHEN EATEN AND HOW	FREQUENCY OF CURRENT INTAKE (this month)					ACCEPTANCE			
		sev. times a day	once a day	sev. times a week	sev. times/ month	rar.	whole family	F	M	C

e. What new vegetables (seen or grown by you) are you unfamiliar with their use and preparation?

f. Why eat vegetables? Are they necessary/optional in the diet?

g. Are there certain/any vegetables to avoid or for which to limit or avoid consumption? (If so, when and how?)

	How often do you eat it - when and how				
	sev. times a day	once a day	sev. times a week	sev. times a month	rarely
E. FRUITS What fruits do you eat now (this mo.)?					
F. CEREALS What cereals/cereal products do you eat?					

	When eaten and how? How often are they eaten?				
	sev. times a day	once a day	sev. times a week	sev. times a month	rarely/ seldom
G. MILK & MILK PRODUCTS What milk/milk products are eaten?					
H. MEAT/FISH/POULTRY What is eaten?					
I. LEGUMES What is eaten?					

J. MISC. INFORMATION ON FOOD HABITS AND FOOD BELIEFS AND KNOWLEDGE

Are there any foods that you used to eat that you don't eat anymore?

Are there any foods you eat now which you didn't used to eat?

Are you pleased with your current diet or, how would you improve it? (What would you like to have that you don't have/have enough of?)

How do women and girls eat to have the desired physique?

How do men and boys eat to have the desired physique?

Mauritanian meals: Who eats first, who supervises children during meal, what portion is given to different persons in the family?

Tea intake: How many times a day and who prepares it? Who drinks more tea (men, women, old, young)? From what age can one drink tea? What effect does teach have on people?

III. FOOD STORAGE AND PRESERVATION

Foods preserved at home last year:

Food

Quantity

Source

Method of preservation and storage

Food

Quantity

Source

Method of preservation and storage

Changes in quality during preservation or storage: (color, taste, etc.)

Losses

Any foods which you would like to preserve:

APPENDIX 3

A PARTIAL LIST OF COMMERCIAL SEED COMPANIES PRODUCING VEGETABLE SEEDS FOR DEVELOPING COUNTRIES

A PARTIAL LIST OF COMMERCIAL SEED COMPANIES PRODUCING VEGETABLE SEEDS FOR DEVELOPING COUNTRIES

France

Clause
Boetigny-Sur-Orge
Seine et Orse

Tegier
B.P. 222
Valence sur Rhone

Vilmorin Andrieux
4 Quai de la Megisserie
75001 Paris

Japan

Hazera
P. O. Box 1565
Haifa

United Kingdom

Sutton and Sons Inc.
Reading

USA

Asgrow Seed Company
P. O. Box 72
Milford, Connecticut

Burpee Company
Philadelphia, Pennsylvania

Desert Seed Company
P. O. Box 187
El Centro, California

Ferry-Morse Seed Company
P. O. Box 100
Mountain View, California

Harris Seed Company

Peto Seed Company
P. O. Box 4206
Saticoy, California 93003

APPENDIX 4

A SUGGESTED MODEL EXTENSION HANDBOOK FOR MAURITANIAN VEGETABLE PRODUCTION

CONTENTS

1. Introduction
2. Illustrated Subjects
   A. Introducing the rural family
   B. The ideal garden site
   C. Marking out beds
   D. Soil improvement
   E. Choice of site for a seed bed nursery
   F. Seeding a nursery bed
   G. Transplanting
   H. Crop-method sheet, Okra
   I. Plant protection by means other than sprays
   J. Life cycle of a leaf eating larvam
   K. Making your own insecticide
   L. Making and using a hand-held sprayer
   M. Sun-drying of tomatoes
3. Suggestions and discussions of additions to the above list

1. INTRODUCTION

The idea of producing a handbook of vegetable agronomy occurred halfway through the project and several conventional outlines were sketched and rejected as being unhelpful in the Mauritanian context. The comic strip format was arrived at largely as a result of leafing through the notebooks of our artist and concentrating attention on certain "margin doodles" rather than on the formal drawings they contained.

During four months a number of pages were planned and re-planned, drawn and re-drawn. As this was a "first" for both the artist and the horticulturist it was a far from straightforward process and on the following pages are presented an idea requiring more work and much development. The list of agricultural subjects, for instance, is incomplete, the drawings not sufficiently varied and the protagonist characters too few and the accompanying discussion pages not detailed in final form.

Draft pages have been viewed by two of the Chefs de Secteur Agricole working with the project and have been found amusing and, in their opinion, potentially very instructive.

They have been tested in the field by the horticulturist and extension workers in the Rosso and Assaba regions with some success.* They are intended for the agents of the Agriculture department to serve as an "aide memoire" when working in the field with growers and cooperatives. From the point of view of both grower and agent the pictures isolate vegetable cultural and scientific questions and present an organized account of agricultural specifics in an abbreviated and understandable form.

The very incompleteness of these pages should encourage agents to submit their own ideas for additional subject matter. Their fundamental knowledge of

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*Inevitably some pages proved in being tested in the field to need rearranging, drawing, or rewriting, but the idea of the book has been well received and two cooperative presidents have requested a copy should it ever be completed.

Sahelian conditions will, it is hoped, create a field-workers text book relevant wherever climatic conditions are similar to those Mauritanians are familiar with.

2. ILLUSTRATED SUBJECTS

A. Introducing the Rural Family

(See illustration)

B. Choice of a Site (The Ideal Garden)

The following factors should be considered.

- Easy access. Vegetable garden requires high labor input. Though many of the tasks may be light or of short duration their timing is of great importance. For example, a weekly or bi-weekly reduction of pests by physical means does not take much time but if not carried out promptly can become irrelevant as the crop is destroyed by the pest. For this reason the distance from the garden to the home must be short.

- Access to water. The greatest profits are made in the market at the time it is most difficult to transport water by hand. The distance over which water is carried must be as short as possible. Wells or canals should be in the garden or centrally placed. The ideal situation, for which the gardeners should aim is to ration water transport to the crops so that no hand carrying is necessary. Only thus will the gardeners be able to maintain a significant level of production throughout the year.

- The lie of land within the garden must be flat in order to avoid the unequal application of water. Crops will not tolerate flooding or grow in saturated conditions, nor will they grow well if they are left short of water. If the garden has slopes and low and high places it must be flattened or terraced.

- Wind break. A row of trees should be planted in the path of the prevailing wind. Neem trees are recommended as being deep rooted and

La Famille

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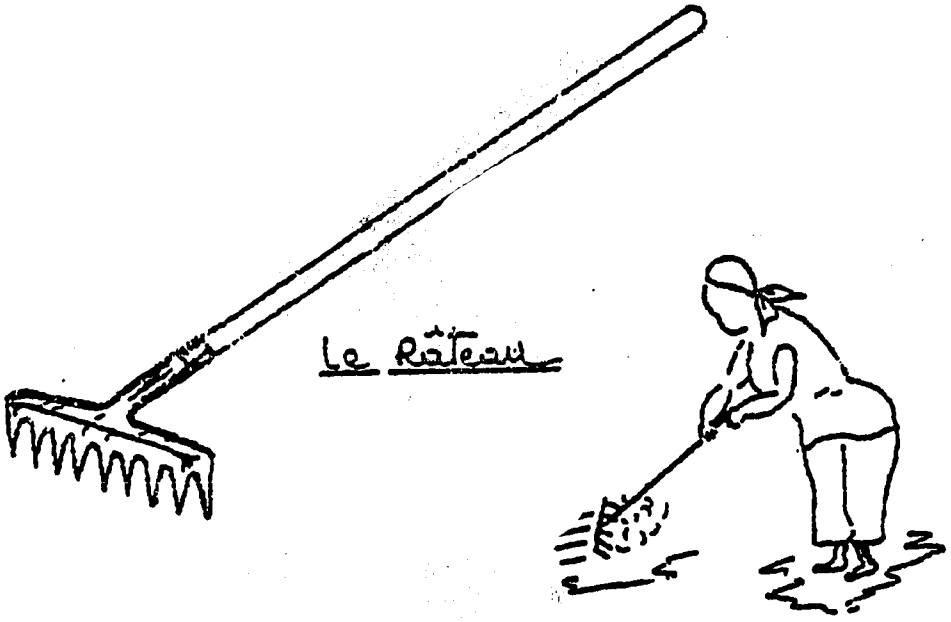
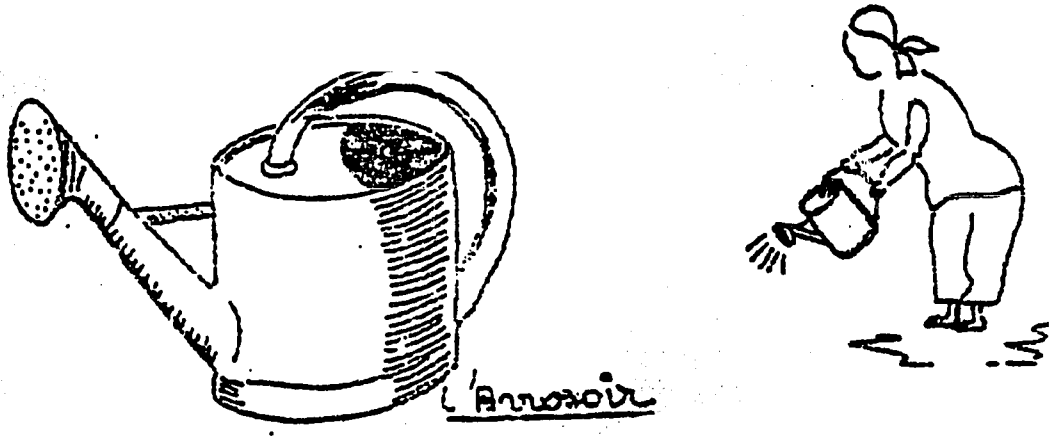
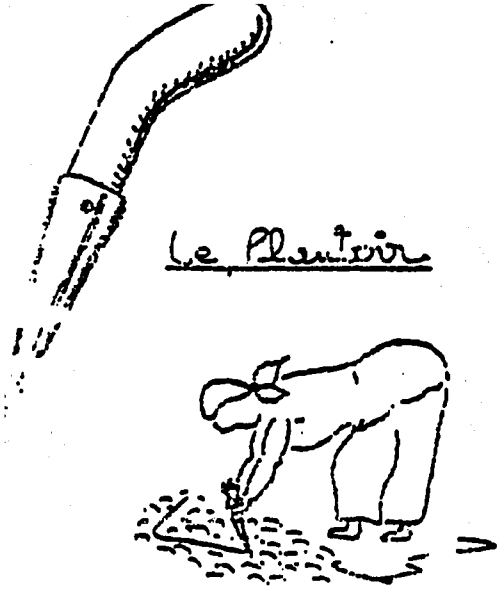
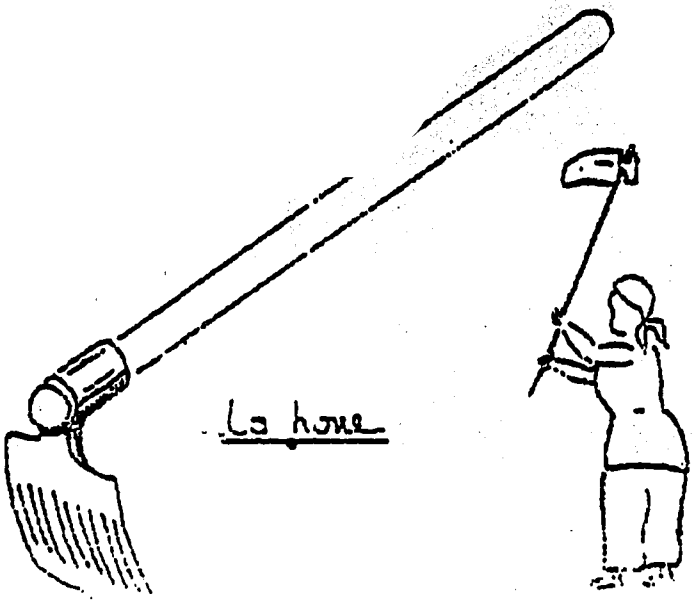
Outils - fabriqués Par le forgeron

