volume two • SENEGAL

WEST AFRICA FERTILIZER STUDY

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER IFDC

Prepared for

AGENCY FOR INTERNATIONAL DEVELOPMENT

by West Africa Study Team
International Fertilizer Development Center

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
FLORENCE, ALABAMA, U.S.A. 35630

AID/afr-C-1176

Volume I–Regional Overview
Volume II–Senegal
Volume III–Mali
Volume IV–Upper Volta
Volume V–Niger
Volume VI–Chad
Volume VII–Mauritania

PREFACE

A series of severe droughts in the late 1960's and early 1970's greatly reduced agricultural production in the Sahelian countries of west Africa. The human suffering during that time led to an international focus on the region in terms of food aid and development assistance.

The U.S. Agency for International Development (USAID) was aware of the contribution of fertilizers to food production and the limited fertilizer use in this region. Thus, USAID requested the International Fertilizer Development Center to determine the current capacity and potential of the Sahelian region to produce, market, and use fertilizers. This series of documents is a result of that assessment. Published and unpublished literature was obtained in each country and from international development agencies. Field level interviews were also conducted.

Principal team members were Ray B. Diamond (team leader), Donald R. Waggoner, and Kham Thanh Pham from IFDC along with Hans Braun on loan from FAO. Many other members of the IFDC staff contributed greatly to the report. Bernard Raistrick (consultant from the United Kingdom) and Travis P. Hignett (consultant from the United States) assisted in preliminary collection and analysis of data before the field visits. Josiah Royce (USAID, REDSO/WA) assisted in data gathering during field visits. Appreciation is expressed to representatives of national agencies, USAID, and other international organizations for assistance.

TABLE OF CONTENTS

TABLES

ABBREVIATIONS USED IN THIS REPORT

FERTILIZERS

N . . . . . Nitrogen
P . . . . . Phosphorus
P_2O_5 . . . . . Phosphate
K . . . . . Potassium
K_2O . . . . . Potash
B . . . . . Boron
B_2O_3 . . . . . Borate
Ca . . . . . Calcium
S . . . . . Sulfur

Fertilizer Formula—% of N-P_2O_5-K_2O by Weight

AS . . . . . Ammonium Sulfate (21-0-0)
DAP . . . . . Diammonium Phosphate (18-46-0)
DCP . . . . . Dicalcium Phosphate (0-40-0)
KCl . . . . . Potassium Chloride (0-0-60)
KS . . . . . Potassium Sulfate (0-0-50)
PR . . . . . Phosphate Rock
SSP . . . . . Single Superphosphate (0-20-0)
TSP . . . . . Triple Superphosphate (0-45-0)
Urea . . . . . Urea (45-0-0 to 46-0-0)

MEASURES

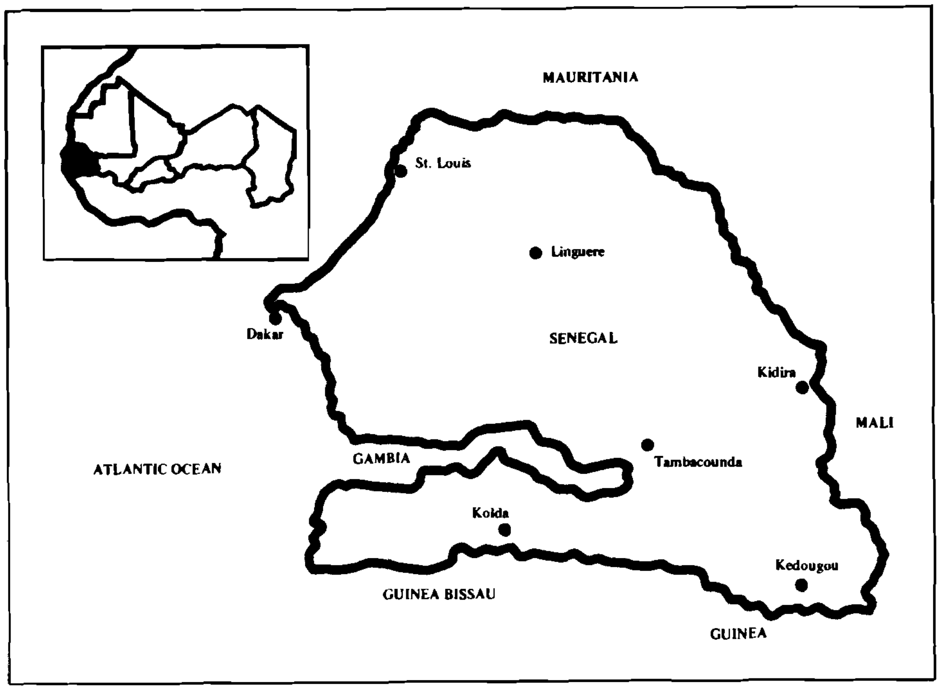
ha. . . . . . hectare (2.47 acres)
kg. . . . . . kilogram (1 pound = 0.454 kg)
km . . . . . kilometer (1 mile = 1.61 km)
mm. . . . . . millimeter (1 inch = 25.4 mm)
mt . . . . . metric ton (2,204 pounds = 1,000 kg)
% . . . . . percent

ECONOMIC AND MONETARY

c.i.f. . . . . . cost, insurance, and freight
F CFA. . . . . . CFA Franc, currency of the West African Monetary Union (Communante Financiere Africaine Franc: US $1 = 225 F CFA)
f.o.b.. . . . . . free on board
GNP . . . . . gross national product
GDP . . . . . gross domestic product

GOVERNMENTAL AND INTERNATIONAL AGENCIES

BNDS . . . . . National Development Bank of Senegal
CER . . . . . Rural Extension Centers
CFDT . . . . . French Textile Development Company
CIDA . . . Canadian International Development Association
CNRA. . . . . . National Agronomic Research Center
CSS . . . . . Senegalese Sugar Corporation
FAC . . . . . Development Aid Agency of the French Government
FAO . . . . . Food and Agricultural Organization
FED . . . . . European Development Fund
FERTISEN . . . . . A joint N-REN-Senegalese enterprise
GOS . . . . . Government of Senegal
IBRD . . . . . International Bank for Reconstruction and Development
IRAT . . . . . Research Institute for Tropical Agronomy
IRCT . . . Research Institute for Cotton and Textile Fibers
IRHO . . . . . Research Institute for Oil and Oil Crops
ISRA . . . . . Senegalese Agricultural Research Institute
N-REN . . . An American Fertilizer Corporation in Senegal
OAC . . . . . Agricultural Marketing office
ONCAD. . . . . . National Office for Cooperation and Assistance for Development
PIDAC . . . . . Casamance Interim Agricultural Development Project
PRS . . . . . One of four organizations involved on the rice growing in Casamance.
SAED . . . . . Society for Development of the Delta
SIES. . . . . . Industrial Fertilizer Society of Senegal
SODAGRI . . . . . Society for Agricultural and Industrial Development of Senegal
SODEFITEX . . Society for Development of Textile Fibers
SODEVA. . . . . . Society for Development and Promotion of Agriculture
SSEPC. . . . . . Senegalese Society of Fertilizer and Chemical Products
STN . . . . . Society of the New Land
TVA. . . . . . Tennessee Valley Authority
UNDP. . . . . . United Nations Development Program
USAID . . . . . United States Agency for International Development



SUMMARY OF FINDINGS

1. The series of droughts in the late 1960's and early 1970's drastically reduced cereal production in Senegal. Cereal imports reached 570,000 mt in 1974; rice accounted for 40% of total cereal imports.

2. Average cereal demand is projected to increase by 24,000 mt/year between 1975 and 1980 and 28,000 mt/year between 1980 and 1985. Increased urban demand will account for about 46% of the increase to 1980 and 50% to 1985.

3. Potential cereal deficit (projected demand minus 1974 production) could reach 500,000 mt in 1980 and 690,000 mt in 1985 if production is not increased.

4. Agronomic research shows consistent cereal responses to N and P and responses to K under continuous intensive cultivation.

5. Agronomic work on farmers' fields is limited and more is needed. It appears that on-farm fertilization with N and P gives a cereal response of 7-15 kg of grain per kg of nutrient. At 1976 farmer prices, this gives a return of 5-10 times the investment in fertilizer.

6. Even though nutrient concentration varies from 28-53%, the farmer price for fertilizer (domestically produced) is constant, resulting in a wide discrepancy in the farmer cost for fertilizer nutrients.

7. Considering the least-cost form of fertilizer nutrients at the farm, the cost of a kg of

nutrient approximately equals the price of a kg of sorghum or millet.

8. Estimated fertilizer nutrient consumption in 1976 was about 50,000 mt and projected to reach about 78,000 and 114,000 mt in 1980 and 1985, respectively

9. Two large deposits of phosphate rock (PR) at Thies and Taiba are already in production and supply the domestic market as well as exports. No other potential fertilizer raw materials are known to exist in Senegal except some rumors that sulfur and/or potash have been discovered during offshore drilling operations for petroleum.

10. Senegal produces all phosphoric acid, triple superphosphate (TSP), diammonium phosphate (DAP), and NPK fertilizers for domestic consumption and exports small quantities. Imported ammonia is used for the DAP and NPK fertilizers. Plans are developing for additional phosphate and NPK fertilizer capacity and beginning N production.

11. Some fertilizer grades produced are low analysis, which result in higher cost of delivered nutrients because of greater freight and handling cost.

12. The transportation network appears adequate for moving increased quantities of fertilizer to the more populated areas in the near future if adequate maintenance is performed. But improved or new roads are likely needed in new production areas.

RECOMMENDATIONS

1. Initiate a study of the effect of public policies for price stabilization and equalization for agricultural inputs and crops on regional and national economies.

2. Begin a concentrated soil fertility project in liaison with current research and extension groups and crop production projects designed to obtain relevant information for crop response to fertilizer nutrients including PR on small- and medium-sized farms. This project is needed in the Casamance and Eastern Senegal regions as crop production and integrated agricultural development projects are expanded.

3. Reevaluate the agronomics and economics of expanding the use of PR for direct application. Several well-designed P rate experiments should be conducted on farms to determine the relative efficiency of PR in comparison with soluble P sources.

4. Evaluate the possibility of eliminating the manufacturing of low-analysis fertilizers and substitute high-analysis products.

5. Study the adaptability of a few high analysis grades of fertilizer to meet the total crop production needs and attempt to eliminate the wide discrepancy of nutrient cost to farmers caused by the range in analysis.

INTRODUCTION

Senegal, located on the west coast of Africa between 12° and 17° west longitude and 12° and 17° north latitude, is Africa's most westerly country and covers an area of 196,700 km^2 (76,000 mi^2). It is bordered on the north by Mauritania; on the east by Mali; and on the south by Guinea (Bissau) and the Republic of Guinea.

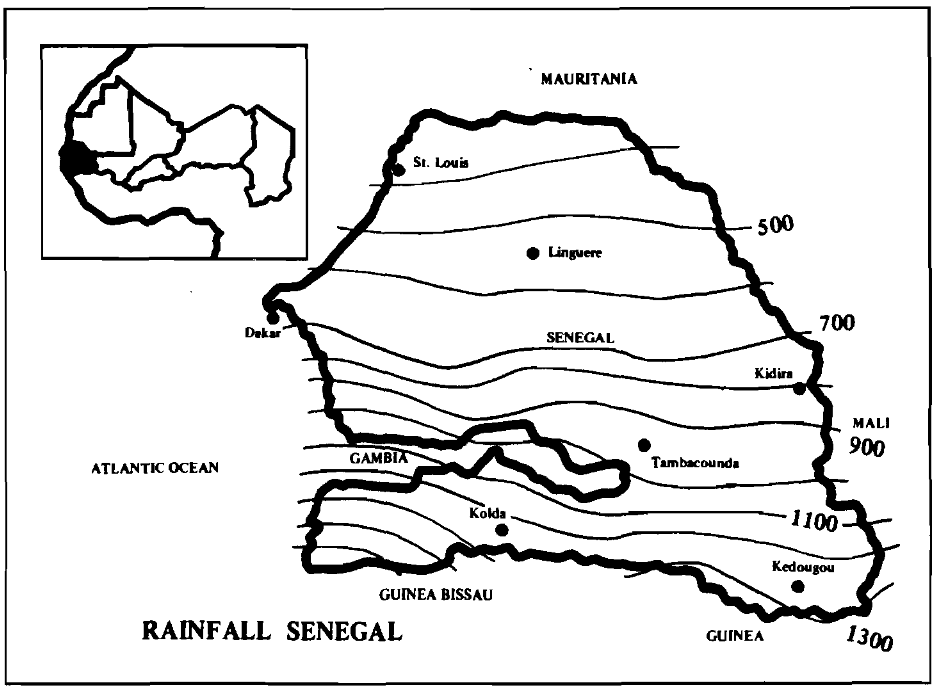
The Republic of Gambia, a small state whose borders correspond to the valley of the navigable Gambia River, forms a semienclave extending into Senegal.

Physical Characteristics

Senegal's topography is relatively flat except for the eastern borderlands. There are four principal rivers flowing from east to west: they are the Senegal River in the north, the Gambia and Saloum Rivers in the middle, and Casamance River in the south.

The country is situated on the western edge of the Sudanese climatic zone. The climate varies widely. Average annual temperatures range between 18° and 31°C. The coast is relatively cool. Temperatures and the length of the rainy season increase moving inland. Mean annual rainfall ranges from 300 mm in the north to about 1500 mm in the south. Most of the land is flat, open savannah, and gets no rain at all for 8 months of the year. However, during the 4 months of rain, downpours fill swamps and flood crops.

Natural vegetation ranges from Sahel savannah in the north to Sudan savannah in the south-central region to Guinea savannah where oil palm is common in the southern Casamance area.



RAINFALL SENEGAL

The main agricultural soils of Senegal are ferruginous tropical soils. These soils are predominant in the central and southern peanut basins and middle Casamance. Dominant soils in eastern Senegal are shallow over a ferruginous crust. Deep ferruginous soils suitable for cropping are found in valleys. Soils are more weathered and less coarse textured in the southern areas. Soils in western or lower Casamance are ferrallitic. Semiarid brown soils are found in the northern peanut basin.