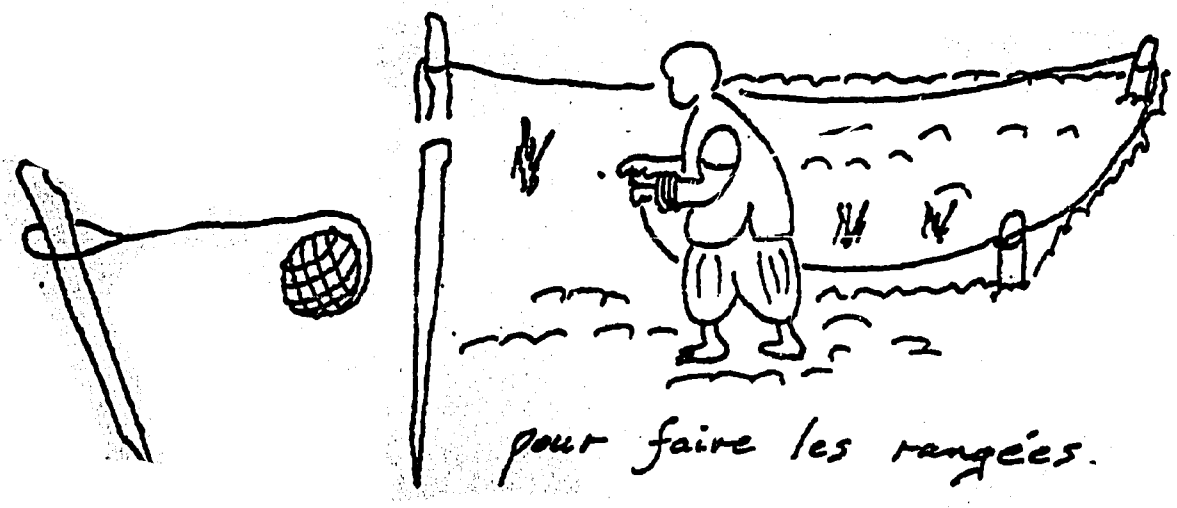


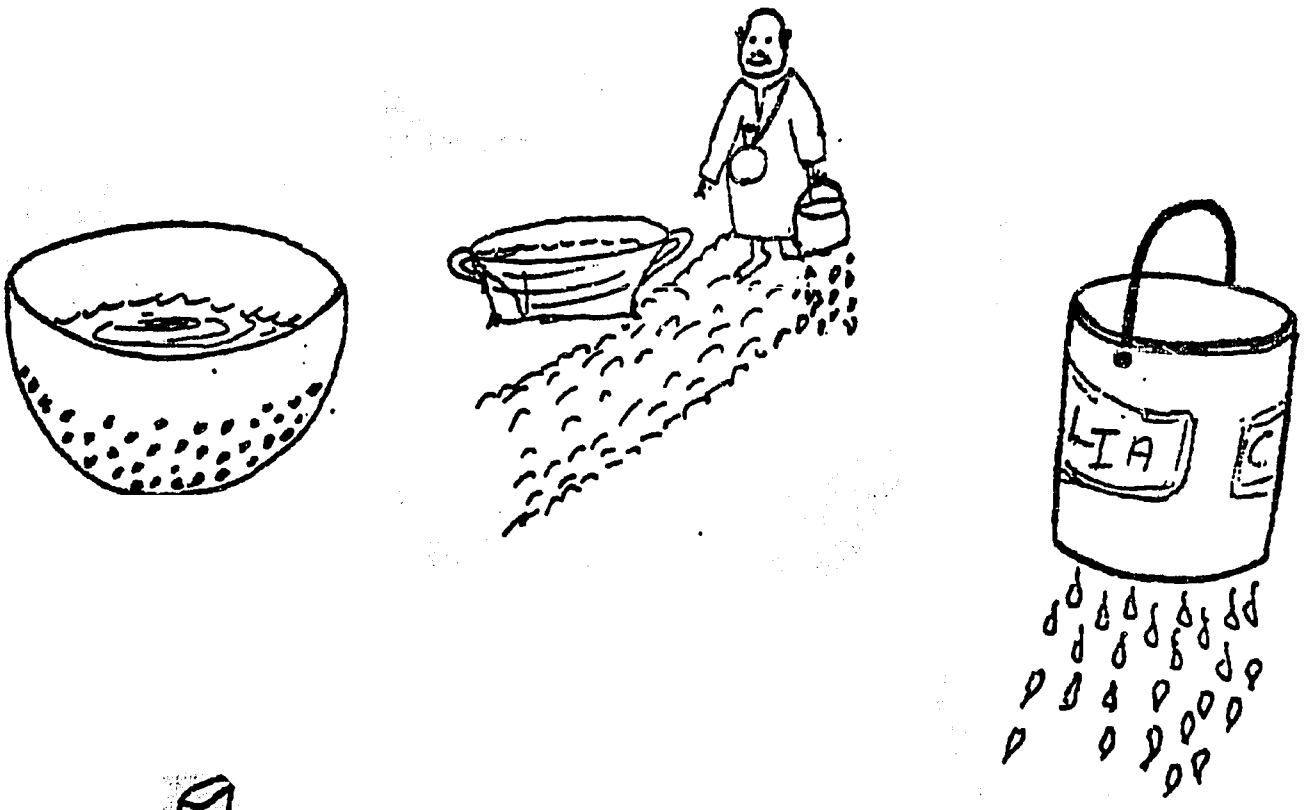


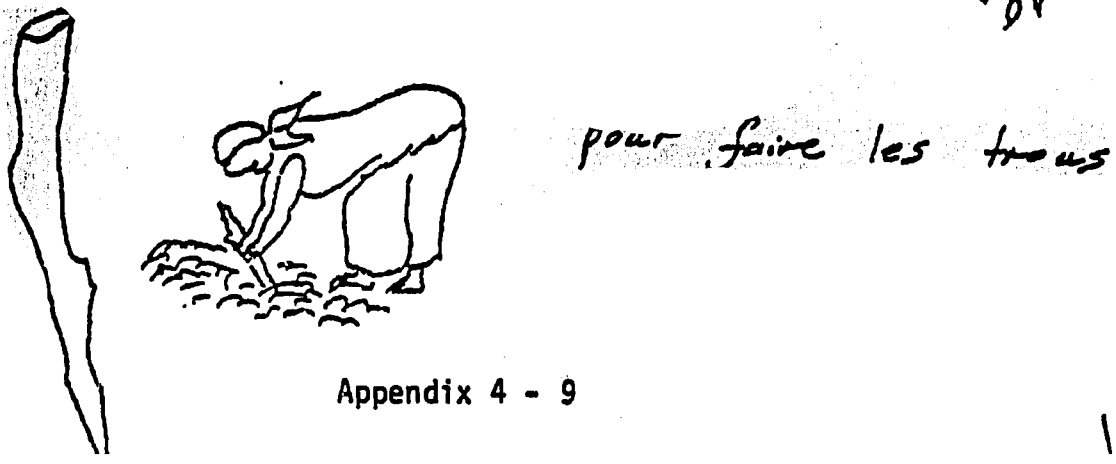




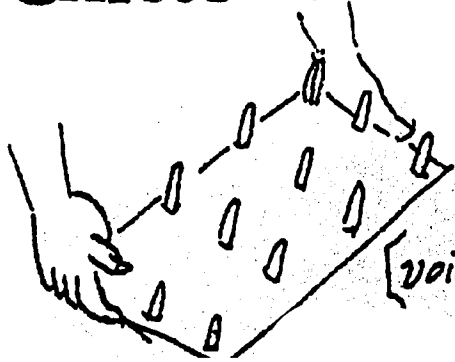
Outils fabriqués Par le fermier



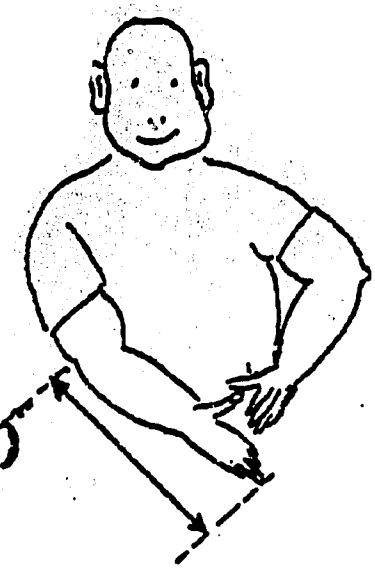




Unités de mesure

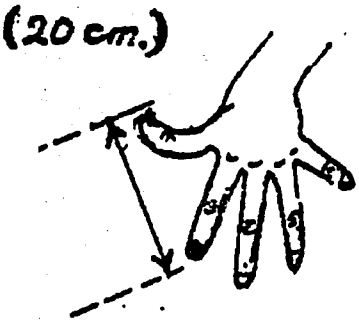


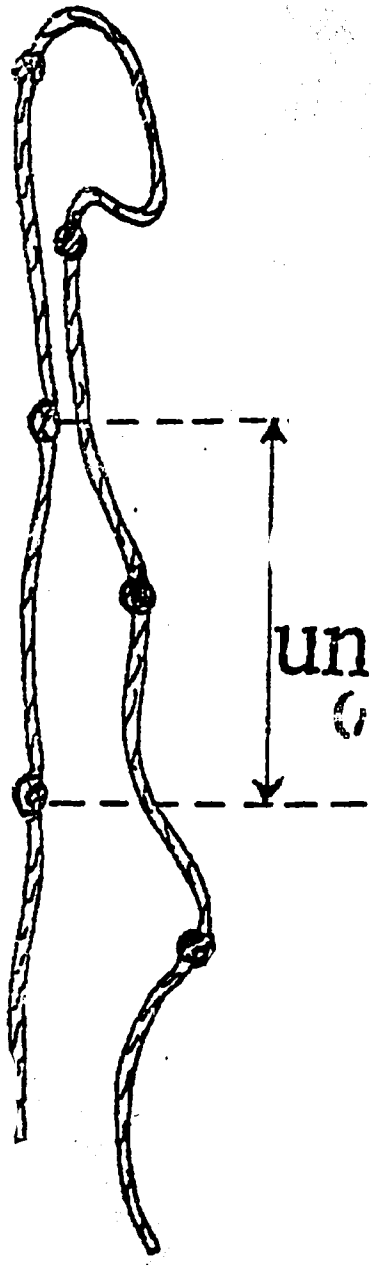
[voir page .]



un drärr (50 cm.)

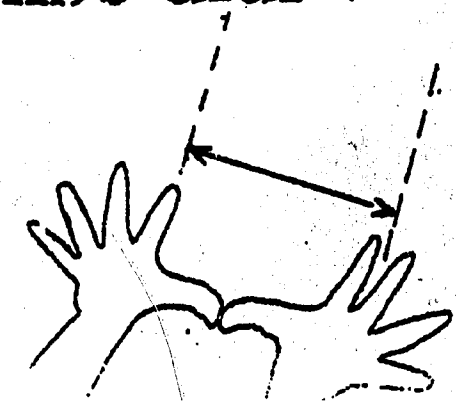
un sibri (20 cm.)



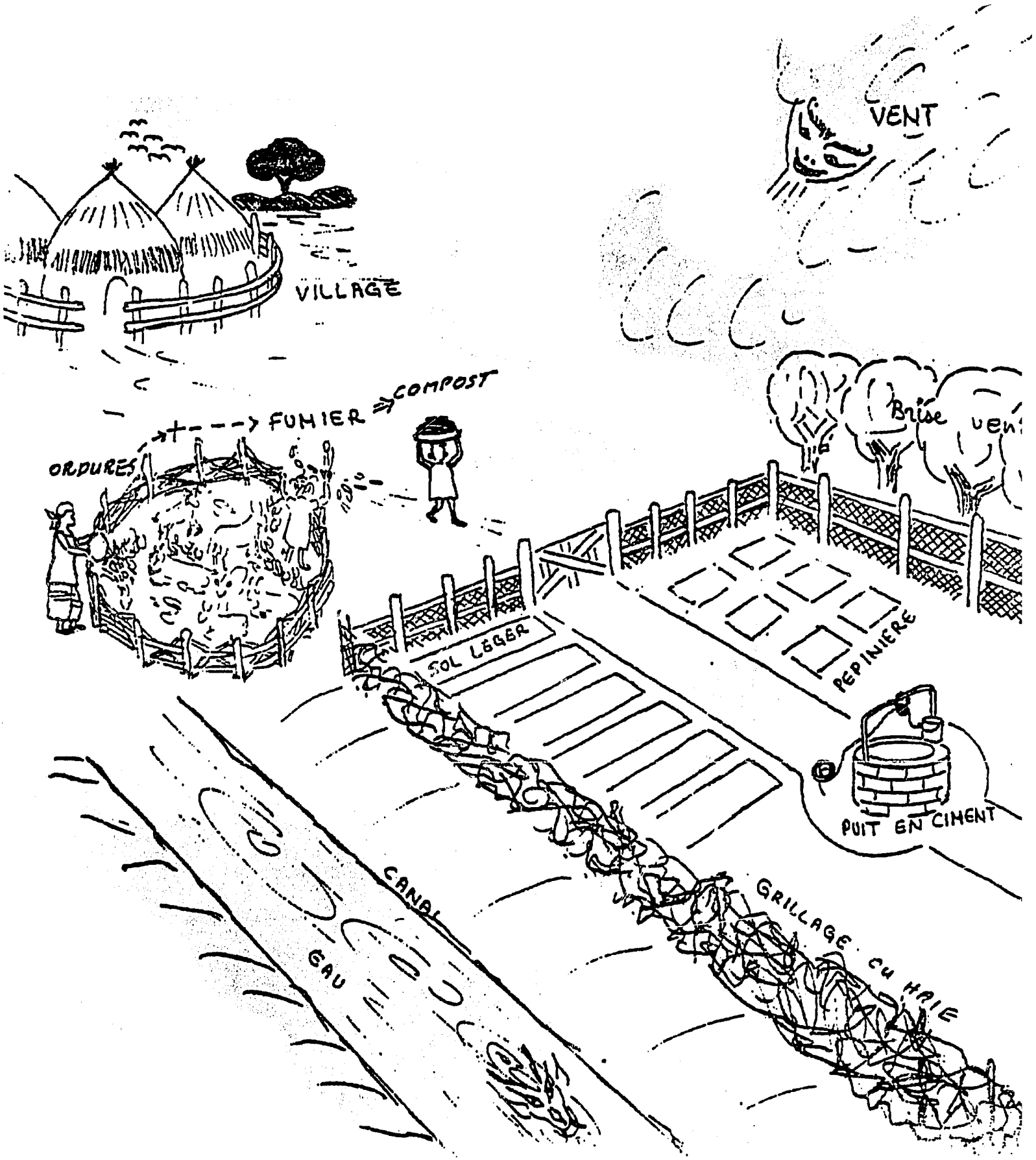


un metre
(100 cm.)

chibe didi (40 cm.)



Le Jardin Idéal



Entretien d'une Planche

therefore not in competition for water with the crops, also their roots do not harbor nematodes.

- o Manure. If animals can be penned near the garden this will provide a source of manure which will not have to be transported a long way and can even be supplied to the soil when new.

C. Marking Out Beds and Working the Soil

Having laid out the beds in an orderly manner -- for ease of working, their soil must be thoroughly prepared.

- o Many vegetable species root up to 60 cm deep and unless they can root easily to this depth they will not grow well. The effects of proper soil preparation are to facilitate water penetration, to aerate the soil, and to loosen it. This is particularly important where root and tuber crops are being grown.

- o Appropriate tools are necessary as the alluvial soils of most Mauritanian gardens are well compacted and hard to break up. Picks and heavy hoes will be required to dig the soil and break up the large clods.

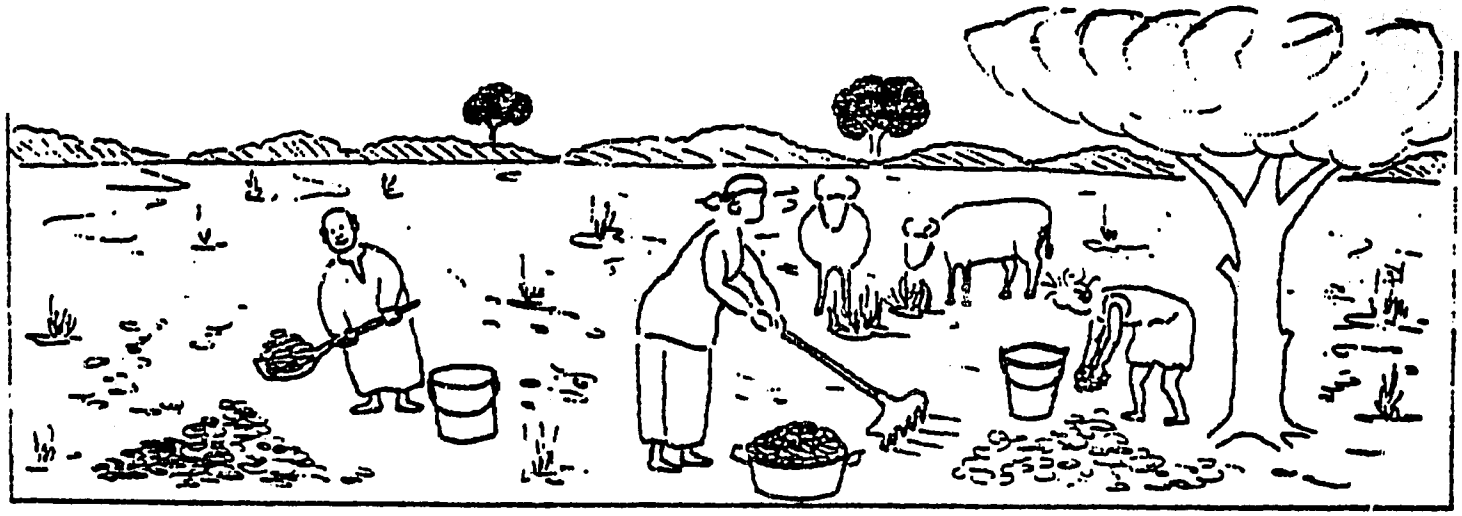
- o These large clods can then be further broken up with the saccade, or small Mauritanian hoe.

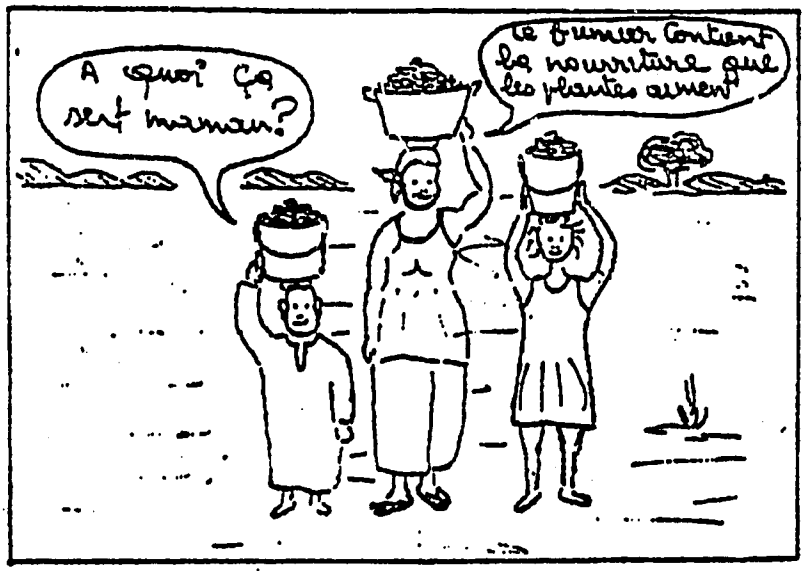
- o Watering and raking will complete the work to the point where the soil is loose and evenly reduced to small pieces.

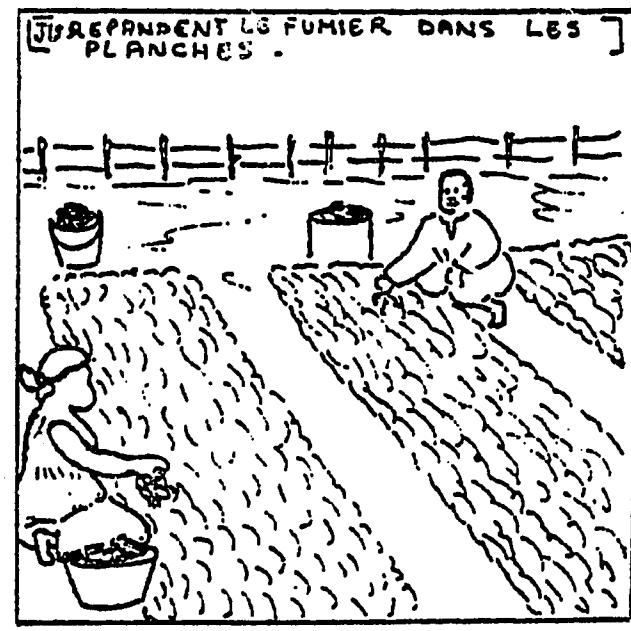
D. Soil Improvement

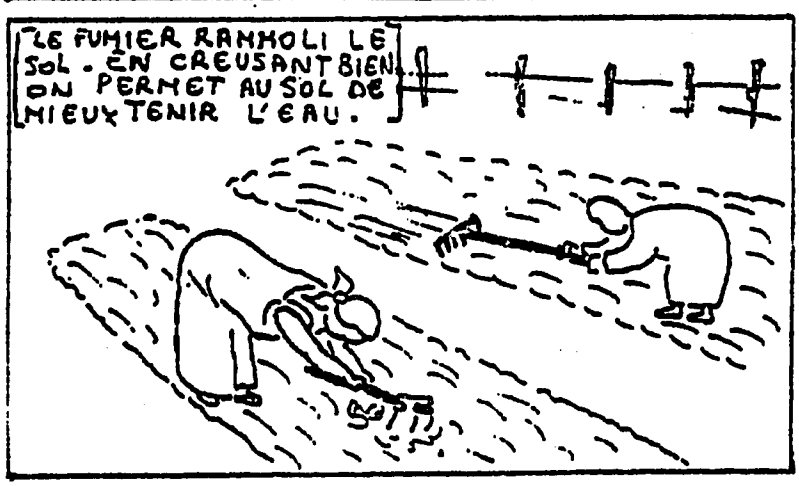
The nutrient quality of the soil should be improved at the same time that it is being broken up. There are a number of good soil additives available to the Mauritanian gardener.