Political Characteristics

Senegal is a republic and has a civilian government. The chief executive is the President, who has the power to define national policy, control foreign affairs and national defense. A Prime Minister and Cabinet assist and advise the President. The National Legislature has the responsibility of passing the national budget. Both the legislature and the President are elected to 5-year terms.

In Senegal, the Union Progressiste Senegalaise (UPS) has dominated political decision making since its inception in 1948. Senegal has in recent years encouraged opposition parties, and several have now been formed. Leopold Senghor has served as President of Senegal and Secretary General of the UPS since independence in 1960.

Cultural Characteristics

Culturally, Senegal lies within a sub-Saharan region known as the "Fragmentation Belt." Within this region, stretching from Senegal on the west to Kenya and Ethiopia on the east, a wide diversity of culture groupings can be identified. There are five general culture groups in Senegal: Wolof (37%); Fulani-TuKulor (24%); Serer (16%); Diola (9%); and Mande (7%) (1). The principal livelihoods of the Wolof and Fulani-TuKulor groups are farming and mixed farming/herding.

Although French is the official language, the African languages of Wolof, Poular, and Serer are commonly spoken. Eighty percent of the population is Moslem; the remainder is Christian or animist.

Economic Characteristics

Agriculture is the key to the economy of Senegal. About 70% of the population is engaged in farming and livestock production. This sector contributes about 30% to the Gross Domestic Product (GDP). Peanuts, millet, and sorghum are the main crops. Millet and sorghum are grown in subsistence agriculture and peanuts are the major export commodity.

The rural market economy was hard hit in the late 1960's and early 1970's by a decline in peanut production, due to drought, lower peanut prices, and the introduction of a new marketing system (the responsibility for buying the entire peanut crop was thrust upon a single organization). Improved peanut prices and sufficient rainfall in 1973, 1974, and 1975 have resulted in larger peanut harvests and increased use of fertilizer and other farm inputs. Production of cereals has also increased.

Senegal is moving toward increased industrialization. In 1974, manufacturing contributed almost 20% to the $1.1 billion GDP (2). Food processing of peanuts is the major industrial activity. This industry contributed 30% to the value added by the industrial sector in 1974 (3). The second most important industrial activity is phosphate mining and processing. Phosphate exports were valued at nearly $100 million in 1974. The Government of Senegal (GOS) reached an agreement in 1975 with mine owners for government to purchase 50% interest in the mines.

Outside of the two major industries described above, manufacturing activities are carried on by small plants processing imported materials for local consumption.

The services sector accounts for 50% of the national product (3). This sector is dualistic with a few large centralized enterprises and many small enterprises located throughout the country. In recent years, tourism has brought foreign exchange and employment and has been the most dynamic part of the services sector.

Senegal's trade deficit has increased from $89 million in 1970 to $142 million in 1974 (4). During this period, net trade in agricultural products changed from a net export of $21 million to a net import of $66 million (5). The trade deficit situation is not likely to improve in the short run because of the relatively inelastic prices of export products and the probable increase (in both price and volume) of capital goods imports.

The agricultural recovery during 1974 and 1975 has improved the economic situation in Senegal. This recovery is primarily due to favorable weather conditions and intensified investment in agriculture. New investment has been aimed at reducing food crop imports by increasing domestic crop production via greater use of agricultural inputs in the cultivation of such crops as millet, sorghum, rice, and sugar. These efforts resulted in an estimated 5% increase in real output per capita in food crops in 1974 and 1975 (3).

Future economic development in Senegal is aided by a $1.4 billion Development Plan, of which 27.3% is allocated to the services sector (transport infrastructure, communications, etc.); 26.7% is earmarked for development of social services (housing, water resources, health, etc.); and 23.3% is directed to rural development (agriculture, livestock, fishing, etc.) (3).

POPULATION AND FOOD NEEDS

Population

Senegal's population in 1975 was estimated to be 4.45 million (table 1) with an estimated net annual growth rate of 2.5%/year. A new census was taken in December 1975 but results were not available at the time this report was written. FAO estimates a population of 5.1 million by 1980 and 5.8 million by 1985, with the rural sector accounting for 71.6% in 1975 and 66.5% in 1985 (4). In 1970 about 54% of the population was between the ages of 15 and 64 (table 2).

Population in the urban areas is increasing at a rate more than twice that in rural areas. The economically active population is increasing more than four times as fast in urban areas as in rural areas since it is mostly the young who are migrating to urban centers.

The estimated population and density by regions are shown in table 3. In 1970, 50% of the population was located in the peanut basin (Regions of Diourbel, Thies, and Sine-Saloum).

Table 1. Estimated Population and Growth Rates in Senegal (4)

Section of Population	1970	1975	1980	1985	1990
Total, 1,000 persons	3,925	4,452	5,086	5,833	6,706
Rural, % of total	73.9	71.6	69.2	66.5	63.6
Growth rate preceding 5 years					
Total, %/year	-	2.5	2.7	2.8	2.8
Rural, %/year	-	1.9	2.0	2.0	1.9
Urban, %/year	-	4.3	4.4	4.5	4.5
Growth rate of active population preceeding 5 years					
Total, %/year	-	2.8	2.0	2.2	2.2
Rural, %/year	-	1.0	1.0	1.1	1.0
Urban, %/year	-	4.5	4.6	4.7	4.6

Table 2. Estimated Distribution of Population of Senegal by Age Groups, 1970 (6)

Age Group, Years	Population, 1,000	Population % of Total
Under 4	650	17
5-14	980	26
15-39	1,420	37
40-64	640	17
Over 65	140	3

Table 3. Estimated Distribution of Population of Senegal by Region (6)

	Population, 1,000		Density, no/km^2	
Region	1960	1970	1960	1970
Cap Vert	440	680	807	1,236
Casamance	530	610	19	22
Diourbel	500	600	15	18
Eastern Senegal	150	220	3	4
Senegal River	350	390	8	9
Sine Saloum	730	810	30	34
Thies	410	520	62	79

Thies, the central basin, had the greatest population density of the rural regions with 79 inhabitants/km^2. Sine-Saloum (south basin) was next with 34 persons/km^2. Resettlement projects are underway to encourage population growth in eastern Senegal and in Senegal River regions.

Total Food Requirements

Food requirement projections are based on FAO data (4). Food requirements were projected through 1990 using two methods.

One projection (L) assumes that average per capita private consumption levels will remain constant and projects consumption increases based on population changes. The other projection (H) includes elasticity of demand changes based upon a 1% annual increase in per capita food expenditures and consequent preference changes in food purchases. Neither projection, however, differs much in magnitude from the other.

Estimated per capita food consumption in 1970 and the (H) projections for the period 1975 to 1990 are shown in table 4. Per capita consumption of sugar and wheat are projected to increase 25% to 34%, respectively, over 1970 levels by 1990; fruits, vegetables, and rice by about 10%, and meat and fish by 18% and 10%, respectively. Millet, sorghum, and starchy food per capita consumption should remain relatively constant.

Estimated (L) and (H) projections for total food requirements to 1990 are shown in table 5. Total demand, using (H) projection, for millet/sorghum is projected to increase by 32% in 1980; 53% in 1985; and 78% in 1990 over 1970 levels.

Increased requirements for major cereals over 1975 requirements are shown in table 6. The average annual increase needed to meet food demand is 24,000 mt/year between 1975 to 1980; 28,000 mt/year between 1980 to 1985; and 33,000 mt/year between 1985 to 1990.

Table 4. Estimated Levels of Food Consumption for Senegal (4)

	Estimated Consumption, kg per capita/year[a]				
Commodity	1970	1975	1980	1985	1990
Millet/sorghum	94.3	95.2	96.1	97.1	98.0
Rice	55.8	56.9	58.0	59.1	60.2
Wheat	22.4	24.2	26.0	28.0	30.2
Maize	15.8	16.0	16.1	16.3	16.4
Potato	3.6	3.6	3.6	3.6	3.6
Sweet potato	3.1	3.1	3.1	3.1	3.1
Cassava	33.6	33.3	33.0	32.6	32.3
Beans/peas	5.4	5.5	5.6	5.7	5.8
Vegetables	13.2	13.6	14.0	14.4	14.8
Peanut	8.9	9.1	9.2	9.3	9.4
Sugar	18.1	19.3	20.6	22.0	23.4
Fruit	9.4	9.8	10.0	10.3	10.5
Meat	16.6	17.3	18.0	18.8	19.6
Fish	39.2	40.2	41.2	42.2	43.1

[a]Figures for 1970 are estimated actual consumption and others are based upon an elasticity of demand.

Table 5. Estimated Food Requirements in Senegal, 1975-1990 (4)

Commodity	1970 L	1975 L	1975 H	1980 L	1980 H	1985 L	1985 H	1990 L	1990 H
	Estimated Food Requirement, 1,000 mt[a]								
Millet/sorghum	370.0	419.7	423.9	479.4	489.0	549.9	566.3	632.2	657.3
Rice	219.0	248.4	253.3	283.8	295.1	325.5	344.9	374.2	403.9
Wheat	88.0	99.8	107.5	114.0	132.5	130.8	163.6	150.4	202.6
Maize	62.0	70.3	71.0	80.3	81.9	92.1	94.8	105.9	110.1
Potato	14.0	15.9	16.0	18.1	18.3	20.8	21.1	23.9	24.4
Sweet potato	12.0	13.6	13.7	15.5	15.7	17.8	18.1	20.5	20.9
Cassava	132.0	149.7	148.2	171.0	167.6	196.2	190.3	225.5	216.6
Beans/peas	21.0	23.8	24.3	27.2	28.3	31.2	33.1	35.9	38.7
Vegetables	52.0	59.0	60.7	67.4	71.4	77.3	84.2	88.8	99.4
Peanut	35.0	39.7	40.3	45.4	46.7	52.0	54.3	59.8	63.4
Sugar	71.0	80.5	85.9	92.0	104.8	105.5	128.1	121.3	157.1
Fruit	37.0	42.0	43.2	48.0	50.9	55.0	60.1	63.3	71.2
Meat	65.0	73.6	76.9	84.3	87.3	96.7	109.2	111.1	130.6
Fish	154.0	174.7	179.0	199.6	209.5	228.9	245.9	263.1	289.3

[a]L is based upon per capita consumption at estimated level of 1970 and H is per capita consumption based upon elasticity of demand.

Table 6. Estimated Increased Requirements for Major Cereals Over 1975, Senegal[a]

Food	1980	1985	1990
	-1,000 mt-		
Millet/sorghum	65	142	233
Maize	11	24	39
Rice	42	92	151
Total	118	258	423

[a]Based upon FAO projections, considering elasticity of demand.

Urban Food Requirements

A distinction between urban and rural food demand is important in analyzing potential food demand. Subsistence type farming accounts for much of the cereal production in Senegal. With large areas of potentially cultivatable land out of production, subsistence type farming can expand to meet growing rural food demand. In contrast, urban food demand requirements must be supplied through some form of commercial agriculture (domestic or imports). In Senegal, the urban sector population is growing at more than twice the rate of the rural population.

Urban food requirements were derived for major cereals using FAO (H) per capita consumption projections and urban population growth rates (table 7). Urban food demand for millet, sorghum, maize, and rice is expected to increase at a rate of 11,000 mt/year between 1975 and 1980 and at a rate of 14,000 mt/year between 1980 and 1985. Increased food demand by the urban sector will account for about 50% of the national increase.

Cereal Supply Situation

Senegal has the potential to be self-sufficient in the production of millet, sorghum, maize, and rice, although recently it has depended on growing cereal imports to supply domestic food demand. The changing cereal supply situation for selected years between 1960 and 1974 is portrayed in table 8.

The per capita supply of cereals has varied between 162 to 275 kg/person since 1970 averaging 232 kg/person for the period. Adjustment for milling of rice and the typical losses gives an average annual supply of cereals of 197 kg/person which is reasonably close to the FAO estimated consumption (4). Statistics for individual years are erratic. However, the trend since 1970 is toward increasing imports. Cereal imports, including grain relief aid, increased to 570,000 mt in 1974.

Cereal production in 1974 exceeded that of the 1961-65 period by about 20,000 mt. However, population since 1960 has increased by about one million. The increased population requires about 248,000 mt of cereals to maintain 1961-65 per capita levels of supply.

Unofficial reports indicate that millet and sorghum production in 1975 about met domestic demand. Senegal's cereal deficit is almost entirely made up of wheat and rice. Researchers are currently introducing wheat production in the Senegal River Valley. Wheat yields of about 3 mt/ha can be obtained

Table 7. Estimated Urban Requirements for Major Cereals in Senegal, 1975 to 1990[a]

Food	1975	1980	1985	1990
	-1,000 mt			
Millet/sorghum	120.1	150.6	189.6	239.0
Maize	20.2	25.2	31.8	40.0
Rice	71.8	90.9	115.4	146.8
Total	212.1	266.7	336.8	425.8

[a]Based upon FAO projections, considering elasticity of demand and assuming an urban consumption pattern similar to national pattern.

Table 8. Cereal Supply Situation in Senegal, 1961-1974 (5, 6)

Crop	1961-65	1970	1971	1972	1973	1974
	--Cereal Production, 1,000 mt--					
Total	614	535	729	380	581	635
Millet	482	405	582	323	486	500
Rice paddy	100	91	108	37	64	95
Maize	32	39	39	20	31	40
	--Cereal Imports, 1,000 mt--					
Total	234	239	365	288	521	570
Wheat	65	113	113	97	132	117
Rice paddy	138	119	186	170	192	230
Maize	16	5	33	10	51	60
Other	15	2	33	11	83	70
Grain Relief Aid	-	-	-	-	63	93
	--Cereal Exports, 1,000 mt--					
Total	25	30	8	1	1	14
Wheat	25	29	8	1	1	14
Other	-	1	-	-	-	-
	--Total Supply, 1,000 mt--					
Total	823	744	1,086	667	1,101	1,191
Wheat	40	84	105	96	131	103
Rice paddy	238	210	294	207	256	325
Maize	48	44	72	30	82	100
Millet	482	405	582	323	486	500
Other	15	1	33	11	83	70
Grain Relief Aid	-	-	-	-	63	93
	--Per Capita Supply, kg/person--					
Total	247	190	270	162	261	275

as an irrigated winter crop, grown in rotation with a summer crop of rice. At current yields, 40,000-50,000 ha planted to wheat is needed to meet present domestic demand.

The major increases in rice production are likely to come from irrigation projects. The greatest potential is in the Senegal River delta, once the delta dam is built (possibly by 1980). The International Bank for Reconstruction and Development (IBRD) estimated this dam would permit production of 200,000 mt of rice/year (7). The Casamance Region also has considerable potential for increased rice production.

FOOD PRODUCTION

Agriculture plays a major part in the economy of Senegal. About 70% of the labor force is in the rural sector, which accounts for about 30% of the GDP. The rural sector's economic importance is even greater because of the contribution to exports (peanut products) and the large domestic demand for locally produced goods and services.

Crop production largely depends upon rainfall, which has been subject to large annual fluctuations. Senegal had droughts in 1968 and 1970, and in 1972 the worst drought to hit the country in 60 years. Peanut production in 1972 was less than 60% of the 1961-1965 average.

Senegal is attempting to diversify its agricultural base by increasing cotton area and intensifying efforts in rice and other food crop production. Peanuts, however, are expected to remain the most important export commodity.

Indices of agricultural production and population in table 9 show steady population growth; general decline in food and agricultural production; and a marked decline in per capita production. However, production of most crops in 1974 was at or above 1972-73 levels; and in 1975, there is an indication of even greater improvement.

Agricultural Policy Institutions

At the national level, the Ministry of Rural Development formulates development goals, plans action, and supervises autonomous agencies. Major directorates within

Table 9. Indices of Population, Agricultural, and Food Production, Senegal (8)

	Indices[a]				
Year	Population	Food Production	Agricultural Production	Per Capita Food Production	Per Capita Agricultural Production
1961	95	96	96	100	100
1962	98	91	91	93	93
1963	100	98	98	98	98
1964	102	104	104	102	102
1965	105	112	113	107	108
1966	107	97	97	91	91
1967	110	119	119	108	108
1968	112	97	98	87	87
1969	115	105	105	91	92
1970	118	81	82	69	70
1971	121	113	115	94	95
1972	124	73	74	59	60
1973	127	88	90	70	71
1974	130	98	100	75	77

[a]World--1963 = 100.

the Ministry are: Directorates of Agricultural Services, Livestock, Fishery, Rural Engineering, Water Resources, and Forestry.

Agricultural research is performed by the Senegalese Agricultural Research Institute (ISRA). Technical services to farmers are provided through Rural Extension Centers (CER's), public development corporations, and private project management corporations. The distribution of agricultural extension personnel by regions and organization is shown in table 10.

The CER's, under the Ministry of Rural Development, are charged with assisting economic and social development by: promoting new techniques; training young people; assisting cooperatives; and handling health, education, and literacy work.

There are two main national development agencies: National Office for Cooperation and Assistance for Development (ONCAD) and National Development Bank of Senegal (BNDS). CER's have assigned assistance to cooperatives to ONCAD and promotion of new techniques to project organizations.

Examples of public development corporations dealing with agriculture are:

Society for Development and Promotion of Agriculture (SODEVA)--working primarily with peanuts and food crops in the peanut basin.

Society for Development of Textile Fibers (SODEFITEX)--concerned with cotton production in Casamance, Sine-Saloum, and Eastern Senegal (only departments in which cotton is grown).

Society for Development of the Delta (SAED)--focusing on the rice culture in the Senegal River Delta area.

Society of the New Lands (STN)--concerned with resettlement of people from densely populated areas to new areas, including assistance in crop production and marketing.

Society of the Development of the Casamance (SOMIVAC)--working with rice and other food crops in the Casamance (created in 1976).

Society of Agricultural and Industrial Development of Senegal (SODAGRI)--working in rice, sugarcane, and cotton production. A study is underway for improvement of the Anambi basin in the upper Casamance for rice culture.

Agricultural Marketing and Credit

ONCAD was created in 1966 to provide services for rural communities by assisting cooperatives and precooperative groups distribute agricultural inputs, collect crop production from cooperatives and development corporations, and extend the credit services of BNDS. The BNDS made agricultural loans of 22.4 billion F CFA in 1973 (10). ONCAD received 9.9 billion F CFA for peanut marketing; 8.4 billion for marketing other crops and for operating expense; 2.4 billion for importing rice; 982 million to cooperatives for agricultural inputs and food reserves; 382 million for development corporations; and 30 million for loans to individuals.

In 1976, there were 2,600 cooperatives in Senegal of which 1,664 were primarily involved in peanuts, with millet secondary. The peanut cooperatives supply members with fertilizer, fungicide, equipment and credit; offer centralized collection of crop; and provide administration and accounting services. These cooperatives have 200,000 members, although it is estimated that 1.2 million farmers use the cooperatives either directly or indirectly through

Table 10. Distribution of Agricultural Extension Staff, 1974[a] (9)

Operations	Cap Vert	Thies	Diourbel	Sine Saloum	Le Fleuve	Eastern Senegal	Casamance	Senegal
Rural Extension Centers (CER's)	2	18	20	22	17	17	23	119
OAC, Guede, Boulele				12	4			16
SAED					35			35
SODEVA		141	113	352				606
IRHO				60				60
IRAT				29				29
SODEFITEX				77		132	78	281
STN						5		5
PIDAC							156	156
PRS							166	166
Total by Region	2	159	133	546	56	154	423	1,472
Rural Population	-	310,000	490,000	600,000	190,000	190,000	430,000	2,200,000
Population per Officer		1,950	3,680	1,100	3,400	1,230	990	1,490

[a]This table covers only agricultural staff concerned with extension work (excluding livestock and forestry officers, etc.), supply, marketing, and credit personnel, and execution personnel.

Table 11. Trends of Prices for Crops and Fertilizers Paid by Farmers

	Prices Paid or Received by Farmers, F CFA/kg				
Year	Fertilizer	Peanuts	Millet	Rice	Cotton
1966	13	20.5	17	21	37.7
1967	14	17.1	17	21	32.6
1968	16	17.1	17	21	33.0
1969	12	17.1	18	21	37.8
1970	12	17.1	18	21	37.8
1971	12	18.5	18	21	37.8
1972	12	22.0	18	21	34
1973	12	25.5	25	25	34
1974	12	41.5	30	41.5	47
1975	16	41.5	30	41.5	47
1976	20	41.5	37	41.5	49

family relations. The average membership of an individual cooperative is 120 farmers, serving an area of a 2-5 km radius in the peanut basin and a 5-15 km radius in other areas. Each member's share costs 1,000 F CFA and is paid, over time, by collecting a percentage from the member's sales.

Each cooperative assesses the credit requirements of members; submits a total credit application to BNDS; receives supplies from ONCAD; distributes to farmer; collects crop; and sells to ONCAD. The cooperative's total demand for credit is covered by the collective guarantee of all individual members. The amount due BNDS is collected from the purchase price of crop production; the balance is then paid to the cooperative which distributes it among members.

Agricultural Product Prices

Prices for inputs and commodities are fixed at an equalized level throughout Senegal. The Price Equalization and Stabilization Fund, created in 1973, is financed through government profits from peanut and cotton marketing. In 1973-74, peanuts contributed 14.4 billion F CFA and cotton 1.5 billion F CFA toward a total budget of 16.1 billion F CFA. The history of crops and fertilizer prices is shown in table 11. Even with higher fertilizer prices in 1976, the cost/price relationship in 1976 appears to be better than it was in the 1960's. This is primarily because a greater portion of the fertilizer now used is of higher analysis than before.

The policy of selling all compound fertilizers to farmers at the same price results in a much higher price for nutrients in low-analysis fertilizers (table 12). This places a greater cost burden upon the farmers in the northern peanut basin where low-analysis fertilizers are recommended.

Data in table 12 show that the GOS subsidized fertilizer prices in

Table 12. Cost of Fertilizer Nutrients Contained in Various Fertilizers in 1976, Senegal

	Cost, F CFA/kg of Nutrient		
Fertilizer Material	Paid by Farmer	Received by Industry	World Market, CIF, Dakar
10-10-8	71.4	172	NA
14-7-7	71.4	172	NA
6-20-10	55.6	134	NA
6-10-20	55.6	134	NA
10-21-21	38.5	93	NA
8-18-27	37.7	91	NA
Weighted average, 43% nutrients	50.2	121	81
0-45-0	44.4	107	83
16-48-0	31.3	75	66
45-0-0	77.8	NA	85
Phosphate rock	0	31	44

1976 in two ways. First, the domestic industry was subsidized by receiving payments above the world market price of fertilizer. Second, farmers were subsidized by paying prices below world market price. The GOS subsidy to the domestic industry would be about 1.84 billion F CFA ($8 million) considering the anticipated movement of fertilizer in 1976, and about 1.34 billion F CFA ($6 million) to farmers.

The subsidies to farmers are justified based on the benefits to Senegal through increased fertilizer use and domestic crop production, which has reduced food import requirements and increased exports of peanut and cotton products. The maintenance of the domestic fertilizer industry is justified, based on the benefits of increased domestic employment, savings of foreign exchange, and provision of a hedge against fluctuating world market fertilizer supplies and prices.

The procedure used in establishing prices of agricultural inputs and outputs and their effect upon various aspects of the economy were not studied by the study team. However, we agree with ISRA that a detailed study of the influence of various forms of subsidy and taxes in the agricultural sector upon the regional and national economy would be useful (11). With such research, policy alternatives could be delineated and their effects predicted to provide the GOS with a guide in making policy decisions.

Crop Production

Senegal has about 6.3 million ha of potential cropland. About 2.3 million ha is in crops annually. Of the potential cropland, 12% receives less than 350 mm of rainfall annually, 33% from 350-600 mm, 19% from 600-800 mm, and 36% more than 800 mm (4). FAO estimates a potential for irrigation of 390,000 ha (240,000 ha in Senegal River basin and 100,000 ha in Casamance). Currently about 10,000 ha of rice and 4,000 ha of sugarcane are irrigated, 53,000 ha of rice is under uncontrolled flooding, and 51,000 ha of sorghum and maize are grown under flood recession.

Average areas, yields, and production of major crops during two periods are shown in table 13. Peanuts and millet/sorghum occupy about equal land areas and together are grown on 87% of the crop area. The peanut basin (Diourbel, Sine-Saloum, and Thies Regions) contains 75% of the crop area (table 14). Rice production is primarily in the Casamance but the Senegal River basin has 15% of the country's rice growing area. Eastern Senegal and Casamance each account for 45% of the area in cotton with the remainder grown in Sine-Saloum. Most vegetables are grown in Cap Vert; most maize in Eastern Senegal and Casamance.

Crop area per inhabitant decreased from 0.62 to 0.52 ha between 1960 and 1975 (table 15) due to increasing population density.

The total area in production of various crops was similar for the periods 1961-65 and 1970-74 except that cotton was introduced in 1961-65 and was grown on 40,000 ha by 1974. Yields and production during 1970-74 were lower mainly because of droughts in 1970 and 1972. The effect of those droughts upon production is shown in table 16. By 1974, production levels of most crops were again reaching the 1961-65 levels of production.

Pattern of Land Use

The community structure for crop production in Senegal is similar to other Sahelian countries in the region. That is, the extended family (carre) cultivates a collection of fields (exploitation) under the responsibility of the head of the family. Typically, crops are grown in common on 50-80% of the exploitation. The remaining land is allocated to

Table 13. Crop Area, Yield, and Production in Senegal (8)

Crop	Area Harvested 1,000 ha	Yield kg/ha	Production 1,000 mt
		1961-1965	
Cereals, total	1,072	573	614
Rice Paddy	76	1,306	100
Maize	39	812	32
Millet/Sorghum	956	505	483
Sweet Potatoes	2	6,137	12
Cassava	36	4,244	152
Cow Peas, dry	51	277	14
Peanut in Shell	1,059	954	1,010
Seed Cotton	1	789	1
		1970-1974	
Cereals, total	1,081	529	572
Rice Paddy	72	1,097	79
Maize	40	849	34
Millet/Sorghum	969	474	459
Sweet Potatoes	1.4	6,124	8.4
Cassava	41	3,829	157
Cow Peas, dry	66	282	18.6
Peanut in Shell	1,048	719	754
Seed Cotton	23	1,088	25

Table 14. Distribution of Crop Areas by Regions of Senegal (12)

Region	Crop Area	
	1,000 ha	% of National
Cap Vert	5.7	0.2
Casamance	320.1	13.3
Diourbel	641.8	26.6
Senegal River	100.1	4.2
Eastern Senegal	167.3	6.9
Sine-Saloum	836.0	34.6
Thies	341.6	14.2

Table 15. Average Crop Area Per Person in Regions of Senegal in 1960 and 1975 (12)

Region	Crop Area, ha/person	
	1960	1975
Cap Vert	-	-
Casamance	0.51	0.43
Diourbel	0.91	0.87
Senegal River	0.34	0.22
Eastern Senegal	0.65	0.59
Sine-Saloum	0.99	0.94
Thies	0.65	0.53
Country Average	0.62	0.52