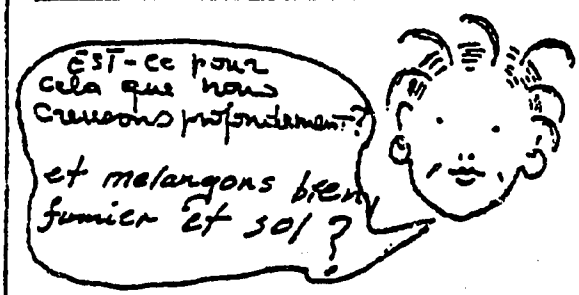
l'Amélioration du sol du jardin

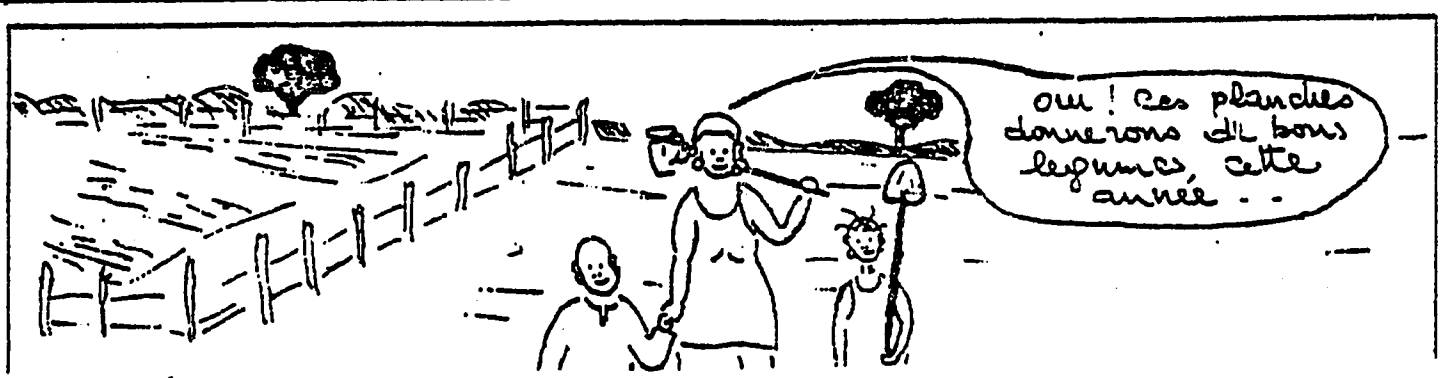




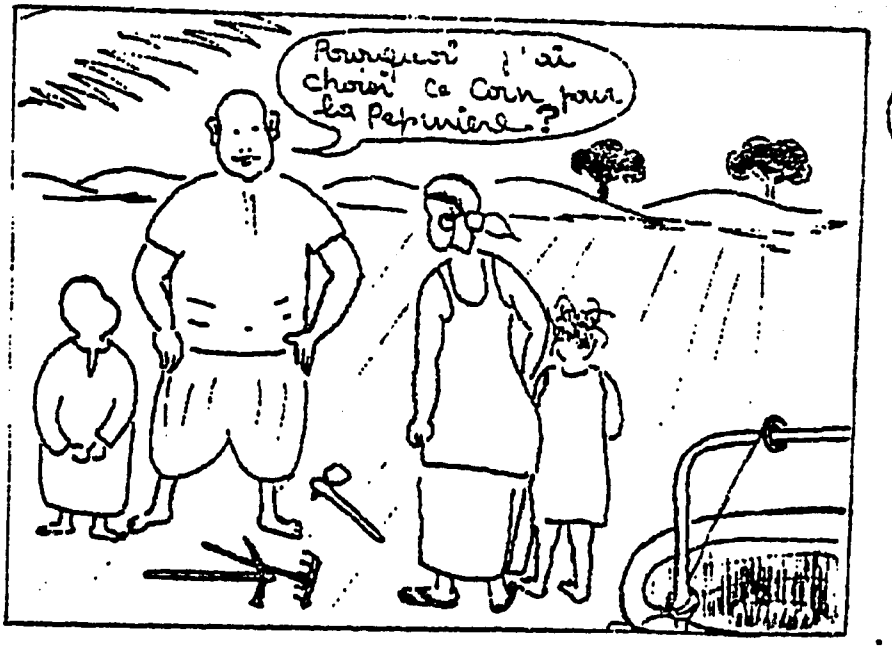


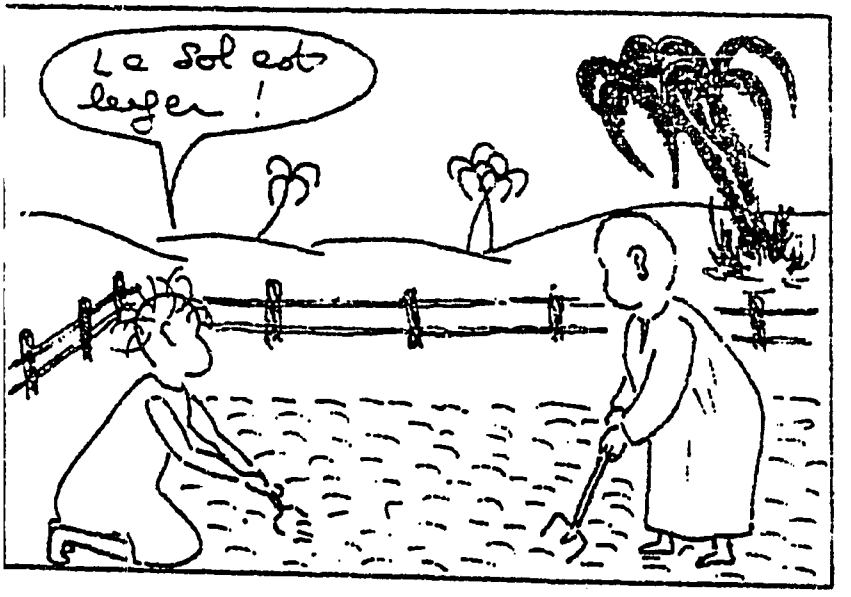


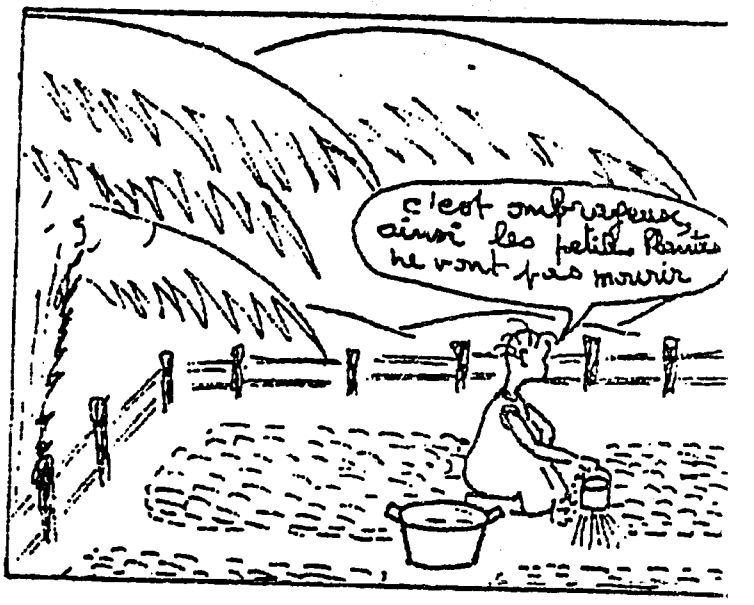




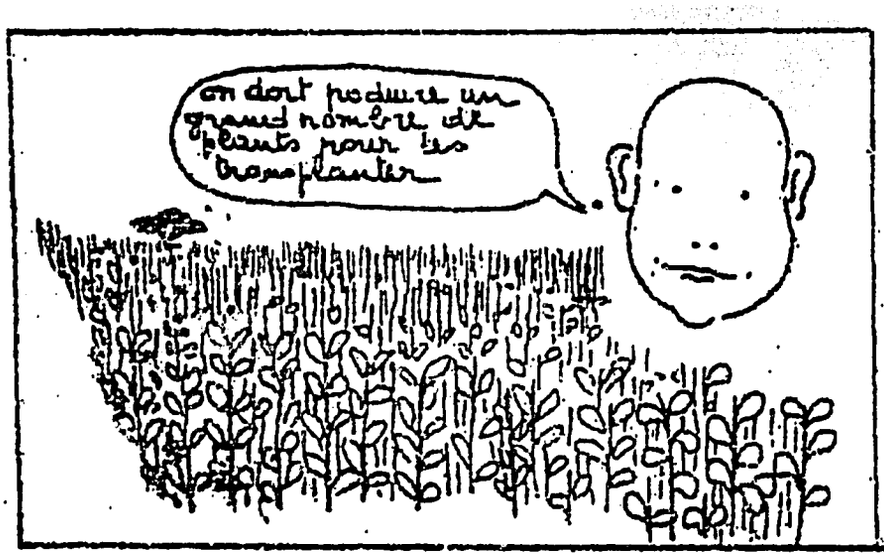
Une Pépinière Idéale

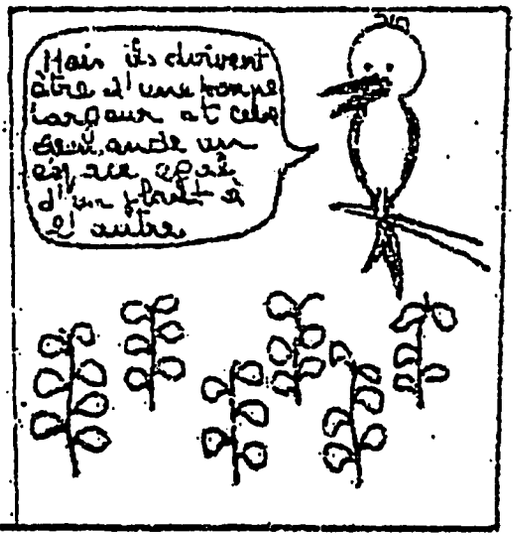


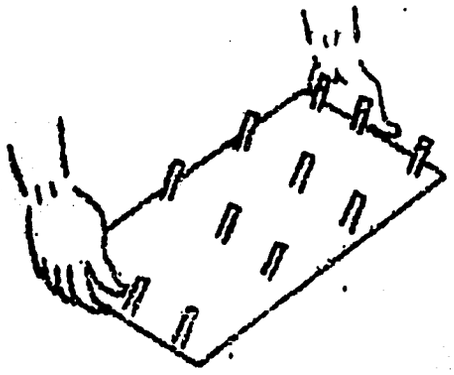




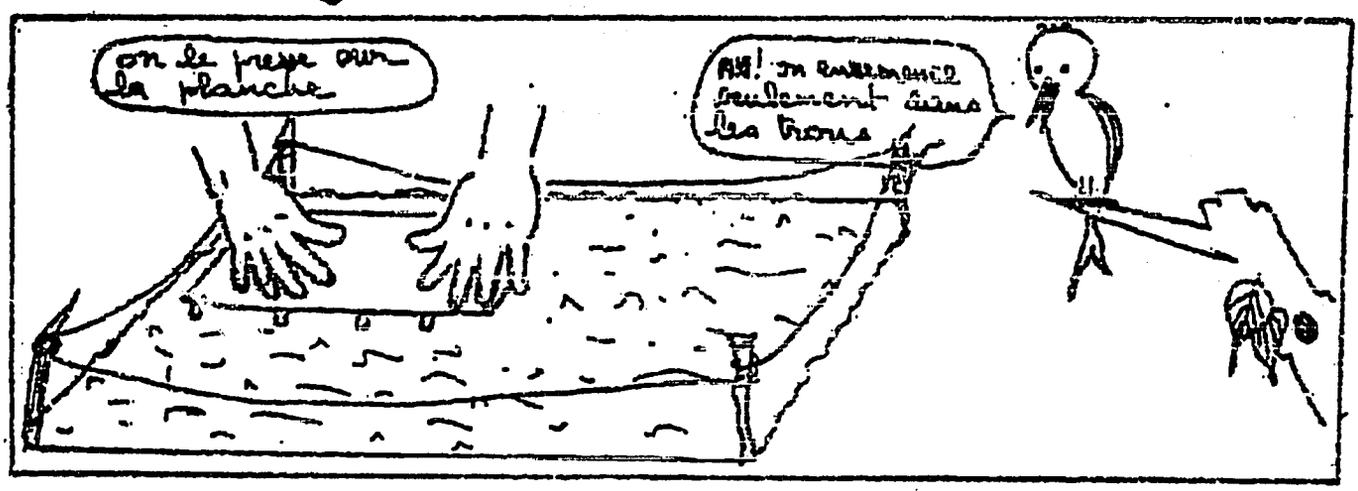
La Pépinière 2

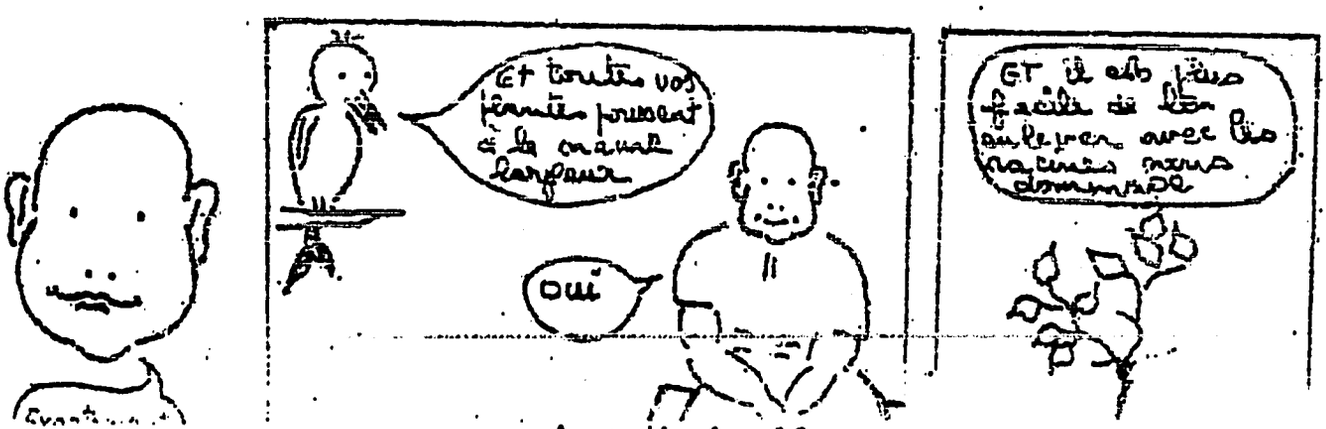






d'ailleurs voila l'espaceuse





- The manure of animals. Cow manure and poultry manure are highest in food value, but horse, donkey, goat and camel manure are all very good soil additives.

- Dried plant remains. The stalks and leaves of last season's crops or the weeds cleared from the garden and surrounding area.

- Well rotted plant remains. This is called compost and can be produced by the gardener by throwing all fresh weeds, manure, household waste, and dried plant parts into a pit, watering the material and leaving it to rot. After a few months it can be dug out and added to the soil.

- Green manure. This can be only carried out where the water is in good supply all year round and where the garden is effectively in production for 12 months of the year. It consists of sowing a crop--of bean plants or of forage plants--and turning it in after a few weeks of growth, while it is young, green and thickly growing.

- Mulching. It is often supposed that manure must be dug into the soil deeply. This is one method of application but manure can also encourage good plant growth if applied as a mulch. In a number of gardens manure is simply spread over the bed five to 8 cm thick. Watering over this carries nutrients down into the root zone and keeps the bed cool and moist. It slows evaporation of water. The good gardener will both dig in manure and mulch with manure.

E. <u>Choice of Site for a Seed Bed Nursery</u>

(See illustration)

F. <u>Seeding a Nursery Bed</u>

There are many reasons for starting plants in a nursery bed rather than directly in the field.

- Many seeds such as onion, pepper, parsley take over 10 days to germinate and must be carefully watered so that their roots are kept damp but not soaked for nearly 30 days. This is best done on a small scale in a nursery.

- Protection. It is easier to shade, spray, and fence a nursery garden than a field, and the tiny plants need intensive care.

- One may be preparing the field while the plants are still in the nursery.

- One can control the depth of seeding and the plant spacing more closely in a nursery than in the field and this controls in turn the quality of the final agricultural product. It follows that in the well-run nursery the plants are put in at precise depths and intervals.

G. Transplanting

When the plants in the nursery are ready they are transplanted into a prepared field.

Points to observe are:

- The seed bed should be watered before they are lifted.

- They should be lifted with as little damage to the roots as possible, and with soil surrounding the roots.

- They should be carried to the field quickly and in a container that keeps their roots moist.

- The holes prepared to receive them should be sufficiently large not to squash the roots and should itself be watered.

je fais les trous...
... et ... les arrose bien
j'arrose aussi les petites plantes que je veux transplanter
... alors, je les enlève sans trop avarier les racines
COUPEZ LES FEUILLES SI ON A TROP
je les port au jardin.
et les plante dans les trouxx deja arrosés

Aujourd'hui on commence la culture du gombo....

ON MET LES PETITS BATONS OU ON VEUT SEMER LES GOMBOS. A UNE DISTANCE DE 30cm x 30cm

Bon! Papa qu'est ce que c'est 30cm?

30cm font à peu près les deux mains ou celle de ta mère

(CETTE PAGE A TRENT -30-; CMS DE LONGEUR-)

30cm (a peu pres)

LES PETITS BATONS MARQUENT OU ON MET LES SEMENCES DES GOMBOS

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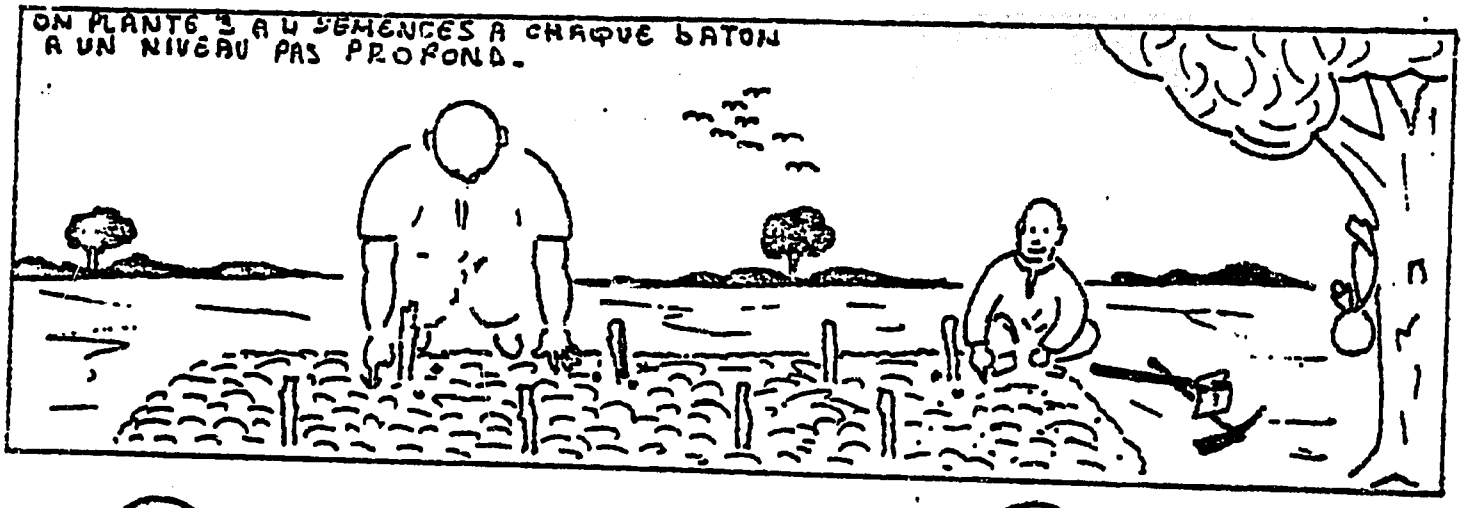
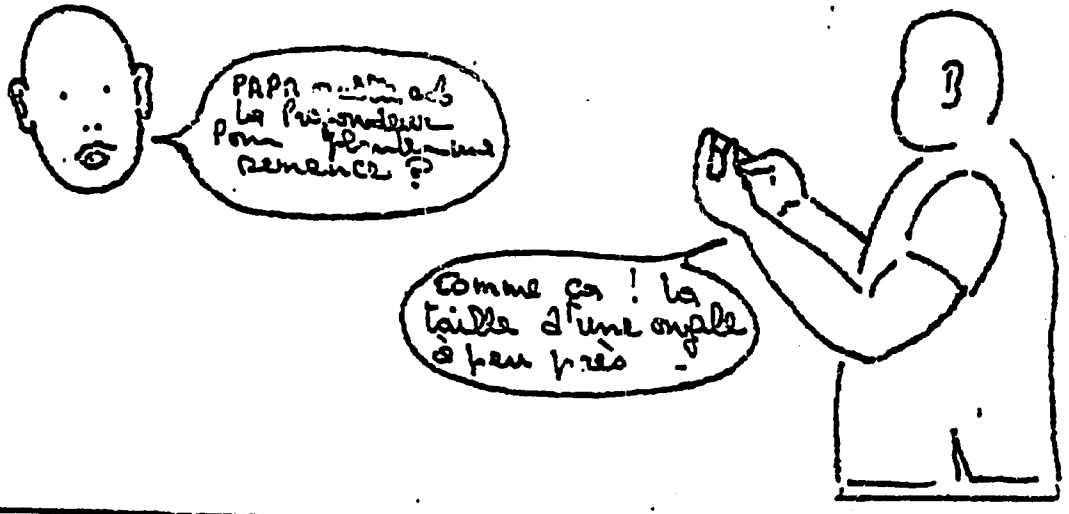
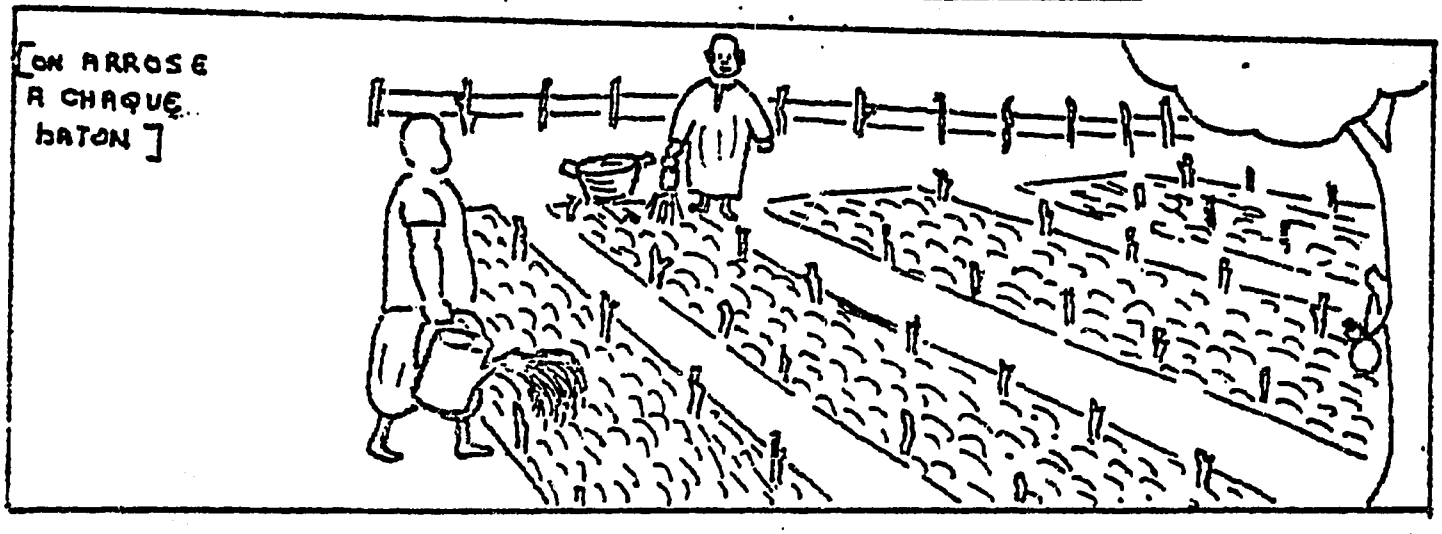
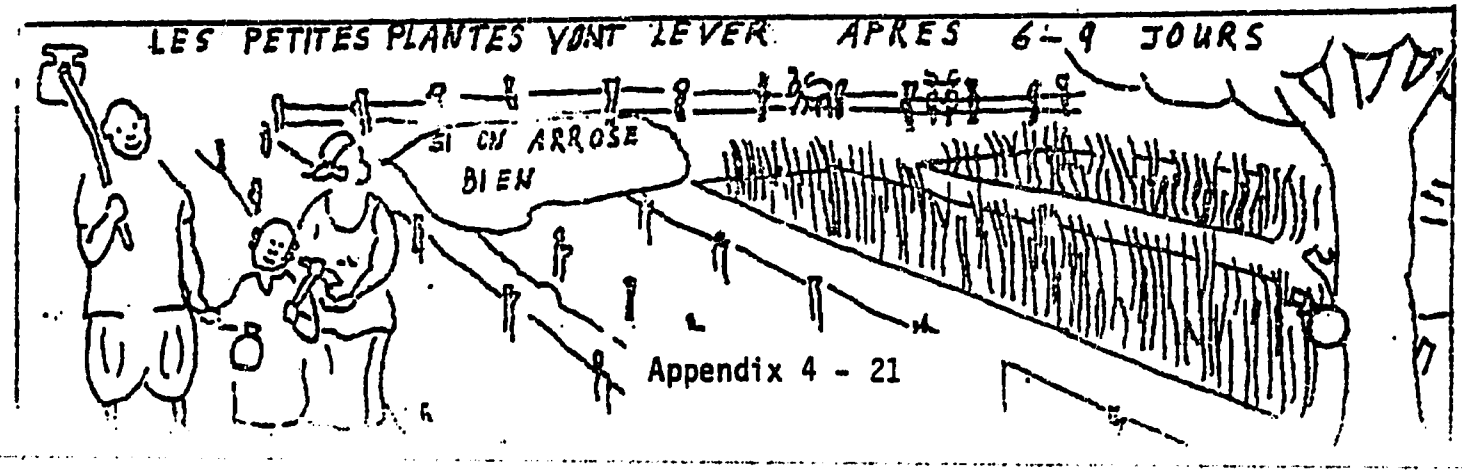

ON PLANTE 3 A 4 SEMENCES A CHAQUE BATON
A UN NIVEAU PAS PROFOND.


PAPA
Comme ça ! la taille d'une ongle à peu près


[ON ARROSE A CHAQUE BATON]


LES PETITES PLANTES VONT LEVER APRES 6-9 JOURS
SI ON ARROSE BIEN

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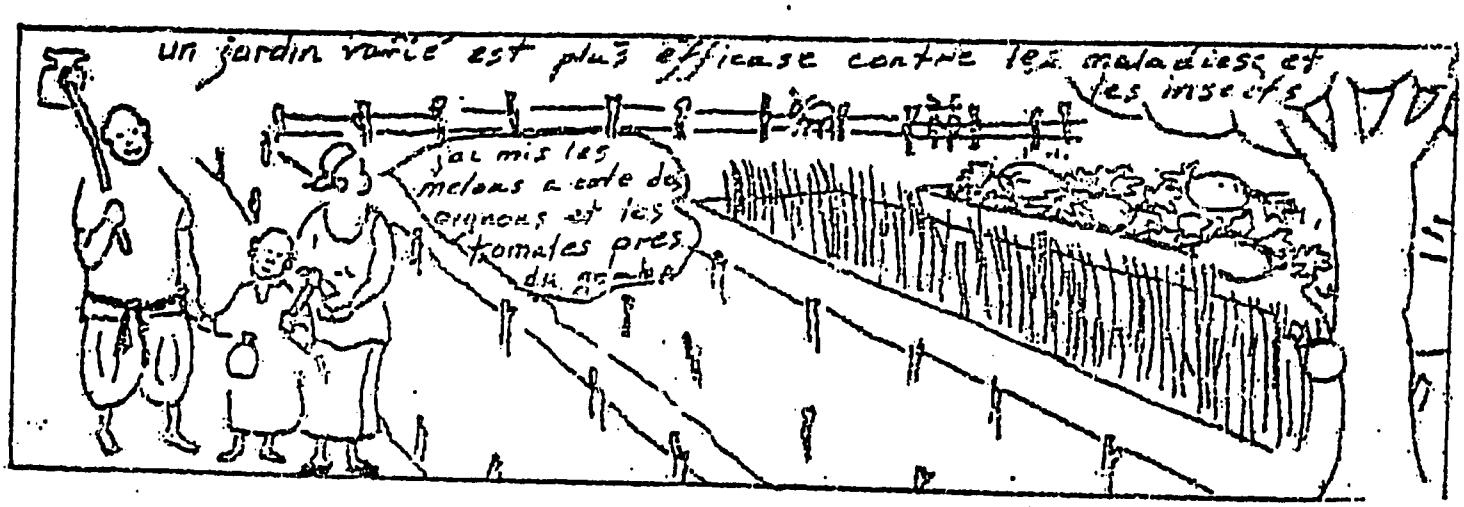
Les Gombos --- 3

Il y a un mois et les gombos ont poussés lentement "HAMDOU LILAH"
Mais PAPA ! Pourquoi tu tires les bonnes plantes..
J'éclaircis les gombos, car une seule suffit à chaque bâton
Ce n'est ni trop loin, ni trop serré
Les gombos aiment être à 30cm l'un de l'autre...
Jamais encore je n'ai vu de gombos comme ça

Protection des Cultures



- The holes should be filled and then the soil firmly pressed round the roots of the transplant.

- Finish by watering the field.

- Do all this in cool weather or in late afternoon.

H. Crop-Method Sheet, Okra

(See illustration)

I. Plant Protection by Means Other Than Sprays

Total reliance on sprays is unwise and unnecessary. Good management can certainly reduce the need to spray against insects and fungi.

- Choice of resistant varieties.

- Rotation, i.e., never planting the same crop in the same bed two seasons running.

- Interplanting. This is done routinely in most gardens in Mauritania. Two or three rows of one crop are flanked by two or three rows of another crop. Large blocks are avoided.

- Fallowing. Leaving the soil dug during the hot dry season.

- Physical destruction. The larger leaf-eating larvae can be picked off the plant and killed if a daily inspection is carried out and the problem dealt with while the population is still small.

J. Life Cycles of Insects

It is not generally realized by Mauritanian vegetable growers that many insects go through a change of form during their life and that the worm eating into their tomatoes comes from the eggs laid by a moth that flies

over the fields at night. The farmers will not attack the problem to their best advantage until this fact is understood. The life cycles here presented will be explained and the diagrams interpreted by the Agricultural Extension agent.

The little green worm that eats holes in your cabbage leaves is originally hatched from an egg.

This egg is laid by a moth, a small butterfly with grey-brown wings that flies at night among the cabbages and lays eggs (many hundreds of eggs) on the leaves.

After a day in the warm sun these eggs hatch and the tiny worms crawl out; immediately they begin to eat.

As they eat they become bigger and eat even more.

When they have been eating for about eight days and have reached a size of about two to 3 cm they stop eating and start to push out a thread of gluey material.

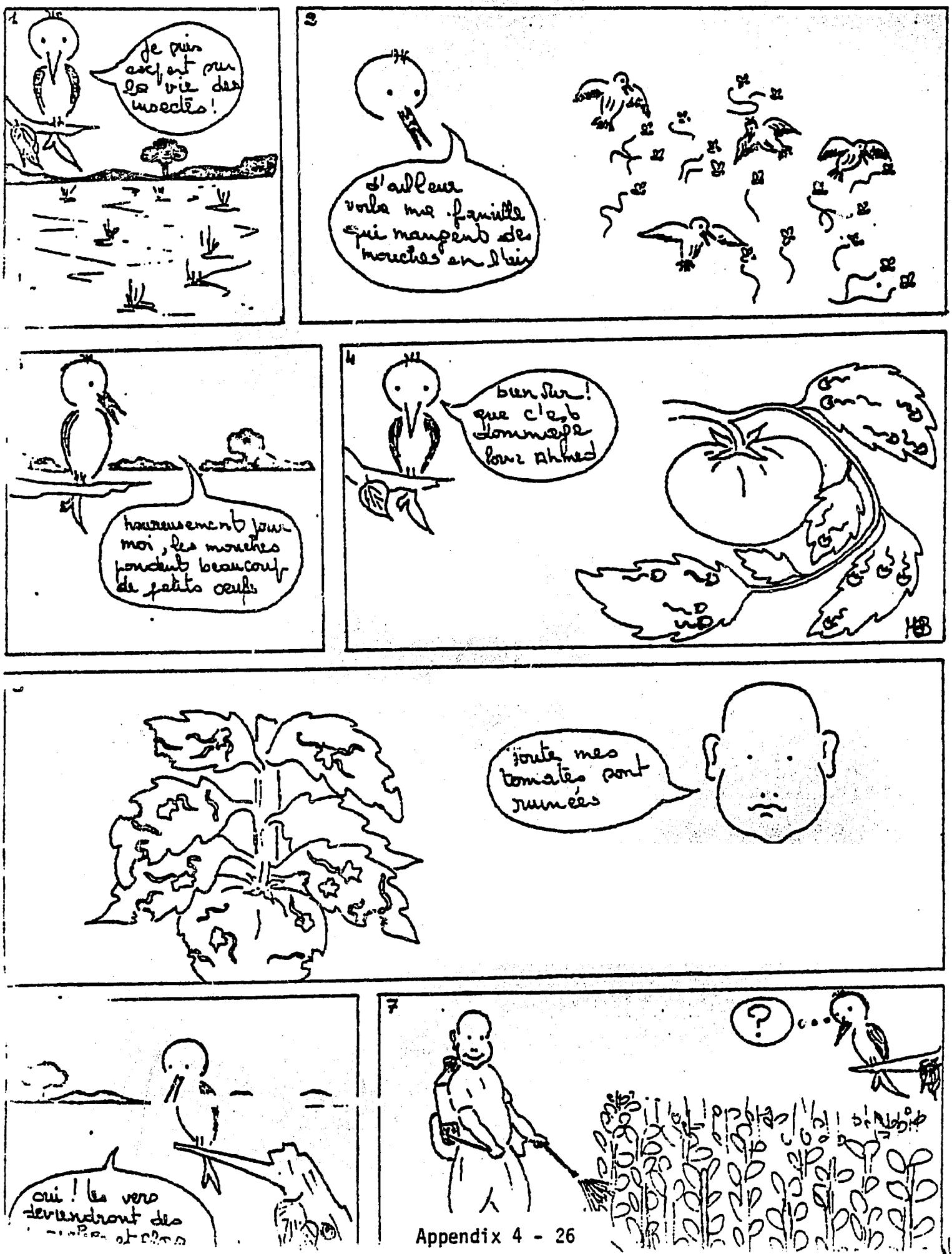
This hardens into a hair-like thread which they start to wind round themselves.