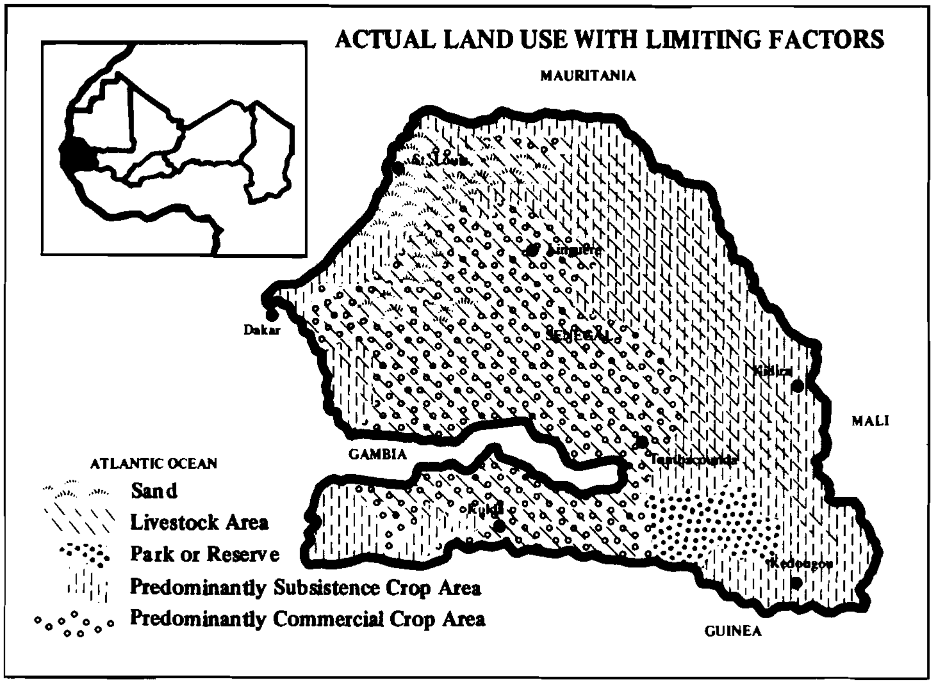


Table 16. Trends of Crop Production, Senegal (8)

Crop	Production, 1,000 mt					
	1961-65	1970	1971	1972	1973	1974
Cereals, Total Primary	614	535	729	380	581	635
Rice Paddy	100	91	108	37	64	95
Maize	32	39	39	20	31	40
Millet	482	405	582	323	486	500
Roots and Tubers	170	176	179	160	165	171
Potatoes	5	6	6	4	5	5
Sweet Potatoes	12	12	13	5	6	6
Cassava	152	159	160	150	155	160
Pulses	14.5	25	30	11	13	14
Peanut in Shell	1,010	583	988	587	760	850
Seed Cotton	1	11	23	23	34	34
Cottonseed	1	6.6	14.6	15	20	20
Cotton Lint	0.3	4.4	8	8	11	11
Palm Kernels	4.5	14.8	8	5	7	7.5
Mangoes	12	25	27	25	25	25
Bananas	3	4	5	4	4	5

nuclear families and the women for their own benefit.

The distribution of responsibility for crop areas found in two recent studies is shown in table 17. The production for the head of the family provides food and cash for the family unit. The distribution of responsibility among crops found in two villages in Sine-Saloum is shown in table 18.

A study in Bambey and Diourbel departments also found 11 to 14 persons per family unit, with less than 50% of those active in work (table 19). Cultivated area per active person was 2-2.5 ha and area per family unit was 12-16 ha. In each village, 55% of the cropland was in peanuts and 38% in millet. In the two villages in Sine-Saloum, peanuts were grown on about 66% of the cropland; millet and sorghum on 25%; and cotton on 4-10%.

Crop Production Projects

The fifth proposed 4-year Senegalese National Development Plan

Table 17. Distribution of Responsibility for Crop Areas in Four Villages of Senegal (13, 14)

	Crop Area, % of the Exploitation			
Responsibility	Koumbidia	Thysse-Kayemor	Ndiamsil-Sessene	Layabe
Head of family unit	70	48	50	49
Head of subfamily	12	30	14	19
Wives	5	7	16	13
Relatives	6	7	18	18
Others	7	8	2	1

Table 18. Distribution of Responsibility Among Crops in Two Villages in Sine-Saloum, Senegal (13)

	Crop Area, % of Area in Crop			
Village/Responsibility	Peanut	Cotton	Millet	Sorghum
Koumbidia				
Head of family unit	42	65	88	86
Head of subfamily	13	9	12	12
Wives	15	4	-	-
Relatives	12	9	-	2
Others	18	13	-	-
Thysse-Kayemor				
Head of family unit	27	48	64	53
Head of subfamily	22	23	35	42
Wives	22	6	-	1
Relatives	15	6	1	3
Others	14	17	-	1

Table 19. Some Characteristics of Two Villages in Bambey and Diourbel Departments, Senegal (14)

Characteristic	Ndiamsil, Bambey	Layabe, Diourbel
Cultivated area, ha	278	533
Number of carre	22	34
Number of inhabitants	305	380
Inhabitants/carre	13.9	11.2
Cultivated area (ha)/carre	12.6	15.7
Cultivated area (ha)/inhabitant	0.91	1.40
Active persons	141	176
Cultivated area (ha)/active person	1.97	2.56
Area/culture, ha		
Peanuts	155.5	301.9
Millet	107.5	195.4
Other crops	4.8	5.6
Fallow	12.7	30.0
Area/culture, %		
Peanuts	55.4	55.6
Millet	38.3	36.7
Other crops	1.8	2.2
Fallow	4.5	5.6
Size of field (overall), ha	0.78	0.86
Peanut	0.78	0.86
Millet	1.01	0.90
Fallow	0.61	1.36

(1977-1980), calls for increasing crop area by 5-7% annually for rice, maize, and cotton (12). Percentage annual increases in area, yield, and production for major crops during this period are shown in table 20. Proposed levels to be reached are shown in table 21.

Estimated area for crops by regions for the period 1972-75 and projections for 1980-81 are shown in table 22. Projections anticipate an increase in crop area of 317,200 ha by 1980-81, with millet and sorghum occupying about 200,000 ha of the projected increase in crop area.

Crop production projects are managed by semi-government development corporations or companies. SODEVA is the largest such corporation and is responsible for agricultural extension activities for peanuts and millet in the peanut basin (Thies, Diourbel, and Sine-Saloum). External funding for SODEVA comes from IBRD and USAID.

SAED is responsible for improvement of irrigation, improving rice culture, and for canning tomato production in the Senegal River Delta. A current project will increase irrigation by 3,050 ha and improve 1,700 ha.

SODEFITEX is responsible for cotton production, ginning, and marketing in Eastern Senegal, Casamance, and Sine-Saloum. The French Textile Development Company (CFDT) provides management and technical assistance to SODEFITEX.

Another development corporation, SOMIVAC, is now being organized. This organization will unify several small development projects that have operated in the Casamance.

Table 20. Projected Rate of Annual Increase (1975-80) in Crop Area, Yield, and Production (12)

Crop	Rate of Annual Increase, %		
	Area	Yield	Production
Rice Paddy	5.2	0.6	5.8
Maize	6.0	0	6.0
Millet/sorghum	2.1	0.3	2.4
Cassava	4.8	-0.7	4.1
Cowpea	3.2	0	3.2
Peanut	1.1	0	1.1
Cotton	7.1	0.4	7.5

Table 21. Levels of Crop Area, Yield, and Production Proposed for 1980-81 (12)

Crop	Area 1,000 ha	Yield kg/ha	Production 1,000 mt
Rice Paddy	92	1,253	115
Maize	59	805	47
Millet/sorghum	1,188	507	602
Cassava	43	3,726	170
Cowpea	79	270	21
Peanut	1,133	830	940
Cotton	59	-	-

The use of several advisory agencies, each oriented to a single crop in a given area, tends to result in duplication of efforts since more than one agency contacts the same farmer. It appears that these projects will be centralized under SOMIVAC. The organization should provide crop production advice to farmers for all major crops. A single organization to extend advisory service within a region is desirable.

SOMIVAC could have a great influence on future crop production in Senegal. Casamance is an area with good rainfall and a population density of only 23-24 persons/km^2. Infrastructure and accessibility to Dakar may be an obstacle, but the ports on the Casamance River may be useful in providing access. One existing project involves the cultivation of 9,500 ha of rainfed rice and improvements for 2,000 ha of swamp rice land by 1981.

STN primarily manages resettlement projects in the Eastern Senegal Region but is not restricted to that region. Between 1972 and 1975, STN successfully resettled 300 families on 1,350 ha in the Maka Pilot Project. A second project is planned where 600 new families will cultivate 3,350 ha by 1980.

Production companies using intensive mechanized systems are the Senegalese Sugar Company (CSS) and Bud Senegal, producing vegetables. CSS is projecting that it will have 8,000

Table 22. Area of Individual Crops by Regions (12)

Crop	Cap Vert		Casamance		Diourbel		Fleuve		Eastern Senegal		Sine-Saloum		Thies		Total	
	1972/75	1980/81	1972/75	1980/81	1972/75	1980/81	1972/75	1980/81	1972/75	1980/81	1972/75	1980/81	1972/75	1980/81	1972/75	1980/81
	ha															
Rice	-	-	65,000	65,000	-	-	9,000	16,000	5,600	9,000	1,700	1,500	500	500	81,800	92,000
Maize	-	-	15,000	20,000	-	-	5,000	8,000	20,000	30,000	3,500	600	-	-	43,500	58,600
Millet and sorghum	1,000	2,000	95,000	120,000	300,000	300,000	70,000	90,000	70,000	80,000	300,000	420,000	153,000	176,000	989,000	1,188,000
Cotton[a]	-	-	16,000	28,000	-	-	-	-	17,000	23,000	6,000	8,000	-	-	39,000	59,000
Peanut	2,000	2,000	120,000	120,000	295,000	300,000	600	8,000	50,000	50,000	500,000	485,000	155,000	168,000	1,122,600	1,133,000
Eating Peanut[a]	-	-	-	-	-	-	-	-	-	-	17,500	54,000	-	-	17,500	54,000
Niebe	100	100	1,300	1,500	37,000	45,000	10,000	10,000	-	1,000	-	3,000	16,500	18,000	64,900	78,600
Fonio	-	-	4,500	4,000	-	-	-	-	4,700	4,000	-	-	-	-	9,200	8,000
Vegetable	2,500	3,000	100	300	300	300	850	1,000	-	-	150	200	1,300	1,500	5,200	6,300
Industrial tomato[a]	-	-	-	-	-	-	850	1,000	-	-	-	-	-	-	850	1,000
Manioc	100	100	2,900	3,000	9,500	15,000	-	-	-	-	6,800	7,500	15,000	17,000	34,300	42,600
Sweet potato	-	-	350	350	-	-	1,750	1,750	-	-	200	200	300	300	2,600	2,600
Tobacco[a]	-	-	-	-	-	-	-	-	-	-	107	150	-	-	107	150
Sugarcane	-	-	-	-	-	-	2,100	6,000	-	-	-	-	-	-	2,100	6,000
TOTAL	5,700	7,200	320,150	362,150	641,800	660,300	100,150	141,750	167,300	197,000	835,957	980,150	341,600	381,300	2,412,657	2,729,850

[a]Crop year 1974/75.

ha of sugarcane in production by 1978, producing 100 mt/ha of cane of 12% sugar content. Soil drainage and salinity problems, howver, have plagued the operation. Bud Senegal has not expanded as rapidly as planned, although it is producing vegetables on 625 ha for marketing in Europe. Proposals have been made to extend vegetable production to plots surrounding Bud Senegal. However, funding has not been finalized.

Some private nonprofit organizations are assisting villages in various ways. CARITAS (roughly equivalent to the Catholic Relief Service) has undertaken a project of settling 72 families on 2-ha plots. CARITAS helps with well drilling, sanitation, training youth, irrigation, and technical assistance for vegetable growing and marketing.

AGRICULTURAL RESEARCH

Research in agriculture is conducted by ISRA under the General Delegation of Scientific and Technical Research. Under ISRA is the National Center of Agronomic Research (CNRA) at Bambey with substations at Nioro-du-Rip, Sinthiou-Maleme, Louga, and Darou. Other research stations are at Sefa, Djibelor, and Richard-Toll. CNRA's budget in 1975 was 900 million F CFA. The research includes studies on soils, crop varieties, crop protection, cultural practices, and crop systems in plant production. General fertilizer recommendations are shown in table 23.

Crop Response to Fertilizer

The level of yield response of crops to applied fertilizer is dependent upon many factors. Some of the more important are: physical and chemical properties of soil which are influenced by soil type, previous cropping and management, soil preparation, quantity and distribution of rainfall during the growing season, crop variety, plant population, date of seeding, adequacy of weeding, and level of nutrient applications.

Crop yields have been studied in Senegal for more than 25 years. The emphasis until the early 1960's was in defining crop response to rates of individual nutrients in the presence of others. But, since that time the emphasis has been on crop uptake and upon the influence of cultural practices and varying doses of NPK fertilizers.

The "cost:price ratio" means the ratio of the price a farmer pays for a kg of nutrient to the price he receives for a kg of crop. "Value: cost ratio" is the ratio of the value of the increased crop to the cost of nutrient(s) giving that value. It is a measure of the profitability of using fertilizer. It is generally agreed that the marginal value:cost ratio (for the last increment of added nutrient) should be greater than 2 to encourage farmers to use fertilizer. In the analysis that follows, we use an average value:cost ratio. Therefore, ratios of somewhat greater than 2 are necessary to provide an economic incentive to the farmer to adopt or increase the use of fertilizer.

Table 23. ISRA's Generalized Fertilizer Recommendations for Senegal, 1975

Crops	Fertilizer		Nutrient Rate, kg/ha		
	Quantity kg/ha	Grade	N	P_2O_5	K_2O
Fallow or green manure at beginning of rotation	400	Phosphate rock, 0-35-0	-	140	-
Peanut (South)	150	8-18-27	12	27	41
(Central)	150	6-20-10	9	30	15
Cowpea	150	8-18-27	12	27	41
Millet (North)	150	14-7-7	21	10	10
(South)	150	10-21-21	60	31	31
	+100	+45-0-0			
Sorghum	150	10-21-21			
	+100-150	+45-0-0	60-82	31	31
Maize	200	8-18-27			
	+200	+45-0-0	106	36	54
Rice (rainfed)	150	8-18-27	57-80	27	41
	+100-150	+45-0-0			
Rice (irrigated)	200	8-18-27	61	36	54
	+100	+45-0-0			
Cotton	150	8-18-27	34	27	41
	+50	+45-0-0			

Peanuts--The Research Institute of Tropical Agronomy (IRAT) conducted multi-rate trials for peanuts between 1950 and 1957. Treatment data were selected from the trials to determine yield response to rates of an individual nutrient while other nutrients were applied at near optimum levels. Trial locations were grouped into regions: Central Basin, Southern Basin, and Casamance. The Research Institute for Oil and Oil Crops (IRHO) conducted multi-rate trials for peanuts between 1951 and 1966 in the Central and Southern Basin. The data were analyzed by regression analysis to determine yield response to nutrients individually.

Peanut responses to N were about twice as great in the Southern Basin as in the Central Basin (table 24). No response to N was obtained in Casamance. Optimum N rates at cost: price ratios of 1 to 4 were between 4 and 11 kg/ha in the Central Basin and 7 to 12 kg/ha in the Southern Basin. With cost:price ratios less than 3, value:cost ratios were greater than 2 at optimum N rates in both regions. The data indicate that optimum N rates are 6 to 8 kg/ha in the Central Basin and 8 to 10 kg/ha in the Southern Basin. Farmers would be encouraged to use the optimum N rates for peanuts in both regions with a cost:price ratio of 3 or less.

Peanuts responded to P in all three regions. However, considering the trials by IRAT, the response was greatest in Casamance (table 25). The optimum rate of P_2O_5 was 19 to 31 kg/ha for the three regions at a cost:price ratio of 1. These rates gave value:cost ratios from 5.0 to

Table 24. Yield Response and Economics of N Fertilization of Peanuts, Senegal

Cost:Price Ratio	Optimum N Rate, kg/ha	Yield Increase kg/ha	Yield Increase kg/kg N	Value:Cost Ratio
	Central Basin, IRAT Trials ($\Delta y = 9.185N - 0.710N^2$)			
1.0	6	30	5.0	5.0
1.5	5	28	5.6	3.7
2.0	5	28	5.6	2.8
3.0	4	26	6.5	2.2
4.0	4	26	6.5	1.6
	Central Basin, IRHO Trials ($\Delta y = 35.095N - 1.543N^2$)			
1.0	11	199	18.1	18.1
1.5	11	199	18.1	12.1
2.0	11	199	18.1	9.0
3.0	10	198	19.8	6.6
4.0	10	198	19.8	5.0
	Southern Basin, IRAT Trials ($\Delta y = 22.308N - 0.924N^2$)			
1.0	12	135	11.2	11.2
1.5	11	134	12.2	8.1
2.0	11	134	12.2	6.1
3.0	10	131	13.1	4.4
4.0	10	131	13.1	3.3
	Southern Basin, IRHO Trials ($\Delta y = 80.404N - 5.427N^2$)			
1.0	7	298	42.6	42.6
1.5	7	298	42.6	28.4
2.0	7	298	42.6	21.3
3.0	7	298	42.6	14.2
4.0	7	298	42.6	10.6

19.9. At a cost:price ratio of 3, optimum rates of P_2O_5 were from 15 to 25 kg/ha in the three regions and value:cost ratios were from 2.0 to 6.9. Based upon these data, it is profitable to use 20 kg of P_2O_5/ha when cost:price ratios are less than 3.

K gave significant responses for peanuts in IRHO experiments in the Southern Basin and for IRAT trials in the Central Basin, but only at the Nioro location in the Southern Basin. In the Central Basin, optimum levels of K_2O were only 2 to 4 kg/ha, which is too low to be considered practical. In the Southern Basin, the optimum rate of K_2O was 14 and 25 kg/ha for the two sets of data at a cost:price ratio of 1 (table 26). These rates gave value:cost ratios of 6.5 and 2.8. At a cost:price ratio of 3, the optimum rate of K_2O was 11 for each set of data and value cost:ratios were 2.6 and 1.3. These data indicate a reasonable return on investment in 15-20 kg of K_2O/ha for peanuts in at least part of the Southern Basin at a cost:price ratio of 1, but the profitability of K_2O fertilization is questionable with the cost:price ratio of 3 or larger.

Comparing IRAT and IRHO data, peanut response to all nutrients was greater in the IRHO trials. However,

Table 25. Yield Response and Economics of P Fertilization of Peanuts, Senegal

Cost:Price Ratio	Optimum P_2O_5 Rate, kg/ha	Yield Increase kg/ha	Yield Increase kg/kg P_2O_5	Value:Cost Ratio
	Central Basin, IRAT Trials ($\Delta y = 12.944P - 0.288P^2$)			
1.0	21	145	6.9	6.9
1.5	20	144	7.2	4.8
2.0	19	142	7.5	3.8
3.0	17	137	8.1	2.7
4.0	16	133	8.3	2.1
	Central Basin, IRHO Trials ($\Delta y = 11.702P - 0.173P^2$)			
1.0	31	196	6.3	6.3
1.5	29	194	6.7	4.5
2.0	28	192	6.9	3.4
3.0	25	184	7.4	2.5
4.0	22	174	7.9	2.0
	Southern Basin, IRAT Trials ($\Delta y = 8.955P - 0.195P^2$)			
1.0	20	101	5.0	5.0
1.5	19	100	5.3	3.5
2.0	18	98	5.4	2.7
3.0	15	90	6.0	2.0
4.0	13	84	6.5	1.6
	Southern Basin, IRHO Trials ($\Delta y = 38.740P - 0.754P^2$)			
1.0	25	497	19.9	19.9
1.5	25	497	19.9	13.3
2.0	24	496	20.7	10.4
3.0	24	496	20.7	6.9
4.0	23	492	21.4	5.4
	Casamance, IRAT Trials ($\Delta y = 28.359P - 0.726P^2$)			
1.0	19	277	14.6	14.6
1.5	18	275	15.3	10.2
2.0	18	275	15.3	7.6
3.0	17	272	16.0	5.3
4.0	17	272	16.0	4.0

optimum fertilizer levels were similar. It is also of interest that by varying the cost:price ratios from 1 to 4, the optimum level of nutrient application generally changed very little.

In 1976, farmer price for peanuts was 41.5 F CFA/kg and cost of fertilizer was 20 F CFA/kg. The cost per kg of nutrient at subsidized and unsubsidized prices and the cost:price ratios for peanut fertilizers are shown in table 27. Cost:price ratios range from 0.91 to 1.72 at 1976 farmer prices, depending upon the fertilizer grade used.

On the basis of our analysis of the preceding data and the present cost:price relationships, it appears that the appropriate rate of N, P_2O_5,

Table 26. Yield Response and Economics of K Fertilization of Peanuts, Senegal

Cost:Price Ratio	Optimum K_2O Rate, kg/ha	Yield Increase		Value:Cost Ratio
		kg/ha	kg/kg K_2O	
	Central Basin, IRAT Trials ($\Delta y = 6.236K - 0.657K^2$)			
1.0	4	14	3.5	3.5
1.5	4	14	3.5	2.3
2.0	3	13	4.3	2.2
3.0	2	10	5.0	1.7
4.0	2	10	5.0	1.2
	Southern Basin, IRAT Trials ($\Delta y = 4.617K - 0.0729K^2$)			
1.0	25	70	2.8	2.8
1.5	21	65	3.1	2.1
2.0	18	60	3.3	1.6
3.0	11	42	3.8	1.3
4.0	4	18	4.5	1.1
	Southern Basin, IRHO Trials ($\Delta y = 12.014K - 0.393K^2$)			
1.0	14	91	6.5	6.5
1.5	13	90	6.9	4.6
2.0	13	90	6.9	3.4
3.0	11	85	7.7	2.6
4.0	10	81	8.1	2.0

Table 27. Subsidized and Unsubsidized Cost of Nutrients in Peanut Fertilizers and Resulting Cost:Price Ratios, Senegal, 1976

Fertilizer Grade	Subsidized Fertilizer		Unsubsidized Fertilizer	
	Cost, F CFA/kg Nutrient	Cost:Price Ratio	Cost, F CFA/kg Nutrient	Cost:Price Ratio
6-20-10	55.6	1.34	134	3.23
10-10-8	71.4	1.72	172	4.14
6-10-20	55.6	1.34	134	3.23
8-18-27	37.7	0.91	91	2.19

and K_2O is 8, 24, and 18 kg/ha, respectively, in the southern peanut basin; 8, 24, and 0 kg/ha in the central basin; and 0, 24, and 0 kg/ha in Casamance. The accuracy of these statements depends upon how well the response data correspond to the current responses obtained by farmers. It is recognized that the data used in this analysis were obtained 15 to 20 years ago. Cropping patterns, K supplied by soils, and peanut varieties all may have changed.

Results from 220 demonstrations conducted by IRHO in the southern peanut basin in the 1950's showed more than 500 kg/ha peanut yield increase from 8, 24, and 12 kg/ha of N, P_2O_5, and K_2O (15). At current prices, the value:cost ratio is 11.4. Also, Gillier and Prevot reported no response to P in an area roughly between Thies, Tivaouane, Tilmakha, and M'Bour (15).

An FAO Fertilizer Program was conducted in Senegal from 1961-1966 (16, 17). Results from 353 demonstrations for peanuts show the response to the combination of N + P_2O_5 (40 kg of nutrients/ha) was 10.8 kg peanuts/kg of nutrient. At cost:price ratios of 1 and 3, the value:cost ratios are 10.8 and 3.6, respectively. The available results show no treatment of N or P alone. It is impossible to determine the amount of yield response from each. On the average, there was no response of peanuts to K.

Extension demonstrations conducted by IRHO and IRAT, mostly in the last 10 to 15 years, have shown responses of peanuts to light doses of fertilizer of 4 to 6 kg/kg of nutrients in the north and central peanut basin (tables 28 and 29). Responses in northern Sine-Saloum were about 4.5 kg of peanuts per kg of nutrients for both light and heavy doses (primarily a difference in rate of K). In southern Sine-Saloum and Casamance responses were similar for each dose (8 to 10 kg of peanuts per kg of nutrients). Based upon the subsidized price for the light dose of fertilizer, value:cost ratios were 6.2 to 6.6 in the southern Sine-Saloum and Casamance and 3.0 to 3.5 further north. Returns were greater for the heavy dose. But, when based upon the real cost of fertilizer, returns were only greater than 2 in the area of higher rainfall (southern Sine-Saloum and Casamance).

It should be noted that under current fertilizer pricing policy, all complex fertilizers are sold to farmers at the same price. This means that the light (54 kg of nutrients) and heavy (79 kg of nutrients) doses cost the farmer the same, since each is supplied by the same quantity of different grades of fertilizer. Therefore, the farmer can receive a greater return from the heavy dose, even with less yield increase per kg of applied nutrient. A similar analogy exists for real costs also, because the unit nutrient cost is less for more concentrated fertilizers.

Millet and Sorghum--The results of six fertilizer trials for millet conducted by IRAT in a similar manner to the trials for peanuts are shown in table 30. There is only an 80% chance that observed yield differences were due to N or P applications and no response to K. With the cost:price ratio at 2 (present cost:price relationship for fertilizer recommended in the central basin), the optimum N and P_2O_5 rate was 13 and 15 kg/ha and each nutrient gave a response of 6 to 7 kg per kg of nutrient applied. This results in value:cost ratios greater than 3. At a cost:price ratio of 3, the value:cost ratios remain greater than 2.

Results from 83 FAO fertilizer trials for millet showed yield responses of 7.2, 8.2, and 5.7 kg of grain/kg of N, P_2O_5, and K_2O, respectively (table 31). At a cost:price ratio of 2, value:cost ratios ranged from 2.8 to 4.1 for N, P_2O_5, and K_2O, when each was applied at a rate of 22 kg/ha. However, 780 demonstrations showed an average response to N only.

Table 28. Nutrient Rates Used in Extension Demonstrations and Cost:Price Ratios for Crops and Various Fertilizer Formulas Used, Senegal (11)

	Nutrient Rates, kg/ha						Cost:Price Ratio			
	Light Dose			Heavy Dose			Light Dose		Heavy Dose	
Region	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Subsidized	Unsubsidized	Subsidized	Unsubsidized
					Peanuts					
North	15	15	12	-	-	-	1.7	4.1	-	-
N. Central	9	30	15	-	-	-	1.3	3.2	-	-
N. Sine-Saloum	9	30	15	12	27	40	1.3	3.2	0.9	2.2
S. Sine-Saloum	9	30	15	12	27	40	1.3	3.2	0.9	2.2
Casamance	9	30	15	12	27	40	1.3	3.2	0.9	2.2
					Millet					
N. & N. Central	21	10.5	10.5	-	-	-	1.9	4.6	-	-
N. Central	21	10.5	10.5	60	31.5	31.5	1.9	4.6	1.4	2.4
Casamance	21	10.5	10.5	60	31.5	31.5	1.9	4.6	1.4	2.4
					Sorghum					
N. Sine-Saloum	60	31.5	31.5	82	31.5	31.5	1.4	2.4	1.5	2.4
S. Sine-Saloum and Senegal	60	31.5	31.5	82	31.5	31.5	1.4	2.4	1.5	2.4

Table 29. Response to Fertilizers From Extension Demonstrations in Senegal (11)

Region	Yield, kg/ha[a]			Yield Increase[a] kg/ha		Yield Increase[a] kg/kg Nutrient		Value:Cost Ratio[b] Subsidized Fertilizer		Value:Cost Ratio[b] Unsubsidized Fertilizer	
	F_0	F_1	F_2	F_1-F_0	F_2-F_0	F_1-F_0	F_2-F_0	F_1	F_2	F_1	F_2
					-Peanuts-						
North	841	1,103	-	262	-	6.2	-	3.6	-	1.5	-
N. Central	1,172	1,427	-	255	-	4.7	-	3.6	-	1.5	-
N. Sine-Saloum	1,104	1,334	1,467	230	363	4.3	4.6	3.3	5.1	1.3	2.1
S. Sine-Saloum	1,600	2,073	2,243	473	643	8.6	8.1	6.6	9.0	2.7	3.7
Casamance	1,381	1,816	2,183	435	802	8.1	10.2	6.2	11.3	2.5	4.6
					-Millet-						
N. & N. Central	390	705	-	315	-	7.5	-	3.9	-	1.6	-
N. Central	193	532	1,216	339	1,023	8.1	8.3	4.3	5.9	1.8	3.5
Casamance	1,151	1,792	2,404	641	1,253	15.3	10.2	8.1	7.3	3.3	4.2
					-Sorghum-						
N. Sine-Saloum	587	1,119	1,368	532	781	4.3	5.4	3.1	3.6	1.8	2.2
S. Sine-Saloum & E. Senegal	1,001	1,720	2,349	719	1,348	5.8	9.3	4.1	6.2	2.4	3.9

[a] F_0 = unfertilized; F_1 = light dose; and F_2 = heavy dose.
[b] Value:cost ratios were calculated at 1975 prices.