They wind themselves round with this thread until they are completely covered like a parcel bound in cotton. This is called the pupa. This pupa sticks to the cabbage, sometimes on the leaf, sometimes inside the head and it stays there while changes are miraculously happening to the worm -- in fact, it is changing into a moth.

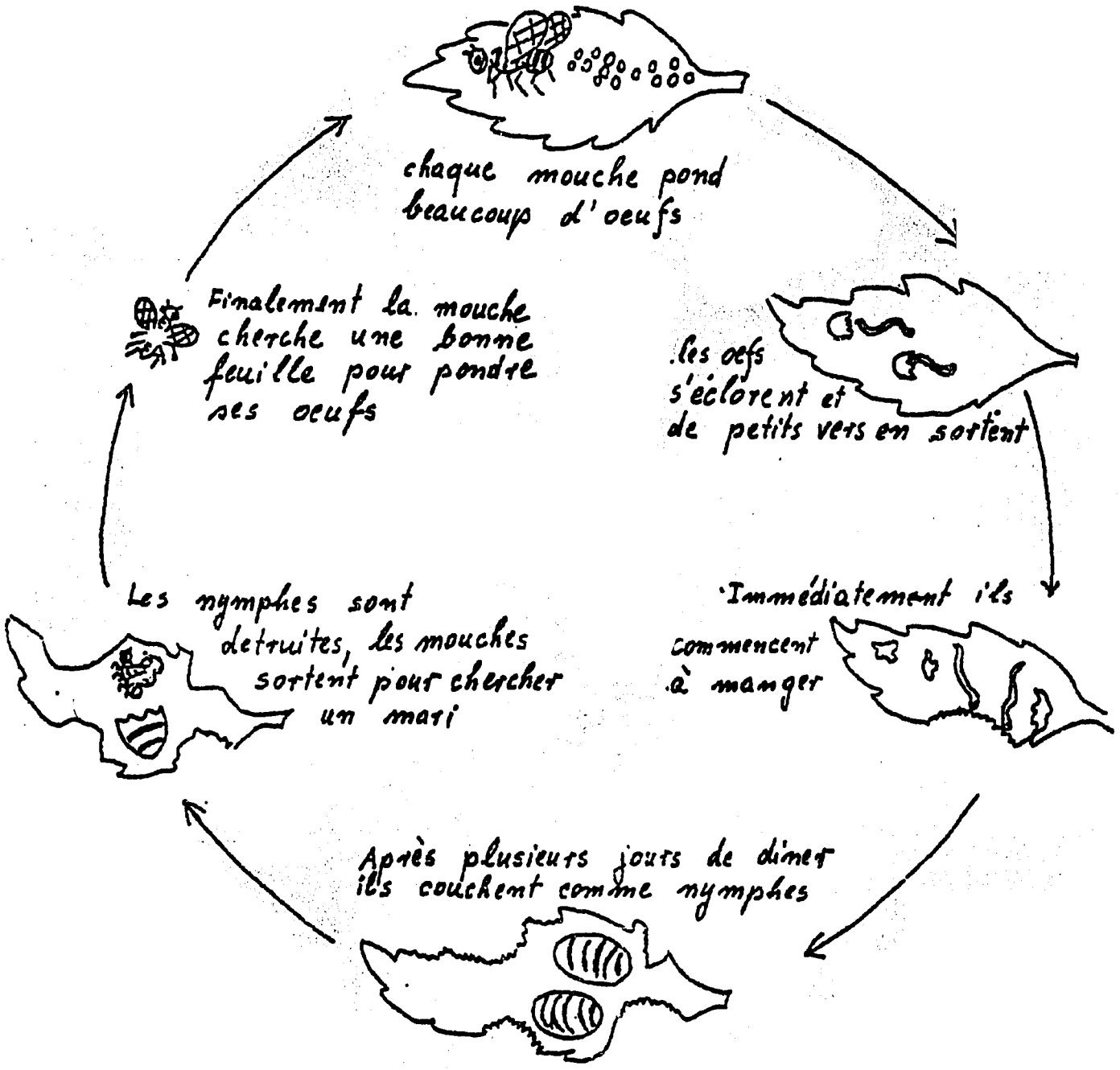
The changes take several days. Then the little moth eats its way out of the pupa, lies for a short while in the air to dry off, and then flies away to mate.

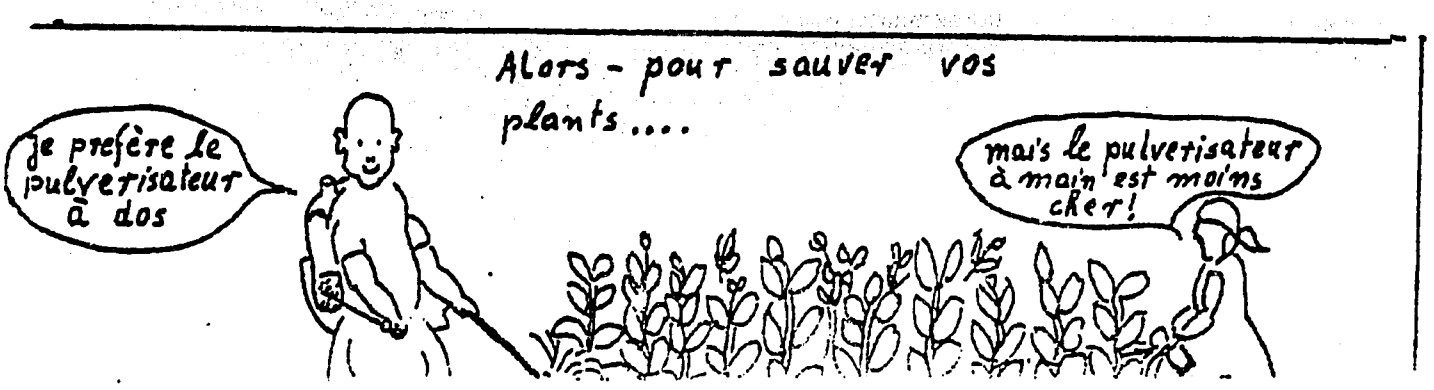
A few days later it lays its eggs on a cabbage leaf.

L'expert parle des insects



Le Cycle de la Reproduction Chez les Mouches





K. Spraying with Home-made Insecticides

There are many good and effective insecticides available in local village stores or growing in the bush. The recipe for kerosene emulsion is illustrated but this the most complicated to prepare. Below are included a few others.

- Kerosene emulsion

  A liter of water
  A liter of kerosene
  100 grams of soap

  Boil the water and dissolve the soap in it. With this mixture as hot as possible slowly add the kerosene, stirring all the while; cool it down and store in bottles. For use dilute it 1:15 with water.

- Disinfectant solution (bottles of Cresol disinfectant, variously colored and scented are found in many village stores)

  One capful or large spoon of cresol
  One pinch of OMO or similar detergent powder
  10 liters of water

  Mix well and spray on crops.

- Bleach solution

  One capful or large spoon of Eau Javel
  One pinch of OMO or similar detergent
  10 liters of water

  Mix well and spray directly on crops; repeat 2 to 3 days running as this chemical is active over a very short period.

- Cigarette solution

  One cigarette or 6 dog-ends (stubs of cigarettes that have been smoked)
  10 liters of near boiling water
  One pinch of OMO or similar detergent

  Steep the cigarette material in the hot water stirring occasionally. When the water is cool, mix in the detergent and spray this solution on the crops.

- Neem tree solution

  A handful of neem fruits, or two handsful of finely divided neem wood chips
  A pinch of OMO or similar detergent
  10 liters of hot water

  Steep the pounded neem tree material in the hot water. When cooled, add the detergent and mix well. Spray on crops

.Take great care to keep children away from all these solutions.

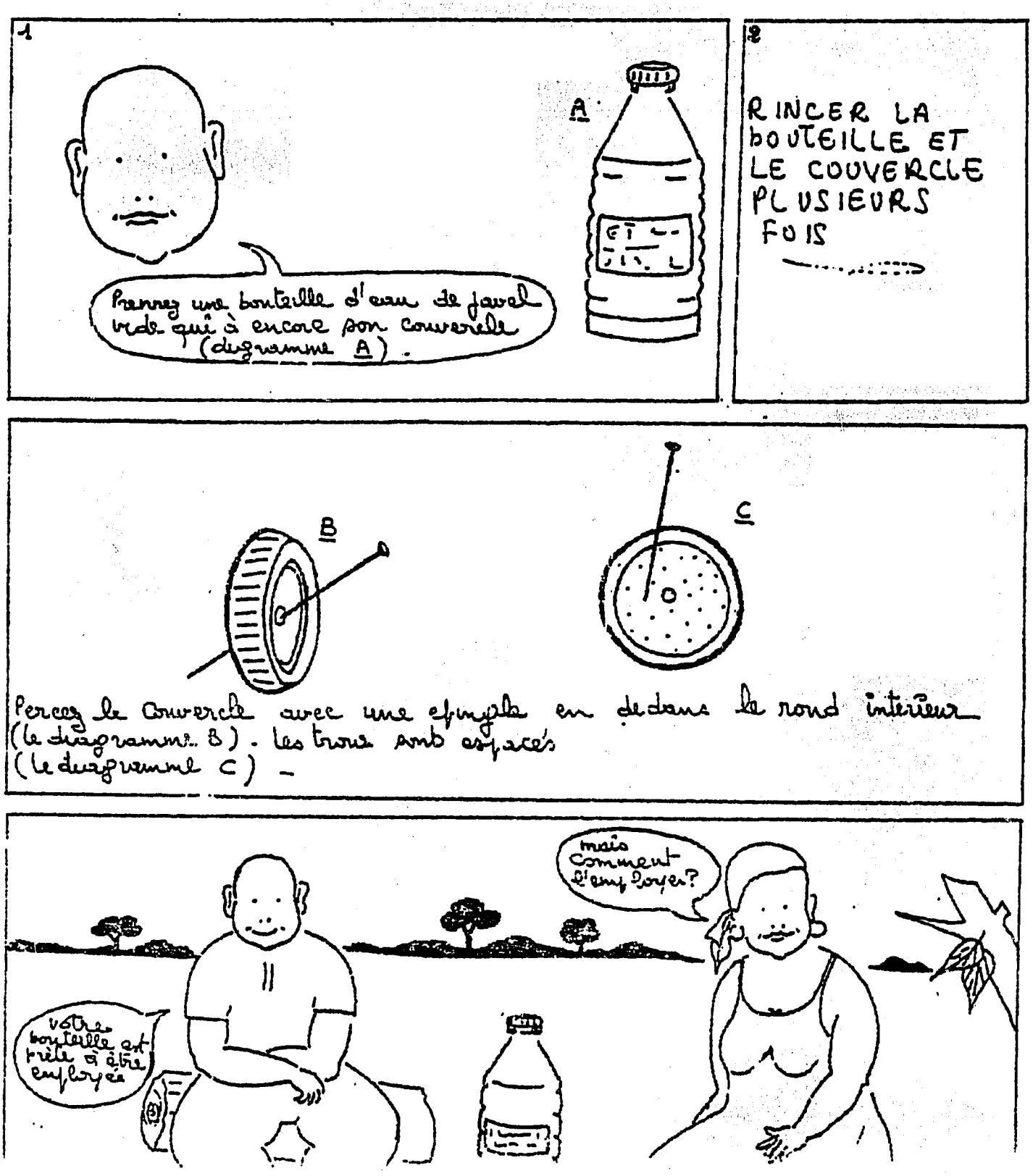
L. <u>Making and Using a Hand-held Sprayer</u>

- The best kind of bottle for a hand held sprayer is made of still plastic that will recover from a slight squeeze immediately.

- The lid must be replaceable and yet firmly fixed. It has to come off to fill in the spray solution, yet it must not come off when the bottle is squeezed.

- When the cap is pierced for the spray, the individual holes must be as tiny as possible. The finer the jet and the more broken up the drops of solution the better the liquid will cover the plant and the more effective it will be against insects.

Achmet fait son propre pulverisateur à main et enseigne son emploi.



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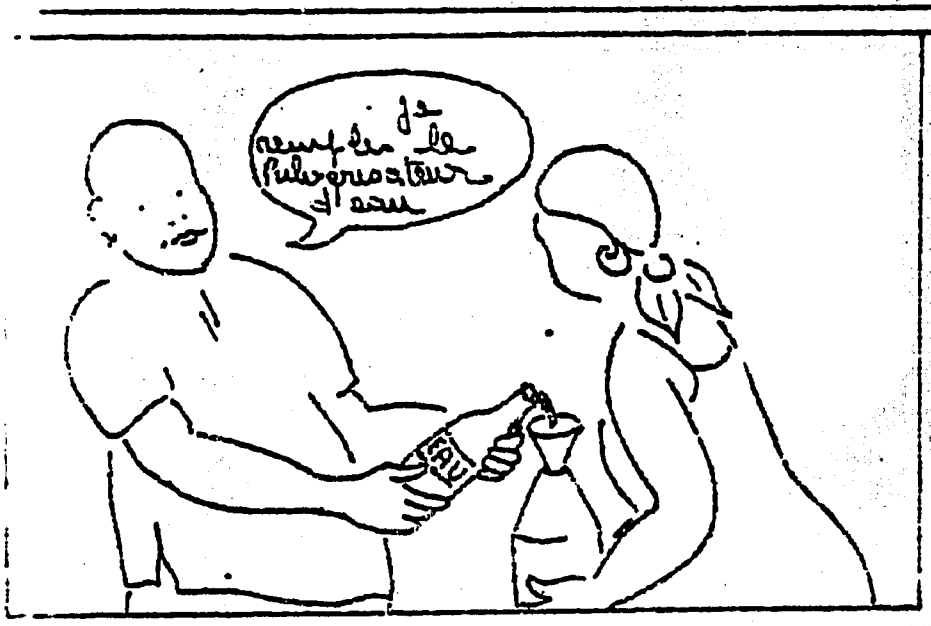
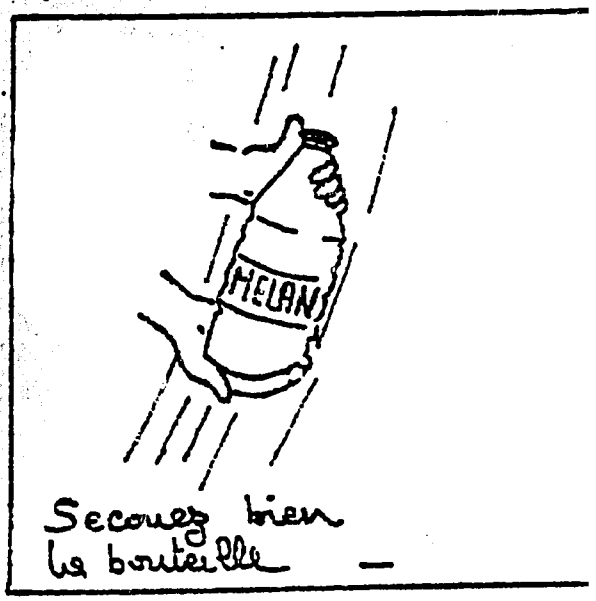
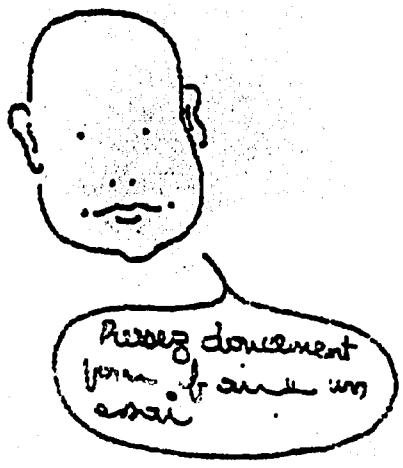
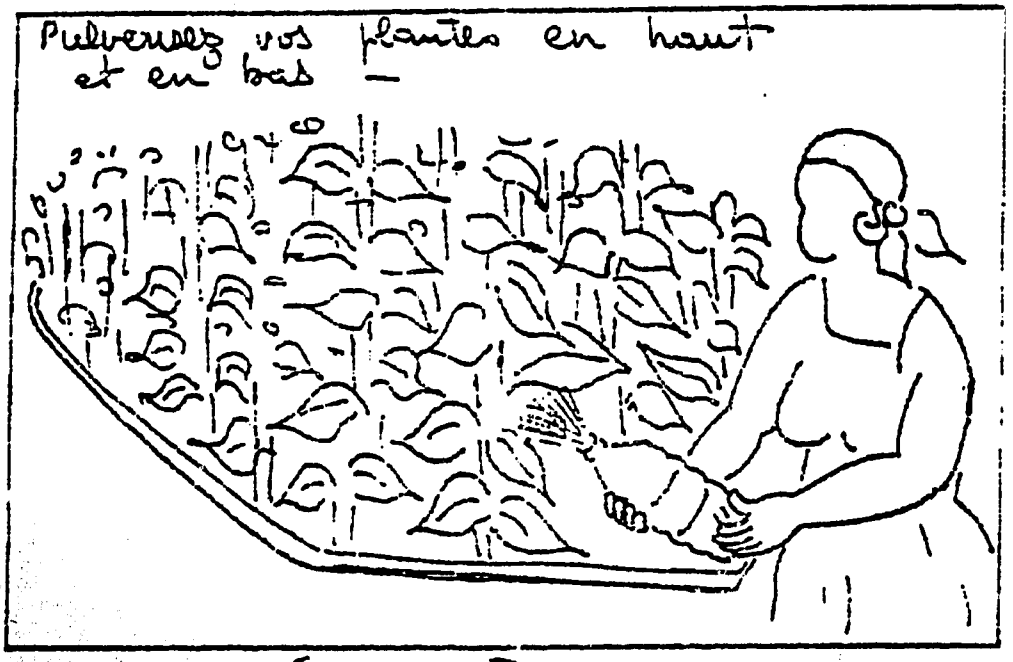
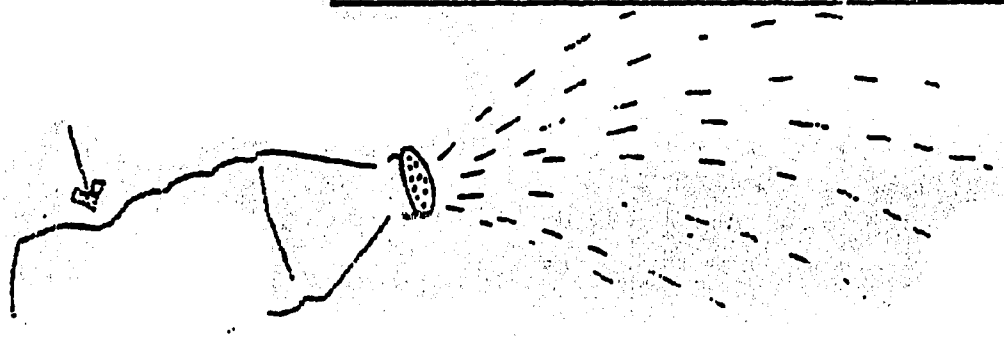
je verse ½ du poison dans votre pulvérisateur
POISON
Ce n'est pas beaucoup !
ET Alors !