Table 30. Yield Response and Economics of N and P Fertilization of Millet in Central and South Basins, Senegal

Cost:Price Ratio	Optimum Nutrient Rate, kg/ha	Yield Increase kg/ha	Yield Increase kg/kg Nutrient	Value:Cost Ratio
	Response to N ($\Delta y = 12.148N - 0.396N^2$)			
1.5	13	91	7.0	4.7
2.0	13	91	7.0	3.5
3.0	12	89	7.4	2.5
4.0	10	82	8.2	2.0
	Response to P_2O_5 ($\Delta y = 10.556P - 0.295P^2$)			
1.5	15	92	6.1	4.1
2.0	15	92	6.1	3.0
3.0	13	87	6.7	2.2
4.0	11	80	7.3	1.8

Table 31. Summary of FAO Fertilizer Trials and Demonstrations in Senegal, 1961 to 1966 (16, 17)

Crop	No. Trials (T) or Demonstrations (D)	Nutrient and Rate, kg/ha		Yield Response, kg/ha Nutrient	Value:Cost Ratio			
					Cost:Price			
					1.5	2	3	4
Millet	83 T	N	22	7.2	4.8	3.6	2.4	1.8
		P_2O_5	22	8.2	5.5	4.1	2.7	2.0
		K_2O	22	5.7	3.8	2.8	1.9	1.4
Millet	780 D	N	20	14.5	9.7	7.2	4.8	3.6
		$P_2O_5+K_2O$	20+20	1.2	0.8	0.6	0.4	0.3
Sorghum	9 T	N	22	3.8	2.5	1.9	1.3	1.0
		P_2O_5	22	0.9	0.6	0.4	0.3	0.2
		K_2O	22	-1.0	-	-	-	-
Rice	122 T	N	32	7.3	4.9	3.6	2.4	1.8
		P_2O_5	32	4.6	3.1	2.3	1.5	1.2
		K_2O	32	5.0	3.3	2.5	1.7	1.2
Rice	398 D	N	45	7.4	4.9	3.7	2.5	1.8
		P_2O_5	45	3.8	2.5	1.9	1.3	1.0
		K_2O	45	1.2	0.8	0.6	0.4	0.3

The extension demonstrations of IRHO and IRAT for millet (table 29) resulted in about 8 kg of grain/kg of nutrient and value:cost ratios of about 4 in the north and north central peanut basin. In Casamance, yields of millet were increased from 10 to 15 kg of grain/kg of nutrient and gave value:cost ratios of about 8 for subsidized fertilizer prices, and value:cost ratios of 3 to 4 for unsubsidized fertilizer prices.

The average response in 9 FAO fertilizer trials for sorghum was 3.8 kg of grain/kg of N for a rate of 22 kg/ha of N (table 31). At the present cost:price ratio of 2, the value:cost ratio is 1.9. On the basis of the results of 9 trials, there was no response to P or K.

The extension demonstrations for sorghum gave 4 to 9 kg of grain/kg of nutrients and value:cost ratios of 3 to 6, at subsidized fertilizer prices (table 29). The value of the returns was approximately 2 to 4 times greater than the unsubsidized cost of fertilizer.

In summary, fertilizer trial data support a recommendation of 15 to 20 kg/ha of N and P_2O_5 and similar quantity of K_2O for certain soils for millet in the central basin. Demonstrations in the south basin and Casamance show 60, 30, and 30 kg/ha of N, P_2O_5, and K_2O, respectively, are profitable. Trials are needed on farmers' fields to refine recommendations for individual nutrients. Present fertilizer pricing policy encourages use of higher rates.

Rice--The results of regression analysis of rice yield responses to N in Casamance from trials conducted by Siband and Diatta are shown in table 32 (18). The optimum rate of N at the present cost:price ratio of 1.5 is 78 kg/ha and this gives 13.8 kg of rice/kg of N, for a value:cost ratio of 9.2. The value:cost ratio is 4.9, if the cost:price ratio should increase to 3. Therefore, if response in farmer's field were only half of those predicted with this data, N fertilization of rice would be profitable.

In 122 FAO fertilizer trials for rice, 32 kg/ha of each N, P_2O_5, and K_2O gave responses of 7.3, 4.6, and 5.0 kg of paddy/kg of N, P_2O_5, and K_2O, respectively (table 31). This response resulted in value:cost ratios greater than 3 for each nutrient, with a cost:price ratio of 1.5. The greatest return was from N. Fertilizer demonstrations gave similar results for N and P, but showed no response to K.

Crop Response to Phosphate Rock

Several types of Senegalese phosphate rock (PR) have been tested for direct application to soil. Some characteristics of the PR are shown in table 33. Examples of the kinds of experiments and crop responses are discussed below.

Table 32. Yield Response and Economics of N Fertilization of Rice, Senegal (18)[a]

Cost:Price Ratio	Optimum N Rate, kg/ha	Yield Increase kg/ha	Yield Increase kg/kg N	Value:Cost Ratio
1.0	80	1,079	13.5	13.5
1.5	78	1,077	13.8	9.2
2.0	76	1,073	14.1	7.0
3.0	73	1,066	14;6	4.9

[a] $\Delta y = 26.129N - 0.158N^2$

Table 33. Characteristics of PR Used for Direct Application in Senegal

Material	Type	Content, % P_2O_5	Content, % CaO
Taiba	Beneficiated apatite	37	52
Schlams	Ground residue	30	28
BAYLIPHOS	Apatite	32	47
PHOSPAL	Calcined aluminum phosphate	34	11

In experiments of 2 years' duration at Bambey, 30 kg/ha of P_2O_5 from TSP applied annually gave equivalent yields of peanut and millet as did a single application of 160 kg/ha of P_2O_5 from Taiba PR (19). Supplemental TSP, in addition to the PR, gave no additional yield response. Comparisons of a single application of Taiba PR, BAYLIFOS, and schlams in a 2-year rotation experiment at Bambey showed similar response of peanut and millet to the three types of PR (19). Basically, it appears that the rate of PR was too high in both series of experiments to give a true evaluation of products.

Annual applications of Taiba PR and PHOSPAL were compared for cotton in two experiments by IRCT on a soil of pH 5.9. Cotton response was similar to the materials and maximum yield was obtained with the lowest rate of P_2O_5 (20).

Gora Beye (21) conducted four experiments comparing phosphate sources for rice at Djibelor on acid (pH = 4.2) sandy soil. Phosphate materials were applied annually at a rate of 100 kg/ha of P_2O_5. All sources gave significant yield responses in each year. Average yield from TSP and DAP was 7,048 kg/ha; PHOSPAL, Taiba and schlams--6,369 kg/ha; DCP--6,817 kg/ha; and Thomas Slag--6,536 kg/ha.

IRHO conducted long-term experiments with PHOSPAL at Darou on soils at pH 6.5. Over a period of 17 years, total yield response of peanut and sorghum increased when increasing rates of single applications of PHOSPAL were applied (table 34). However, yield increase per kg of P_2O_5 decreased as the single application rates were increased. With annual applications of PHOSPAL in another experiment, PHOSPAL was less effective

Table 34. Long-Term Yield Response of Peanut and Sorghum to a Single Application of PHOSPAL at Darou, Senegal, 1953-1969 (20)

Rate of P_2O_5, kg/ha	Yield (17 years), kg/ha		Yield Increase, kg/kg P_2O_5[a]	
	Peanut	Sorghum	Peanut	Sorghum
-	14,560	3,140	-	-
136	17,885	3,465	48.9	4.8
272	19,255	5,250	34.5	15.5
544	20,890	5,530	23.3	8.8

[a]One-half of P_2O_5 considered for each crop.

than dicalcium phosphate for both peanut and sorghum (table 35). An initial single application of PHOSPAL was as effective as annual applications of dicalcium phosphate when considering total yields over a 10-year period. In these experiments, yield responses were still evident 10 and 17 years after PHOSPAL was applied to soil.

Several researchers and reviewers have stated that PR for direct application is less effective in low rainfall conditions. PHOSPAL should be used only with more than 600 mm/year of rainfall (22) and Taiba with more than 800 mm/year (15). In an irrigation experiment, comparing annual applications of dicalcium phosphate (DCP) and PHOSPAL, neither source gave a response at the lowest moisture levels, and the two sources were similar at the highest moisture level (table 36). Some researchers reported the lack of effectiveness of PR at less than 600-800 mm of rainfall. While some show direct comparisons of PR and dicalcium phosphate, others only show no crop response to PR. In the latter instances, these may be in fact no response to applied P_2O_5 in any form. Although many experiments have been conducted in Senegal with PR, it appears that a thorough review of all work is needed. Possibly more experimentation is needed to adequately define the value of PR for direct application.

The Potassium Situation

ISRA has recently increased the rate of K recommended for most crops. The desirability of this recommendation has been questioned by outside sources. The need for some K fertilizer under intensive cultivation has been verified by results of a number of demonstrations. But, on the basis of research data available to the study team, it seems that K recommendations are higher than necessary.

In 1973, K experiments were initiated at three locations: the central basin; southern basin; and Casamance.[1] The trials were conducted under intensive cultivation and included treatments of residue removal and incorporation in soil. Generally with residue incorporation, there was little response to applied K, but a marked response to K within 3 years when the residue was removed. In some cases, yield responses were obtained with rates as high as 90 kg/ha, although verification of actual responses to fertilizer on farmers' fields is still the true evaluation measure.

The agronomic response of crops on farms to the level of K_2O presently recommended is not well documented. Applied research work needs to be expanded to include more fertilizer rate trials with particular emphasis on K and coordinated with a soil testing program.

Cultural Practices

The effect of soil preparation on the response of peanuts and sorghum to fertilizer is shown in table 37. Soil preparation alone shows little overall effect upon peanut yields. However, soil preparation greatly magnifies the crop response to fertilizer. For sorghum, soil preparation alone appears to have a good effect upon yield and again, as with peanuts, permits a greater crop response to fertilizer.

Charreau reported results from a large number of trials comparing manual tillage and no fertilization versus tillage with horse draft and light fertilization (24). Yield increases due to fertilization and tillage were 27% for peanut; 57% for millet; and 68% for sorghum.

[1]Personal communication with Christian Pieri, CNRA, Bambey.

Table 35. Comparison of Phosphate Sources at Darou, Senegal, 1957-1966 (20)

Applied P_2O_5			Yield (10 years), kg/ha		Yield Increase, kg/kg, P_2O_5[b]	
Source	Rate, kg/ha[a]	Time	Peanut	Sorghum	Peanut	Sorghum
-	-	-	8,825	1,420	-	-
Dical	240	annual	13,300	2,585	37.3	9.7
PHOSPAL	240	annual	12,280	2,285	28.8	7.2
PHOSPAL	240	single	13,375	2,420	37.9	8.3

[a]Total P_2O_5 applied during 10 years.
[b]One-half of P_2O_5 considered for each crop.

Table 36. Comparison of Annual Applications of Phosphate Sources Under Varying Soil Moisture Regimes at Bambey, Senegal, Average of 1957 and 1958 (23)

Applied P_2O_5		Peanut Yield, kg/ha — Water Applied During Crop Year, mm		
Source	Rate, kg/ha	330	640[a]	760[a]
-	-	1095	1550	1440
Dical	30	1215	1605	1710
PHOSPAL	30	1090	1600	1665

[a]Water applied by irrigation.

Table 37. Effect of Soil Preparation Upon Crop Response to Fertilizers (11, 13)

Location and Year	No Soil Preparation: No Fertilizer	No Soil Preparation: Fertilizer	Soil Preparation: No Fertilizer	Soil Preparation: Fertilizer
Peanuts				
Koumbidia 1971	831	956	856	1,173
Thysse Kayemor 1971	1,197	1,499	1,358	1,700
Thysse Kayemor 1972	734	1,040	678	1,260
Average	921	1,165	967	1,378
Sorghum				
Nioro-du-Rip (5 yrs)	1,127	1,924	1,760	2,888
Koumbidia 1971	840	1,141	1,081	1,722
Thysse Kayemor 1971	908	1,704	1,154	2,165
Average	958	1,590	1,332	2,258

Yields of peanut, sorghum, maize, or cotton were affected little, whether plowing was done at the beginning or end of the rainy season (24). However, late planting significantly reduced yield of sorghum, maize, and cotton in comparison with early planting.

The beneficial effect of weeding, proper time of seeding, and other practices could be illustrated by data from Senegal. However, the team felt that these are sufficiently well known everywhere and these factors will not be dealt with here.

FERTILIZER USE AND POTENTIAL

Fertilizer Use

While fertilizer consumption is generally low, Senegal is by far the largest user, consuming more fertilizer than the other five Sahelian countries combined.

Nutrient use is not reported in Senegal but is calculated on the basis of reported material use. Apparent nutrient use for 1964 to 1973 was obtained from the FAO/TVA datafile and from Senegal sources for later years (table 38). Differences exist between the FAO/TVA calculations and those used in other reports. From 1964 to 1967, the annual compound rate of increase was about 20%. Fertilizer consumption declined in 1968, 1969, and 1970 because of a decline in peanut prices and droughts.

Changing the peanut marketing scheme by placing the entire responsibility for peanut marketing upon ONCAD has also caused operational problems. Since 1970, the growth rate has been about 40% increase compounded annually. In 1976 crop year, 115,000 mt is expected to be used.

Table 38. Consumption of Fertilizer Nutrients in Senegal[a]

Material	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976 (est.)
	Consumption, mt of Nutrient												
	Nitrogen (N)												
Ammonium Sulfate	...	2,247	3,087	5,355	211	203	...	230	150	18	-	32	-
Ammonium Nitrate	...	-	-	-	-	-	...	35	35	-	-	-	-
Urea	...	-	-	-	-	30	...	1,000	1,900	1,500	2,925	2,840	4,500
Compound Fertilizer	...	20	118	-	5,055	3,199	...	2,510	2,950	3,658	5,155	8,094	9,782
Total	3,000	2,267	3,205	5,355	5,266	3,432	3,000	3,775	5,035	5,176	8,080	10,966	14,282
	Phosphate (P_2O_5)												
Single Superphosphate	...	-	-	-	-	-	5	10	10	-	-	-	-
Triple Superphosphate	...	2,728	3,676	4,966	-	-	150	200	50	240	469	216	225
Ammonium Phosphate	...	-	-	-	-	-	150	300	150	100	331	718	1,056
Other Phosphate Fertilizer	...	2,200	2,644	-	-	-	-	-	-	-	3,010	2,416	2,030
Compound Fertilizer	-	20	108	-	10,732	5,292	2,650	2,200	3,500	5,573	6,453	10,052	14,060
Total	3,500	4,948	6,428	4,966	10,732	5,292	2,955	2,710	3,710	5,913	10,263	13,402	17,371
	Potash (K_2O)												
Potassium Sulfate	...	-	-	-	-	-	15	30	20	-	-	27	-
Potassium Chloride	...	2,706	3,864	5,784	94	-	40	-	-	-	-	351	600
Compound Fertilizer	...	39	206	-	5,846	3,434	1,620	1,400	4,800	4,595	6,988	12,619	17,980
Total	2,800	2,745	4,070	5,784	5,940	3,434	1,675	1,430	4,820	4,595	6,998	12,997	18,580
TOTAL NUTRIENTS	9,300	9,960	13,703	16,105	21,938	12,158	7,630	7,915	13,565	15,684	25,341	37,365	50,233

[a] Figures for 1964-73 are from FAO/TVA datafile and those for 1974-75 are calculated data obtained from SIES, SSEPC, and ONCAD.

Average nutrient content of fertilizers used in the mid-1960's was generally less than 30%, while those in 1974 and 1975 are near 40%. Prior to construction of the Industrial Fertilizer Society of Senegal (SIES) fertilizer plant in 1967, single nutrient materials were used (mainly AS, TSP, and potassium chloride). Since then, most nutrients have been supplied in compound fertilizers.

In recent years, more concentrated compound fertilizers have been used to a greater extent than before (table 39). The most popular fertilizer used in peanut production is 8-18-27 and accounts for about 1/3 of the total fertilizer consumption. The principal millet fertilizer is 14-7-7, although use of 10-21-21 is increasing.

Estimated fertilizer consumption by principal crops is shown in table 40. Currently, about 50% of all fertilizer is used for peanut production; and 30% is used for millet and sorghum production. The estimated proportions of principal crops that are receiving fertilization are shown in table 41. It is estimated that a minimum of 19% of millet and sorghum, 28% of peanuts, and 97% of cotton is fertilized. It appears that the estimate of 70% of rice fertilized is an overestimation.

The estimated fertilizer use by regions is shown in table 42. About 40% of the total is used in Sine-Saloum and 20% of the total is used in each Diourbel and Thies. The greatest percentage increases in fertilizer use have been made in the Casamance in recent years. It appears that the potential for increased fertilizer use in the Casamance and Eastern Senegal in the future is good, provided crop prices and farm input prices are favorable. It is estimated that about 26% of the cultivated area in Senegal received fertilizer in 1975 (table 43).

Table 39. Recent Consumption of Fertilizer Materials and Projection for 1976[a]

	Estimated Consumption, mt		
	Year		
Fertilizer Material	1974	1975	1976
8-18-27	12,696	29,974	45,000
6-20-10	8,055	5,577	5,000
10-10-8	5,065	8,434	8,000
6-10-20	752	2,493	2,000
14-7-7	18,885	25,924	22,000
10-21-21	1,427	2,344	9,000
8-14-18	204	74	2,000
4-17-24	962	-	-
10-10-20	1,024	414	2,000
0-45-0	1,043	216	500
16-48-0	678	1,561	2,200
45-0-0	6,500	6,311	10,000
Phosphate rock	8,600	6,903	5,800
Other	579	2,684	1,500
Total	66,470	92,909	115,000

[a]Personal communication with SIES, SSEPC, and ONCAD.

Table 40. Estimated Use of Fertilizer Material by Crops, Senegal (12, 25)

Year	Crop: Peanut	Millet	Rice	Cotton	Other	Total
	Fertilizer Materials, 1,000 mt					
1962	21.2	2.3	0.9	-	0.4	24.8
1963	23.1	2.9	0.4	-	0.2	26.6
1964	32.2	4.7	0.6	-	0.3	37.8
1965	26.1	4.7	0.8	-	0.3	31.9
1966	38.4	9.1	0.9	0.1	0.5	49.0
1967	48.2	12.1	1.4	0.3	0.8	62.8
1968	25.9	9.6	1.2	0.6	0.5	37.8
1969	12.8	8.4	2.0	1.0	0.8	25.0
1970	6.5	6.2	0.5	1.6	0.1	14.9
1971	12.5	10.5	1.0	2.4	2.8	29.2
1972	23.1	18.5	0.8	3.0	3.7	49.1
1973	19.9	13.2	5.3	4.9	0.9	44.2
1974	29.5	20.5	7.9	7.0	1.6	66.5
1975	46.7	28.3	8.6	6.8	2.5	92.9
1976	57.3	35.1	11.3	7.9	3.5	115.1
	Fertilizer Materials, % of Total					
1962	85.5	9.3	3.6	-	1.6	100
1963	86.8	10.9	1.5	-	0.8	100
1964	85.2	12.4	1.6	-	0.8	100
1965	81.8	14.7	2.5	-	1.0	100
1966	78.4	18.6	1.8	0.2	1.0	100
1967	76.8	19.3	2.2	0.5	1.2	100
1968	68.5	25.4	3.2	1.6	1.3	100
1969	51.2	33.6	8.0	4.0	3.2	100
1970	43.6	41.6	3.4	10.7	0.7	100
1971	42.8	36.0	3.4	8.2	9.6	100
1972	47.1	37.7	1.6	6.1	7.5	100
1973	45.0	29.9	12.0	11.1	2.0	100
1974	44.4	30.8	11.9	10.5	2.4	100
1975	50.2	30.5	9.3	7.3	2.7	100
1976	49.8	30.4	9.8	6.9	3.1	100

Table 41. Estimated Distribution of Crop Area and Fertilizer by Principal Crops in Senegal, 1975

Crop	Crop Area 1,000 ha	Fertilizer Use 1,000 mt	Crop Area Fertilized[a] 1,000 ha	%
Peanut	1,122.6	46.7	311.3	28
Millet	989.0	28.3	188.7	19
Rice	81.8	8.6	57.3	70
Cotton	39.2	6.8	38.1	97

[a]Assumed rate of fertilizer application--150 kg/ha for peanut, millet, and rice. Figures used for cotton were received from SODEFITEX.

Table 42. Estimated Fertilizer Use by Regions, Senegal (12, 25)

Year	Region							
	Sine Saloum	Diourbel	Thies	Casamance	Senegal River	Eastern Senegal	Cap Vert	Total
	Fertilizer Material, 1,000 mt							
1962	13.8	5.1	3.4	1.4	0.2	0.7	0.2	24.8
1963	17.3	2.9	2.7	1.1	0.3	2.0	0.2	26.5
1964	29.1	3.2	2.7	1.3	0.2	1.0	0.3	37.8
1965	23.6	3.6	3.0	0.5	0.3	0.6	0.3	31.9
1966	33.9	6.4	5.2	1.0	0.8	1.3	0.5	49.1
1967	43.9	8.6	6.0	0.9	1.1	1.7	0.6	62.8
1968	23.3	3.4	7.6	1.1	0.9	1.2	0.5	38.0
1969	10.1	5.1	4.2	1.6	1.7	1.5	0.7	24.9
1970	6.9	2.4	2.7	1.3	0.1	1.3	-	14.7
1971	NA	NA	NA	NA	NA	NA	NA	29.2
1972	NA	NA	NA	NA	NA	NA	NA	49.1
1973	NA	NA	NA	NA	NA	NA	NA	44.2
1974	25.8	9.3	13.2	10.8	3.5	2.8	1.1	66.5
1975	37.5	18.9	17.7	9.4	4.5	4.3	0.6	92.9
	Fertilizer, % of Total							
1962	55.6	20.7	13.7	5.6	0.8	2.8	0.8	100
1963	65.3	10.9	10.2	4.2	1.1	7.5	0.8	100
1964	77.0	8.5	7.1	3.4	0.5	2.7	0.8	100
1965	74.0	11.3	9.4	1.6	0.9	1.9	0.9	100
1966	69.0	13.1	10.6	2.0	1.6	2.7	1.0	100
1967	69.9	13.7	9.6	1.4	1.8	2.7	0.9	100
1968	61.3	8.9	20.0	2.9	2.4	3.2	1.3	100
1969	40.6	20.5	16.9	6.4	6.8	6.0	2.8	100
1970	46.9	16.3	18.4	8.8	0.7	8.9	-	100
1971	NA	NA	NA	NA	NA	NA	NA	-
1972	NA	NA	NA	NA	NA	NA	NA	-
1973	NA	NA	NA	NA	NA	NA	NA	-
1974	38.8	14.0	19.8	16.2	5.3	4.2	1.7	100
1975	40.4	20.4	19.1	10.1	4.8	4.6	0.6	100

Table 43. Distribution of Crop Area and Fertilizer Use in Senegal, 1975

Region	Crop Area	Fertilizer Use	Crop Area Fertilized[a]	
	1,000 ha	1,000 mt	1,000 ha	%
Sine-Saloum	836	37.5	250.0	30
Diourbel	642	18.9	126.0	20
Thies	342	17.7	118.0	35
Casamance	320	9.4	62.7	20
Senegal River	100	4.5	30.0	30
Eastern Senegal	167	4.3	28.7	17
Cap Vert	6	0.6	2.0	33
Senegal	2,413	92.9	617.4	26

[a]Assumed rate of application--300 kg/ha in Cap Vert and 150 kg/ha in all others.

Consideration should be given to modifying the grades of fertilizer presently recommended and manufactured in Senegal. In particular, the present trend of replacing low analysis materials with higher analysis should be intensified. For example, the 6-20-10 recommended in the peanut basin could be replaced by a 10-34-17 (mixture of 16-48-0 and 0-0-60) and supply the same quantity of nutrients with 58% as much fertilizer, thus reducing freight and handling cost. Similarly, the 14-7-7 could be replaced by 26-13-13 (45-0-0, 16-48-0, and 0-0-60) and supply the same quantity of nutrients with 54% as much fertilizer. The present trend of increasing use of 10-21-21, supplemented with urea for millet and sorghum, will accomplish about the same thing and is probably more sound on an agronomic basis than using the grade high in N.

Potential Fertilizer Use

Senegal has the agricultural base for increasing fertilizer use. The cost:price relationship between fertilizer and crops is very favorable to the producer. Crop production programs are underway in all major regions of the country and organizations are structured to deliver credit and production inputs and collect farmer produce.

The study team estimates that fertilizer use will increase at a rate of 8 to 12% per year for the next 5 to 10 years, provided the above institutional factors favoring fertilizer use are maintained. Estimates of nutrient use on increased crop area (projected for 1980 in the 5th National 4-year Plan) are shown in table 44.

Under the assumption that 1/4 of the millet and 1/2 of other crops grown on the increased area are fertilized at near recommended rates, the increased production area will require 10,000 mt of N, P_2O_5, and K_2O. In addition, increases in nutrient consumption at rates of 10, 8, and 6% for N, P_2O_5, and K_2O, respectively, are projected, due to intensification on present cropland. This would add another 18,000 mt of nutrients (table 45). The projected consumption in 1980 is 78,000 mt of N, P_2O_5, and K_2O, which is equivalent to 195,000 mt of fertilizer containing 40% plant nutrients.

Between 1980 and 1985, the projected rate of increase in fertilizer use is 10, 8, and 6%/year for N, P_2O_5,

Table 44. Increased Crop Area and Projected Nutrient Use Due to Increased Crop Area, 1980

Crop	Increased Crop Area (12)	Assumed Average Rate of Application[a]			Estimated Nutrient Use		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
	1,000 ha	kg/ha			mt		
Rice	10.2	30	24	24	306	245	245
Maize	15.6	50	24	24	780	374	374
Millet	199.0	12	5	5	2,388	995	995
Peanut	46.9	7	15	15	328	704	704
Cotton	20.0	12	27	40	240	540	800
					4,042	2,858	3,118

[a]Assumed that 1/4 millet area and 1/2 other area is fertilized at near recommended rates.

Table 45. Projection for Fertilizer Consumption in Senegal 1980 and 1985[a]

Fertilizer Nutrient	Estimated Use, 1976	Source of Increase to 1980		Projected Use, 1980	Projected Increase, 1980-1985	Projected Use, 1985
		New Land	Intensification			
	1,000 mt					
N	14.1	4.0	6.5	24.6	15.0	39.6
P_2O_5	17.4	2.9	6.3	26.6	12.5	39.1
K_2O	18.6	3.1	4.8	26.5	9.0	35.5
Total	50.1	10.0	17.6	77.7	36.5	114.2

[a]Projected increase from intensification for 1976-1980 and all of increase 1980 to 1985 is based on 10, 8, and 6%/year for N, P_2O_5, and K_2O, respectively.

and K_2O, respectively (table 45). This would result in additional use of 15,000 mt of N, 12,500 mt of P_2O_5, and 9,000 mt of K_2O, or about 91,000 mt of fertilizer of 40% nutrient content. The projected consumption in 1985 is 114,200 mt of N, P_2O_5, and K_2O, which is equivalent to 285,000 mt of fertilizer containing 40% plant nutrients.