je remplis le pulvérisateur d'eau
EAU

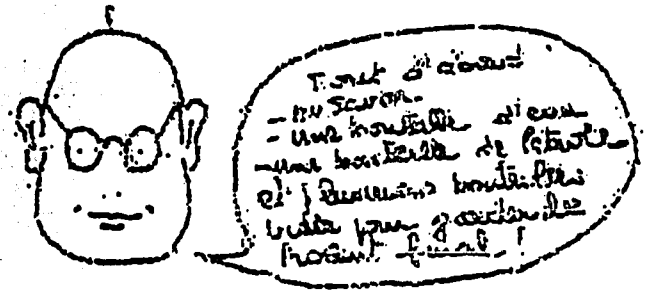

MELANG
Secouez bien la bouteille —

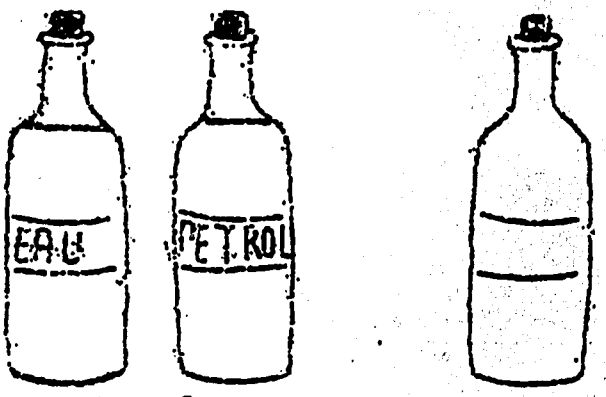

Passez doucement pour faire un essai


Pulvérisez vos plantes en haut et en bas —

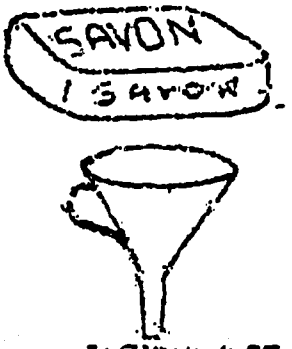


Achmet et le Scientifique font l'insecticide



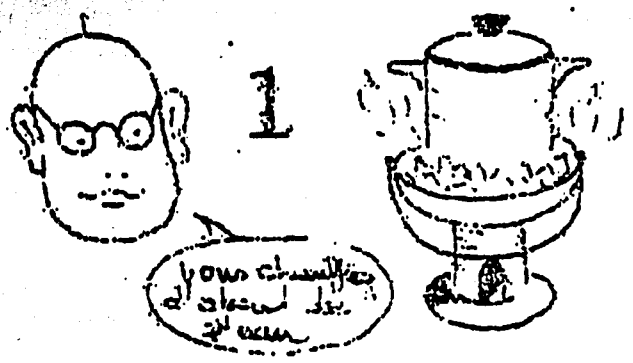


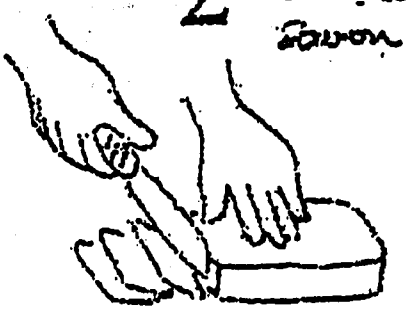
- EAU - PETROLE - VIDE



- ENTONNOIRE

LA METHODE DE FABRICATION





le découpage du savon en tranche

on procède à la dissolution des tranches de savon dans l'eau chaude

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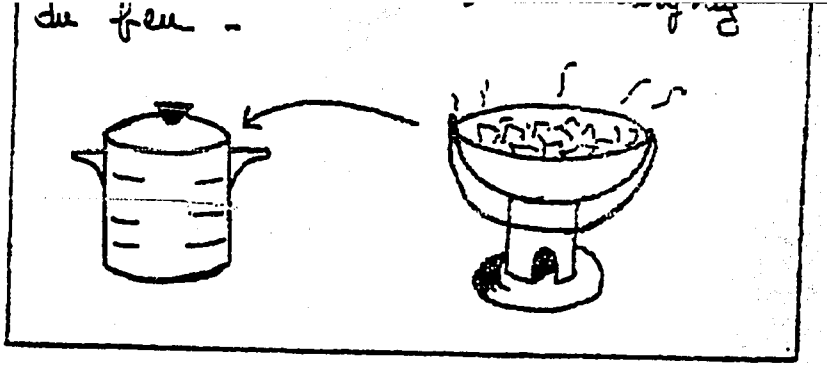
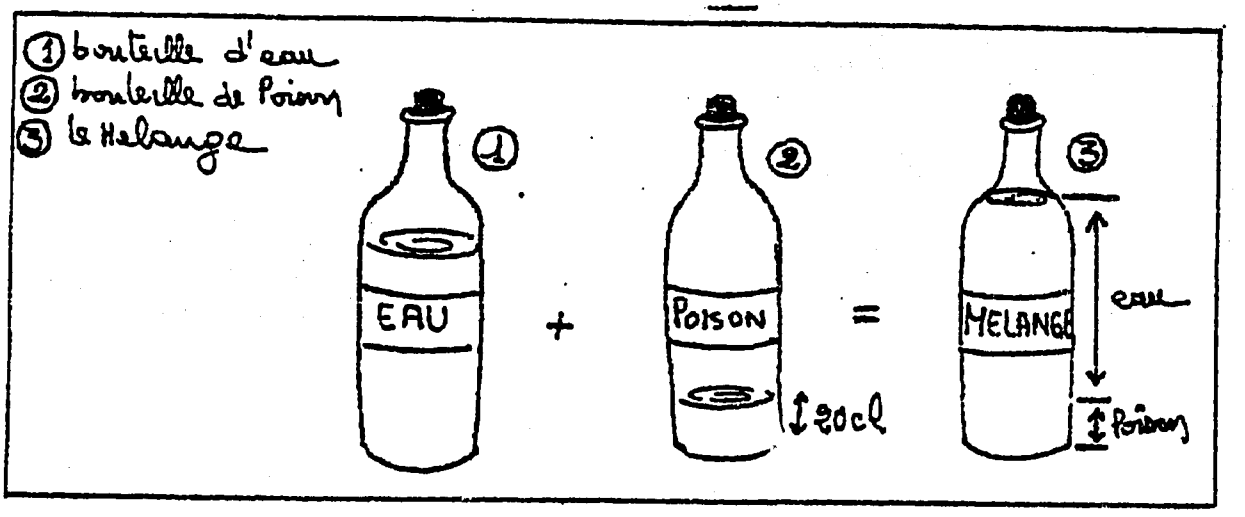
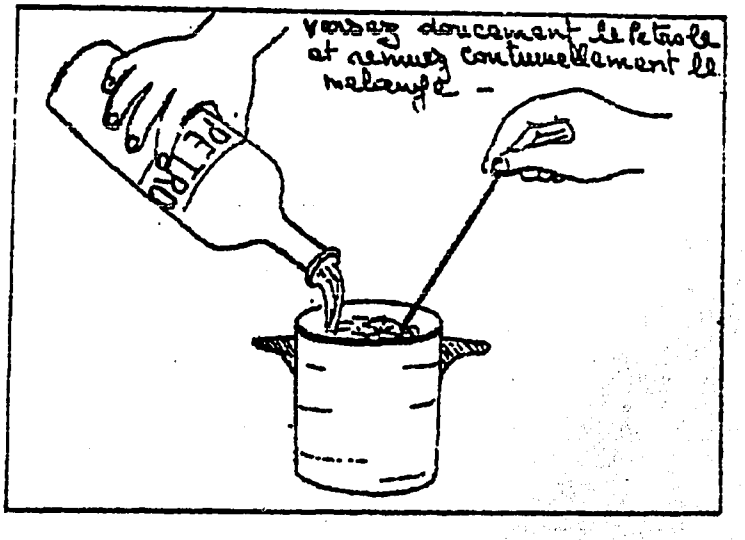
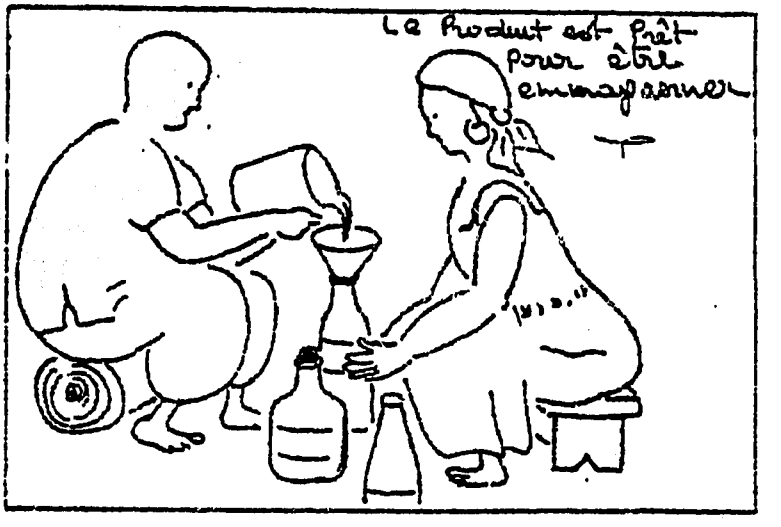


ON DOIT DILUER UN LITRE DE POISON DANS VINGT (20) LITRES D'EAU







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- In using the bottle it is probable that best results will be obtained by shaking at the same time as squeezing out the liquid.

- It is difficult with this technique to spray thoroughly the undersides of the leaf, but every effort should be made to do so.

M. Sun-Drying of Tomatoes

Processing

At the village level this means sun-drying--though smoking and salting are also possibilities. The market for sun dried products is well established in Mauritania as in the surrounding countries and trading into other Sahelian countries could be one of the final options for these products. Each vegetable has its own techniques. Here in this publication priority has been given to the recently introduced crops with the largest trade potential.

- Tomatoes are grown under irrigation after the rains are finished. Relative humidity is decreasing throughout the fruiting season and thus all tomatoes not sold can be dried.

- Fruit for drying should be ripened fully on the vine and be fully red when picked. This affects the color of the final product.

- Fruits should be cut in quarters or in thick slices, i.e., two surfaces should be open to the air.

- Impale on thorn bushes for drying or lay on mats or on the tent roof. In the latter two cases the fruit should be cut in quarters and laid skin side down -- otherwise the fruit will stick to the mat or the tent roof as it dries and will be very difficult to release.

- Dry until moisture cannot be squeezed from the pieces. In the interior of Mauritania the pieces will dry biscuit-hard (less than 1%

Séchage des tomates. 1

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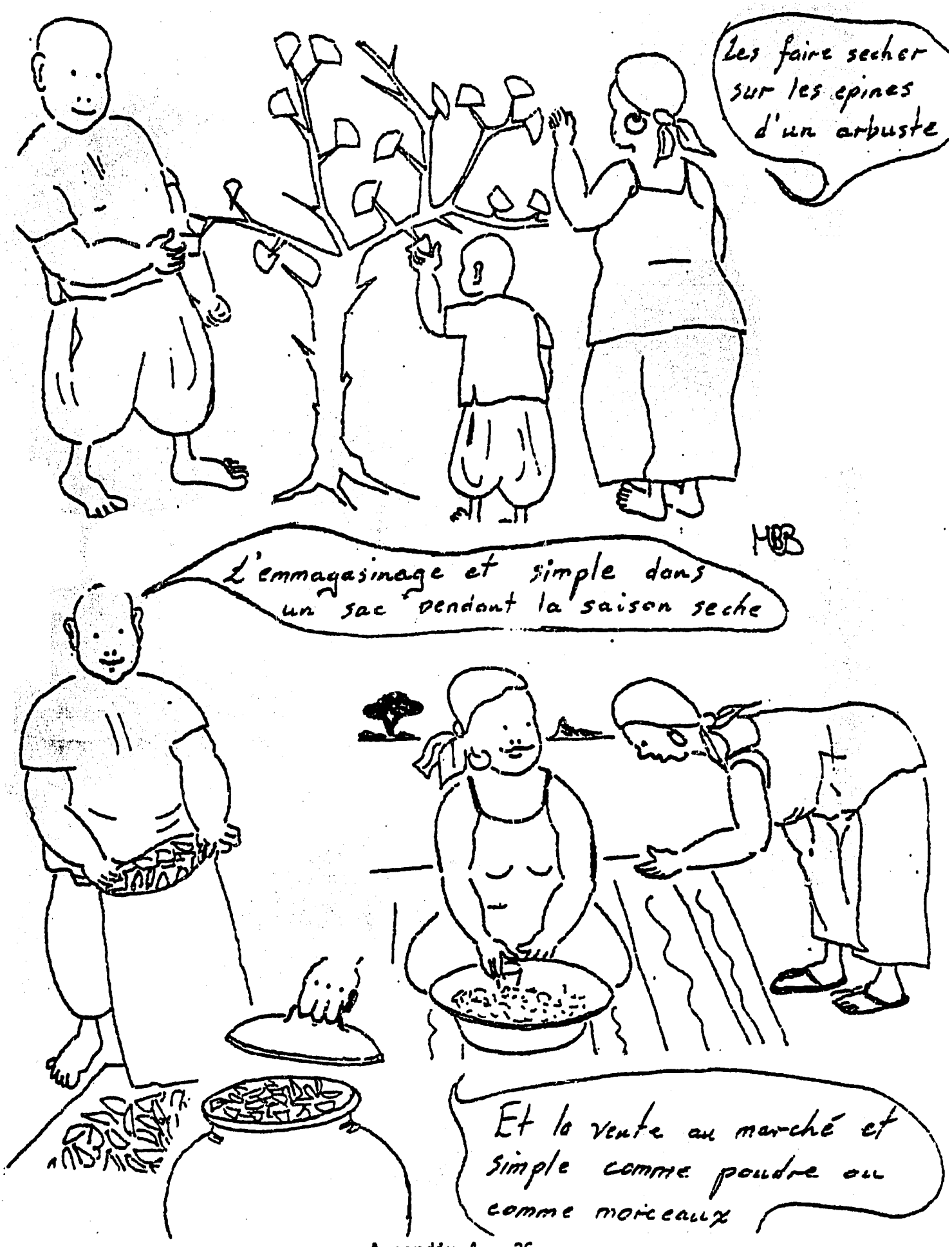
Sechage des Tomates, 2



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by weight of water). On the coast they will dry to the leathery stage, between 2.5 and 4.00% by weight of water.

- Time to dry varies with the month, but should take between 3 and 6 days for quarters and less for thinner pieces.

- Storage. The dried pieces can be kept in sacks in the garden if they are to sold in the same dry season -- when fresh tomatoes are no longer available. Longer storage is a problem. Protection against insect attack would be essential. Possibly the pieces could be powdered and packed into air tight plastic bags or canarie pots.

- The material has been marketed in powder form by the tea glass measure in Kiffa and near Nema.

Sweet Peppers

- These grow under irrigation and fruit like tomatoes during the season of decreasing relative humidity, but unlike tomatoes they survive over one season. Fruit can be dried only from September to June.

- The peppers must be allowed to ripen fully red on the bush. This affects the final color of the product (paprika). Not all varieties of pepper will develop a good even red. California Wonder is, for the moment, recommended.

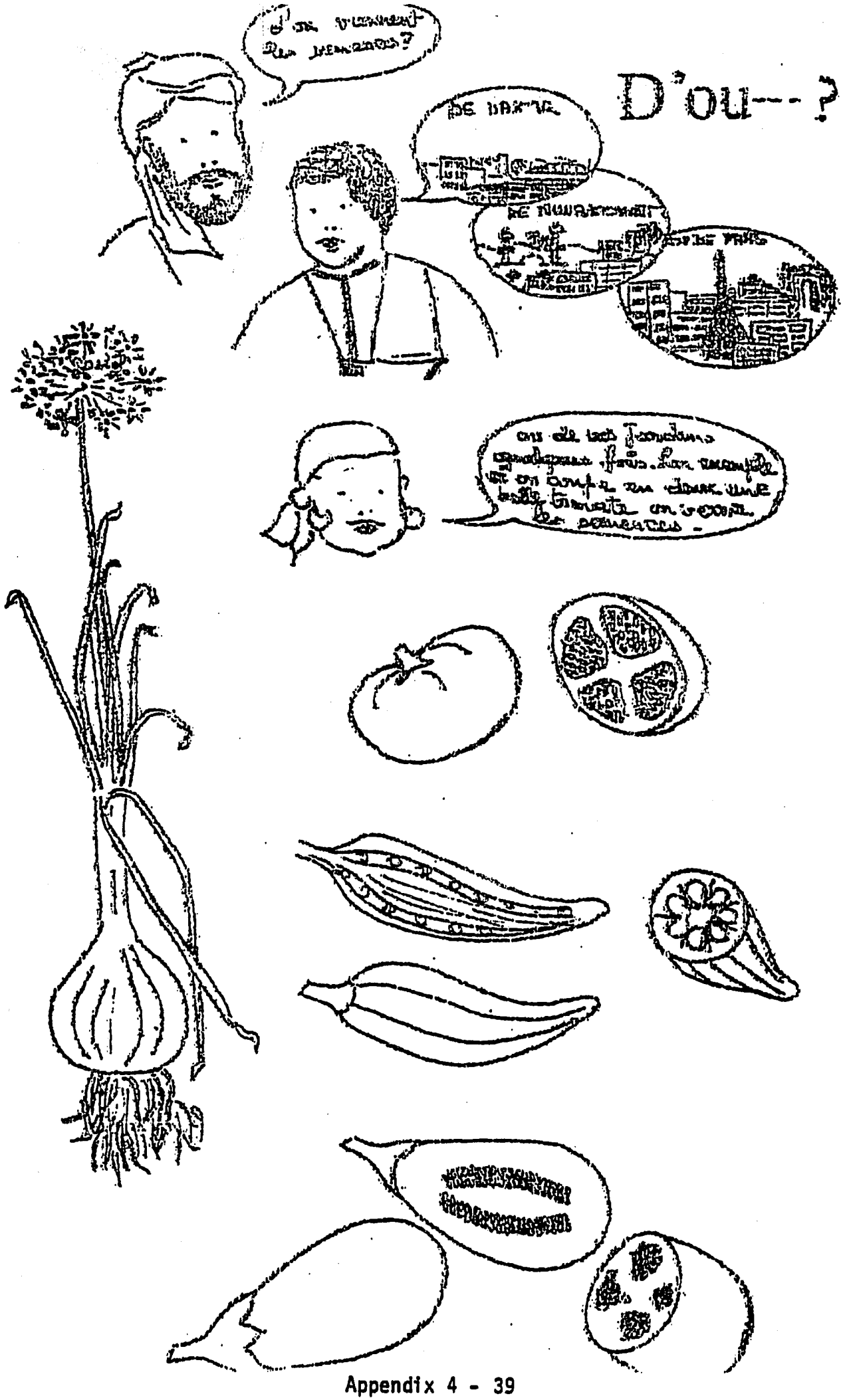
- Cut in slices and discard the seeds.

- Lay out to dry in the shade. Peppers are very susceptible to sun scorch and this would affect the color and taste quality of the final product.

- Time to dry varies with the month and the thickness of slice but should not take more than 4 days.

- Storage -- in sacks as long as the weather holds dry. In air tight plastic once humidity starts to rise.

- Trading -- this powder is a favored condiment from Morocco to Egypt.



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3. SUGGESTED ADDITIONS TO THE EXISTING LIST OF AGRICULTURAL SUBJECTS

Soil Improvement

The benefits of manuring crops are well known to the agronomists of the Senegal Valley and in the past this knowledge has led to amicable arrangements between farmers and herders concerning the grazing of cattle on the stover. Old cattle pens, too, are favorite sites for gardens if other factors make the sites practical. However, once a garden has been permanently sited and fenced off manure must be brought in and stored. Subjects in this section must therefore include information on:

- A storage and composting structure for the creation of humus.
- The effects, physical and chemical, of humus in the soil.
- Nutrient contents of different manures as compared with the nutrient content of fertilizer.
- The different manners of applying manure to the soil.
- The different manners of applying fertilizer to crops, broadcasting, banding.
- Green manuring, turning in leguminous material.
- Mulching with manure and/or leguminous material.

Method Sheets for Individual Crops

The method sheet for okra given here serves as an example. Sheets for both traditional and recently introduced crops should be included in this section. This emphasizes that the same techniques apply to both and also informs growers of one region of the well established varieties in the neighboring region. Crops included in the first instance should be:

- o Onion
- o Roselle (Hibiscus sabdoriffa)
- o Melons
- o Sweet Potato
- o Peppers
- o Carrot
- o Beet
- o Kale
- o Garlic
- o Okra
- o Cabbage
- o Tomatoes
- o Parsley
- o Kohlrabi
- o Turnip
- o Eggplant

Seed Collection, selection and storage of traditional crops are well understood and this section should underline the fact that similar principle and techniques apply to many less familiar plants. In seed production the interaction of climate with both species and variety is critical and must find a place in this section. Subjects should include the appearance and manner of collection of seeds of the following:

- o Onion
- o Garlic (cloves)
- o Okra
- o Beans
- o Roselle
- o Peppers
- o Melon
- o Sweet potato (cuttings)
- o Lettuce
- o Carrot
- o Tomato
- o Eggplant

- o Varietal differences -- taking onions as an example for a general explanation.

- o Hybridizing, and a warning that it is not useful to collect these seeds.

- o A list of useful varieties of all the above species.

Plant Protection

This important section must include a large number of subjects, some of which follow:

- Physical destruction of pests. Good population control can be achieved by a twice weekly survey when leaf eating larvae in particular can be simply knocked off the leaves and squashed. Citrus trees in Mauritania would profit from this treatment.

- Rotation, varying plantings in a time context.

- Companion planting; varying plantings in a space context, also providing to some extent, a physical barrier.

- Life cycles of the most persistent and widespread of insect pests.

- The techniques of thorough spraying and the reasons.

- How insecticides work (and the reasons for treating them with caution).

- "Kitchen chemicals" (such as salt and bleach); home-made formulations of chemicals obtainable in many village stores that are effective against insects.

- Chemically active plants (such as neem and tobacco) that can be used by the farmer to make effective insecticidal liquids.

- How to mix commercial insecticides.

- Parts diagrams for sprayers and dusters and their maintenance in good condition.

Processing

At village level this usually means sun air dessication. The major part of the drying process is the result of air movement and unless it is necessary to dry the air below ambient humidity (by heating it) any structure that impedes air movement will slow the drying process and raise its cost. This should be made clear. Among the subjects treated include the following:

- Methods for drying all traditional crops which are already so treated. This will include onion leaves, dried and fermented at the same time; hot peppers, okra pods, and hibiscus flowers.

- Methods for drying all introduced varieties whose dried products are traded. Sweet peppers and tomatoes are the best known of these.

- Methods for drying other crops, carrots, sweet potatoes and cabbage.

- Sulphuring and subsequent drying of fruits which can then be sold in a slightly moist condition (guava pieces and tomato slices).

- Drying surfaces -- a comparison.

- Accelerated drying structures.

- Drying and smoking techniques.

- Storage.

APPENDIX 5

DRIP IRRIGATION DESIGN FOR VEGETABLE GARDENS IN MAURITANIA

DRIP IRRIGATION DESIGN FOR VEGETABLE GARDENS IN MAURITANIA

Drip systems can be fabricated from material available in Nouakchott with only one specially imported component, the microtubing. For the simple system a steel drum or elevated basin is used for the water reservoir, water hose material is used for the main and lateral lines (required fittings are locally available), and microtubing is used for the emitters (see Figures 1, 2, 3, and 4.) The water should be filtered, any finely woven cloth will do, before or as it is poured into the reservoir. This will diminish emitter plugging problems. To prevent air blown material from entering the reservoir it should be covered. The cost of microtubing is about 2.5 cents per 30 cm in the U.S. and about 1 meter of microtubing is required per 1 m^2 irrigated area (2 plants), a cost of 7.5 cents.

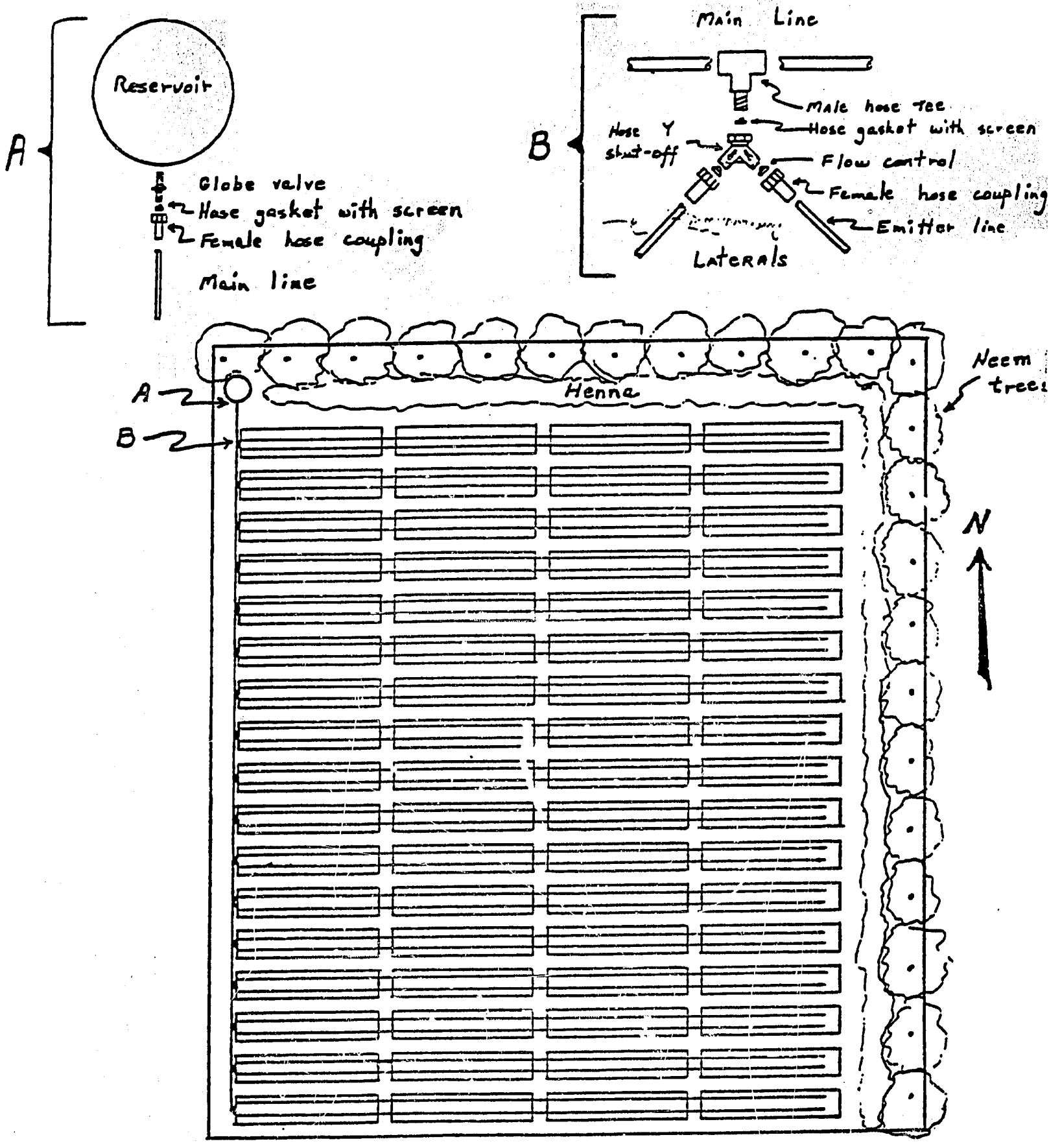


FIGURE 1

TYPICAL DRIP IRRIGATION INSTALLATION

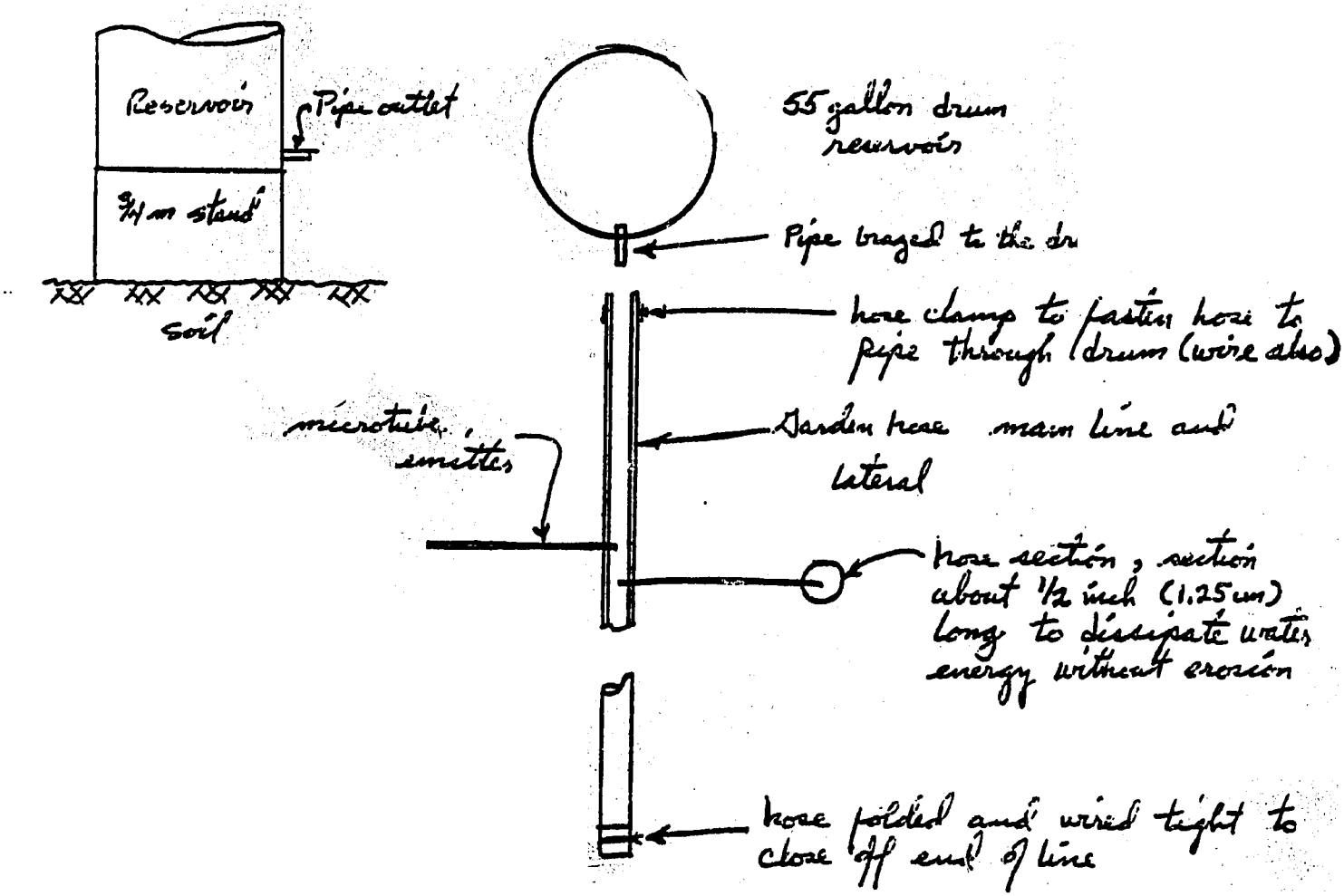
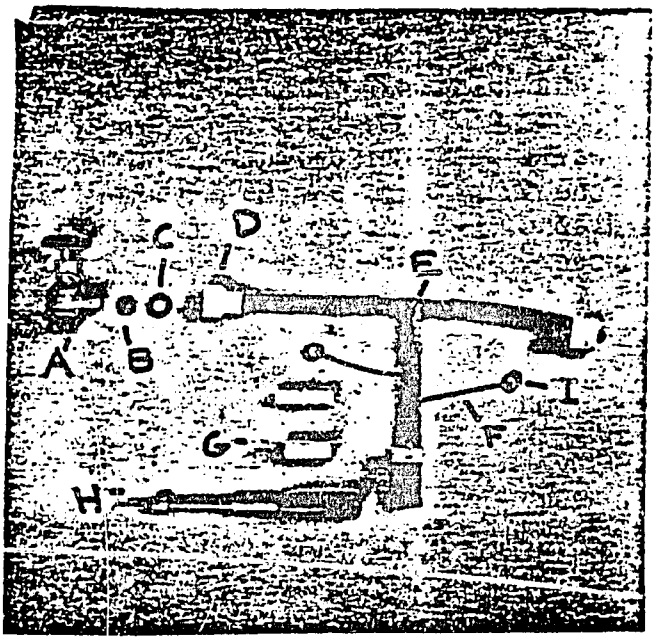


FIGURE 2

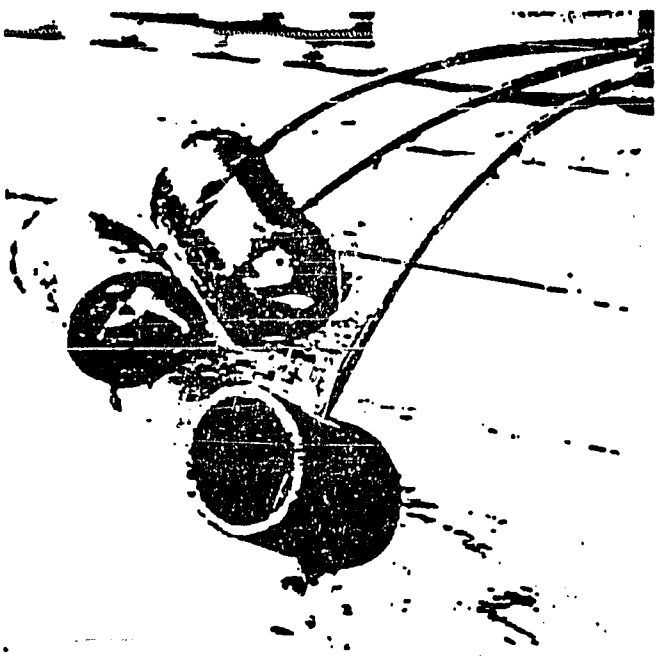
Local Material (Except Microtubing)
Drip Irrigation Installation

Figure 3

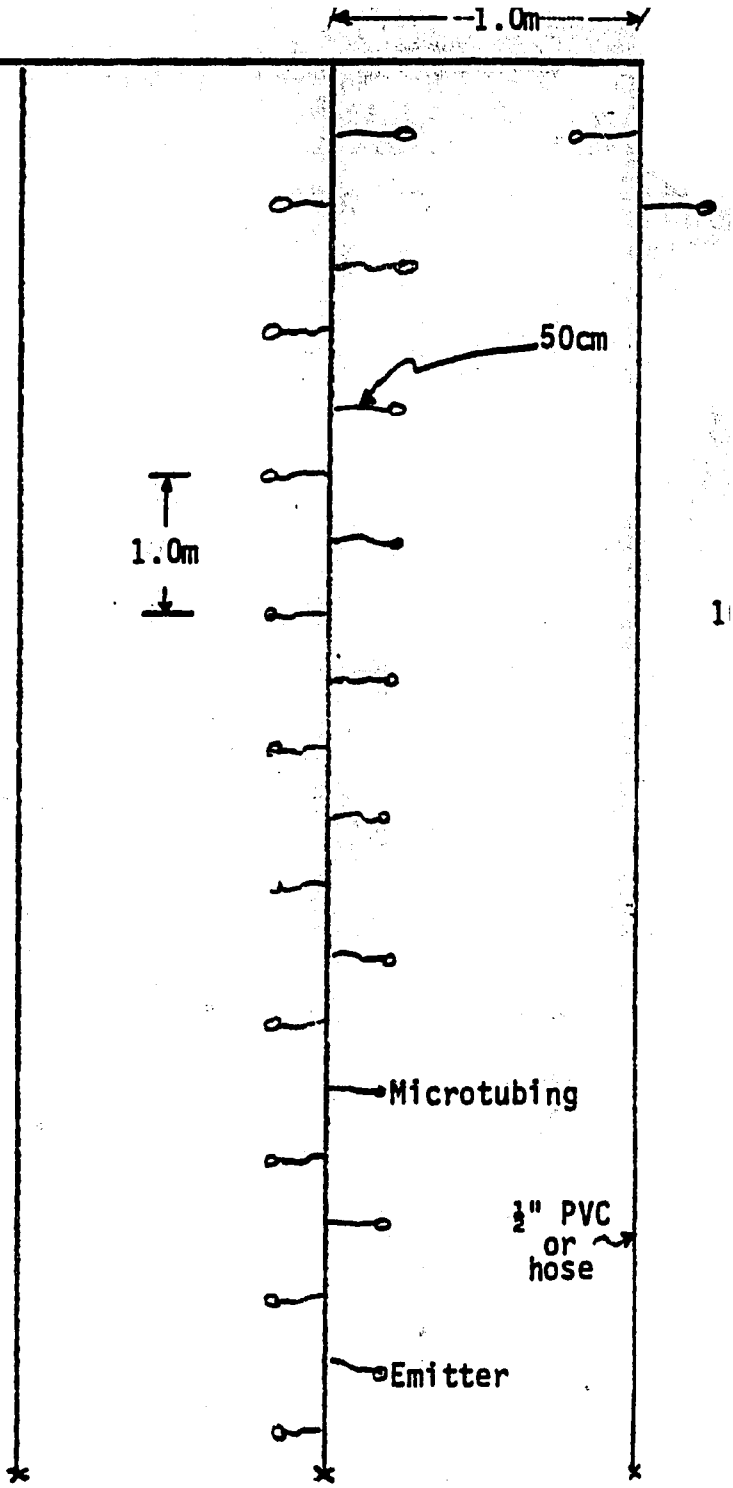
SCHEMATIC DRAWING FOR DRIP ASSEMBLY



Components of a simple drip system



Emitters made from microtubing



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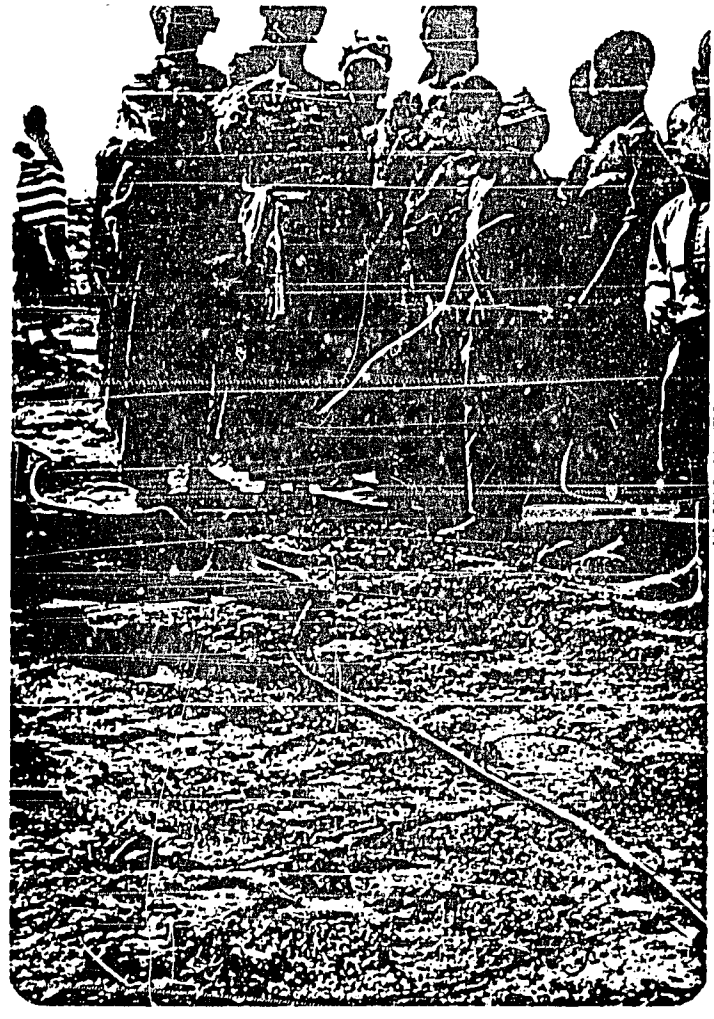

Figure 4

Mauritania
Drip Installation
Using Microtube Emitters

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APPENDIX 6

VEGETABLE CROP TOLERANCES TO CHLORIDE, SALINITY, AND BORON

TABLES 1-3

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TABLE 1

CHLORIDE TOLERANCES IN THE SATURATION EXTRACT OF SOIL
FOR FRUIT CROP ROOTSTOCKS AND SOME VEGETABLES
IF LEAF INJURY IS TO BE AVOIDED

Crop	Rootstocks	Maximum Permissible Cl in Saturation Extract meq/l*
(A)		
Citrus (Citrus spp.)	Rangpur lime, Cleopatra mandarin	25
	Rough lemon, tangelo, sour orange	15
	Sweet orange, citrange	10
Avocado (Persea americana Mill.)	West Indian, Mexican	8
(B)		
Beets (Beta vulgaris)		90
Corn (young) (Zea mays)		70
Tomato (Lycopersicon esculentium)		39
Bean, Kidney (Phaseolus vulgaris)		24
Bean, Navy (Phaseolus vulgaris)		18

(A) Ayers, R. S. and D. W. Westcot. Water Quality for Agriculture. Rome: FAO, Irrigation and Drainge Paper 29, (1976) Table 8 from page 67, Table 9 from page 68.

(B) Soil Improvement Committee, California Fertilizer Association, 1975. Western Fertilizer Handbook. Table B-25, p. 237.

* This figure is usually from four to six times greater than the chloride content in the irrigation water used.

TABLE 2

RELATIVE TOLERANCE OF CROPS TO BORON*

Tolerance decreases in descending order in each column

Tolerant	Semi-Tolerant	Sensitive
4 mg/l of boron	2 mg/l of boron	1 mg/l of boron
Asparagus	Celery	Jerusalem artichoke
Date palm	Sunflower, native	Navy bean
Garden beet	Potato	Orange
Alfalfa	Tomato	Avocado
Broadbean	Radish	Grapefruit
Onion	Field pea	Lemon
Turnip	Barley	
Cabbage	Wheat	
Lettuce	Corn	
Carrot	Sorghum	
	Pumpkin	
	Bell pepper	
	Sweet potato	
	Lima bean	
2 mg/l of boron	1 mg/l of boron	0.3 mg/l of boron

Ayers, R. S. and D. W. Westcot. Water Quality for Agriculture. Rome: FAO, Irrigation and Drainage Paper 29, (1976), page 69.

* Does not necessarily indicate a reduction in yield, based on boron level in irrigation water at which toxicity symptoms were observed.

TABLE 3

TOLERANCE OF VARIOUS CROPS TO EXCHANGEABLE SODIUM (ESP) UNDER NON-SALINE CONDITIONS

Tolerance to ESP and Range at Which Affected	Crop
Extremely sensitive (ESP = 2 - 10)	Citrus (Citrus spp.) Avocado (Persea americana Mill.)
Sensitive (ESP = 10 - 20)	Beans (Phaseolus vulgaris L.)
Moderately tolerant (ESP = 20 - 40)	Rice (Oryza sativa L.)
Tolerant (ESP = 40 - 60)	Wheat (Triticum aestivum L.) Alfalfa (Medicago sativa L.) Barley (Hordeum vulgare L.) Tomatoes (Lycopersicon esc. Mill.) Beets (Beta vulgaris L.)

Estimates of the equilibrium ESP can be made from the irrigation water. Soils at ESP = 20 - 40 and above will usually have too poor physical structure for good crop production.

APPENDIX 7
LIST OF PROJECT COOPERATING INDIVIDUALS

LIST OF PROJECT COOPERATING INDIVIDUALS

I. Islamic Republic of Mauritania/Ministry of Rural Development

Lam Hamedi	Director of Agriculture
Amed Salem	Assistant Director of Agriculture
Thiam Yussuf	Chief, Vegetable Production
Amadou Khan	Chief, Vegetable Production
M. Mangasuba	Chef de Secteur Agricole - Rosso
M. Seckabas	Chef de Secteur Agricole - Boghe
M. Baathily	Chef de Secteur Agricole - Kiffa
Wan Abdullai	Chef de Secteur Agricole - Sonader/Boghe
Sidi Mohammed	Moniteur - Boghne
Mohammed Yarg	Moniteur - Kiffa
R. Brandes	Sonader - Extension
P. Kinderman	Sonader - Planning

II. Peace Corps - Staff and Volunteers

Staff

Jerry Sternin	Country Director
Richard Wall	Country Director
Roger Conrad	Assistant Director
Joseph Hindman	Assistant Director

Volunteers	Dates
Richard Nevins	01/11/79 - 01/11/81
Bradley Favor	01/11/79 - 01/11/81
George Collins	01/11/79 - 01/11/81
Robert Freitas	01/11/79 - 01/09/80
Douglas Rees	01/11/80 - 01/02/81
Nancy Kauper	01/11/80 - 01/16/82
Thomas Hand	01/11/81 - 01/11/82
Steven Crom	01/11/80 - 01/09/81
Laurence Arturo	01/11/80 - 01/11/82
Bill Payne	01/11/81 - 01/11/83
Mark Cady	01/11/81 - 01/11/83
Amy Richwine	01/11/81 - 01/11/83
Cathy Shannon	01/11/81 - 01/11/83
David Muskat	01/11/81 - 01/11/83
Cathy Bruder	01/11/81 - 01/11/83
Susan Pine	01/11/81 - 01/11/83
Dawn Dana	01/11/81 - 01/11/83

III. U.S. Agency for International Development

USAID Contract Staff - Frederiksen, Kamine and Associates, Inc.

Bruno Quebedeaux, Jr.	Team Leader
James M. Wolf	Project Manager
Loren Parks	Agricultural Economist
Kathryn Craven	Economist
Ross Hagan	Agricultural Engineer
Rosalyn Rappaport	Horticulturist
Cynthia Reeser	Nutritionist

USAID - Food and Agriculture Staff

Anthony Wirtz	Director, Food and Agriculture
Richard Goldman	Director, Food and Agriculture
James Hughes	Project Officer
Barry MacDonald	Project Officer
David Carr	USAID Economist
Vicki MacDonald	Project Administrator

APPENDIX 8
INDEX OF PROJECT AFFILIATED VILLAGES AND COOPERATING ORGANIZATIONS

INDEX OF PROJECT AFFILIATED VILLAGES AND COOPERATING ORGANIZATIONS

	Organization
Brakna Region	
Keur Macene	PC[1/]
Dara	PC/Mariam Seck
Garak	USAID[2/]
Bouldoul	USAID
Gani	PC
Teykane	PC
Mele	USAID
Ali Guelel	USAID
Bocar	USAID
Dar el Barka	SONADER
Ganki Toro	SONADER
Bagdad	USAID
Trarza Region	
Bababe School	SONADER/Ba Maman Sileye
Bababe Town	SONADER/Ba Harouna Amadou
Tieneel	PC/USAID
Boghe Forestry Garden	GIRM/USAID
Serendougu School	PC/Ba Malik Sher
Goral Bubu	PC
M'Bagne	PC/USAID
Bagodin	USAID/PC
Ferallah	USAID/PC
N'Goral Guidal	PC/USAID
Assaba Region	
Valle du Kiffa	PC/USAID
1. MOIDI	PC/USAID
2. N'DA	PC/USAID
Tenekeiba	PC
Mouchgag	PC
Aleg Trois	PC
Guimba Sylla	PC
Kankossa School	PC
Sani	Oasis/PC/USAID
Gorgol	
Cire	SONADER/USAID/PC
Kaedi	CNRADA/USAID
Nouakchott	
Market Gardens	Coop. du Capital/USAID

1/ PC = U.S. Peace Corps

2/ USAID = U.S. Agency for International Development