FERTILIZER SUPPLY

The majority of fertilizers sold in Senegal is marketed through ONCAD. The commercial sales organization for SIES is Senegalese Society of Fertilizer and Chemical Products (SSEPC). Most imported materials are also sold through SSEPC. However, certain Senegalese firms can import fertilizers for their own use. About 6,000 mt of urea has been ordered for the 1976-77 season and importation of a 10,000 mt buffer stock of urea is planned.

Fertilizer Distribution to Farms

ONCAD is responsible for distribution from the port-warehouse area or SIES factory to the farmers with the exception of SODEFITEX for cotton and SAED for rice, which directly supply inputs and market their own specific crops.

Planning for fertilizer production/delivery campaigns begins in September. ONCAD estimates the requirements for the coming year based on actual consumption for the previous year. ONCAD orders 50% of the estimated amount immediately to allow SIES ample time to plan and begin production. Meetings are then held from October to December between ONCAD agents, Development Bank agents, and farmer cooperatives to determine demand for the upcoming season. Ideally, by the end of December the results of these meetings are tabulated and a firm commitment for fertilizer purchases can be made by region. Distribution is carried out from December to June 30.

ONCAD has a fleet of 500-600 trucks at its disposal from three sources: trucks owned by ONCAD, trucks under ONCAD's control (development societies, agricultural services, etc.), and private trucks under contract. Whenever possible, trucks delivering farm products to market areas return with fertilizer. ONCAD is responsible for transporting fertilizer from the factory or port to inner-district storage areas. Regional storage is used to supplement storage at the local level. Farmers are responsible for transfer to farms from the inner-district storage. Most of this is done through Senegal's approximately 2,600 cooperatives.

There are 35-40 intermediate regional storage centers throughout the country in addition to one or two high capacity stores in each region. Storage capacity ranges from 100-2,000 mt, the largest being in the regional capitals. In addition to storage warehouses, fertilizer can be stored outside until May.

Frequent supply/transport problems (not in order of importance) were:

1. Production interruptions at the factory because of lack of imported sulfur, potash, or ammonia.

2. Slow rotation of trucks to the factory because of simultaneous transport of farm products.

3. Difficulty in obtaining trucks for moves from regional storage to microdistribution stores because of poor roads and little or no opportunity for backhauls.

Regional development organizations use a similar technique for distribution of fertilizers and other supplies. Member requirements are determined and orders placed. SODEFITEX fertilizers are transported to gins by hired trucks as a return load. From there, SODEFITEX trucks distribute to cotton collection centers and from the centers to the farmers.

Raw Materials for Fertilizer

Outside of some rumors that sulfur and/or potash have been discovered during offshore drilling operations for petroleum, raw materials for fertilizers in Senegal consist of several deposits of phosphate rock. Production is in progress at two of the phosphate deposits. In 1974, Senegal produced 1,702,000 mt of phosphate rock, most of which was exported.

The PR deposit nearest Dakar is located north of Thies and is an aluminum-calcium-phosphate deposit. The average analysis is about 30% P_2O_5, 30% Al_2O_3, 10% CaO, and 8-10% Fe_2O_3. The operating company, Senegalese Society of Phosphates of Thies, estimates the reserves contain 50 million mt of phosphate of 28.5% P_2O_5, or 100 million mt of 27.5% P_2O_5. An additional deposit of 2 million mt of conventional calcium phosphate of 34% P_2O_5 (after beneficiation) is located on another section of the complex.

About 45 km northeast from Thies is a second phosphate deposit owned by Senegalese Company of Phosphates of Taiba (50% Senegal government, 13.5% French Bureau of Geological Research, 12.33% International Minerals and Chemicals Corporation). This deposit contains about 30 million mt of easily recoverable reserves of 37.3% P_2O_5 concentrate and at least a similar amount of more marginal material.

Other phosphate deposits mentioned in the literature (appendix 1) would offer secondary production possibilities, compared with the primary ones listed above. Some reference is also made to the existence of oil north of Thies, but no elaboration is included. The present state of knowledge on the existence of petroleum is not sufficient to assess the potential contribution to fertilizer production. A refinery using imported oil is being planned in the free zone at Dakar.

Production and Plans

Senegal is the only one of the six Sahelian countries which produces fertilizer. Production consists of PR (aluminum and calcium), thermally altered aluminum phosphate, phosphoric acid, DAP, TSP, and granulated NPK fertilizers.

At the Thies facility, production consists of aluminum phosphate rock; calcined aluminum phosphate (clinker); and finely ground clinker (PHOSPAL). Mining capacity is 700,000 mt/year of aluminum phosphate. Largest production to date was 400,000 mt in 1974; the 1976 production is expected to be 350,000 mt. Total calcining capacity is 350,000 mt/year. After calcining, the major portion of clinker is shipped to Europe for grinding and bagging for use in direct application. Small quantities (15,000 mt/year capacity) are ground in Raymond mills for use in Senegal. Partial chemical analysis of aluminum phosphate ore and PHOSPAL are shown in table 46. About 75% of the P in PHOSPAL is soluble in ammonium citrate.

Table 46. Partial Chemical Analysis of Thies and Taiba Phosphates

Chemical Constituent	Thies		Taiba Phosphate
	Aluminum Phosphate	PHOSPAL	
	wt, %	wt, %	wt, %
P_2O_5	29.8	34.6	37.3
Al_2O_3	30.9	35.9	0.75
CaO	9.2	10.9	51.5
Fe_2O_3	7.9	9.1	0.95
SiO_2	2.5	2.9	2.96
TiO_2	1.6	1.9	0.02
MgO	-	0.3	0.10
F	0.7	-	3.70
H_2O	16.2	-	1.65[a]

[a] Includes organic material.

Also, the capacity exists at Thies to process 100,000 mt/year of a calcium phosphate rock of 34% P_2O_5. The material has been marketed as BAYLIFOS. The calcium phosphate facilities at Taiba have the capacity to provide about 1,600,000 mt/year of concentrate. After mining and washing to remove some of the chert, the phosphorite is beneficiated by screening and flotation. The concentrate contains 37% P_2O_5. Concentrations of other constituents are shown in table 46.

The present needs of Senegal are 31,000 mt of phosphate rock per year, while production capacity exceeds 2,400,000 mt. Thus, it is apparent that Senegal will have a substantial export capacity for many years.

Both aluminum and calcium phosphates are used in the fertilizer production facility of SIES at Rufisque. This factory began production in 1968 mainly for export. The plant is capable of producing 230 mt/day of sulfuric acid, 70 mt/day of phosphoric acid, 300 mt/day of TSP, and 130,000 mt/year of granular DAP or NPK compounds. A bulk-blending unit of 40,000 mt/year capacity is installed at the factory but is not currently used. Inputs of raw materials include: potassium chloride from Republic of Congo; anhydrous ammonia from Europe or Gulf of Mexico; tricalcium phosphate from Taiba mine; aluminum phosphate from Thies; and sulfur from Poland, France, or Canada. Aluminum phosphate is used as part of the P component in the low analysis grades. About 5,000-6,000 mt/year is used.

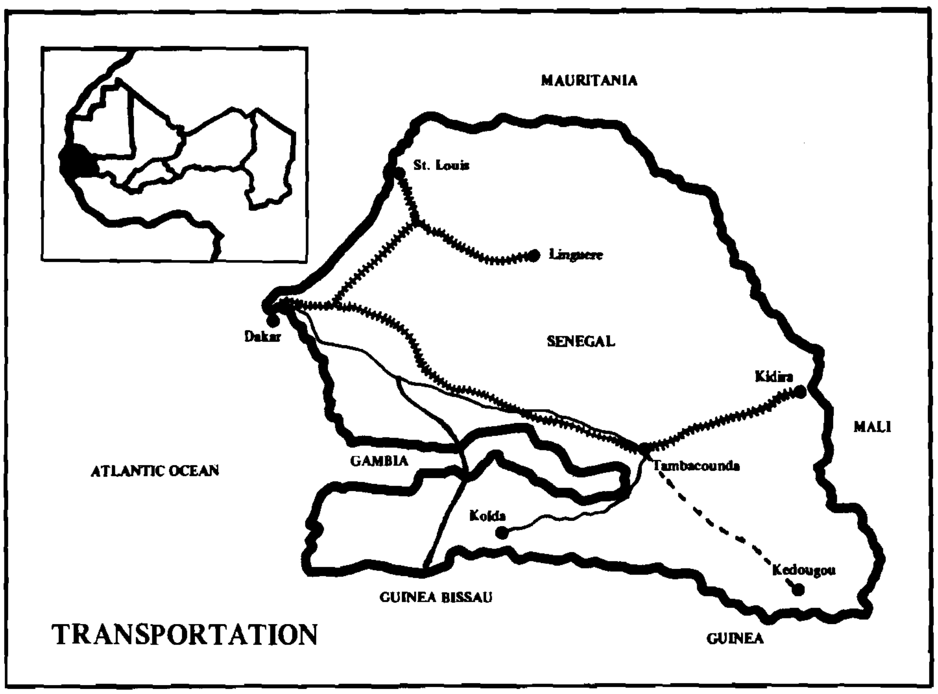
Fertilizer use is projected to increase at a rate of 7-8%/year. Hence, there are plans to increase the production capability since the present capacity of 130,000 mt/year of NPK compounds will soon be insufficient for Senegal's needs. These plans include sufficient sulfuric and phosphoric acid capacity for an additional 400 mt/day of P_2O_5 and an increase in the SIES granulation capacity for the production of TSP, MAP, and DAP for local and export markets.

In addition to this planned expansion, there is a project for producing ammonia and urea from gases from the planned oil refinery in the free zone of Dakar. A company, FERTISEN, has been formed for the nitrogen project. FERTISEN's capital will consist of: 40% by Government of Senegal, 10% by N-REN Corporation (USA), 30% by interested customer companies, and 20% unallocated. The facility will be constructed between SIES and the planned refinery. Installed capacity will be 230 mt/day of urea and 300 mt/day of ammonia in two units of 150 mt/day. Ammonia not used in urea production will be furnished to SIES for use in manufacture of NPK compounds and to local industries. N-REN will handle export of any surplus not used in the country.

TRANSPORTATION

International Transportation

Senegal has 533 km of coastline on the Atlantic Ocean and direct ocean access to world markets. Most of Senegal's international traffic is via the port of Dakar which is capable of handling any size vessel and is equipped for bulk or packaged cargoes. Dakar is the only protected commercial deep-water port among the Sahelian countries. In addition to Dakar, Senegal has three other ports with access to the Atlantic Ocean:



Foundiougne and Kaolack on the Saloum River and Ziguinchor on the Casamance River. Additional description of Senegalese ports as well as other west African ports that serve the Sahelian countries is found in the Regional Overview, Volume 1.

Domestic Transportation

The transportation network in Senegal is fairly adequate in serving the population concentrated in the west (26). Only short distances are required to access most areas, including the ports. Most of the 14,000 km of roads and 1,032 km of railway lines are oriented toward Dakar. About 58% of the roads are either paved, gravel, or earth all-weather roads. Transportation is carried on by private firms operating in a competitive atmosphere.

A main railway line, 660 km in length, originates in Dakar and extends into Mali. A northbound branch line connects Dakar with St. Louis (290 km) and also branches off to access Linguere in north central Senegal. The main railway line between Dakar and Mali carries about 40% of Mali's export traffic and 60% of its imports. This trade activity generates about half of the railroad system's gross revenues.

In addition to overland modes of transport, approximately 1,500 km of waterways are seasonally navigable. The year-round navigability of the Senegal River is limited to small ships and only to Podor, 275 km inland. Between July and January, boats can reach Matam, 646 km inland. In August and September, navigation is possible to Kayes, Mali, 973 km inland. The Saloum River is navigable for vessels of about 4,000-6,000 mt to Kaolack, 118 km inland. The Casamance River is navigable for 178 km by ships of up to 5 ft draft. Water movement is not heavily relied upon.

Transportation rates vary within Senegal, depending upon the mode and the extent of infrastructure development. Truck freight rates are extremely sensitive to road conditions (table 47). The high cost of road transport to Kolda, in the Casamance region of Senegal, is due to the poor roads used to access the town. Railroad transport costs are also variable and are established on an individual contract basis.

Table 47. Truck Transportation Rates in Senegal ,1975

Road Condition	Base Rate, $/mt/km
Tarred road	0.0343
Good path or improved path	0.0429
Ordinary path	0.0644
Bad path	0.1202
Sandy path	0.1631

The estimates of rail and road movement rate charges to key market areas are shown in table 48. The savings from shipping freight by rail are limited by the small number of rail routes and relatively short distance required to access most regions of the country. Thus, much of the domestic freight movement is via truck. Freight forwarding and handling charges are standard for both modes of transportation. The cost of handling each transfer of fertilizer in 50-kg bags is about $1.88/mt.

Table 48. Freight Charges for Moving Bagged Fertilizers From Storage to Population Centers in Senegal ,1975

From	To	Distance	Mode	Handling Charges	Transport Charges	Total Transportation Cost
		km		- - - - - - - -	- $/mt -	- - - - - - - -
Dakar	Linguere	360	Rail	3.76	19.24	23.00
	Kidira	660	Rail	3.76	35.28	39.04
	Kaolack	170	Road	3.76	5.85	9.61
	Kolda	680	Road	5.64	46.42	52.06

POTENTIAL PROJECTS

Senegal has the land resources to achieve self-sufficiency in food production for its people. Only 36% of the potentially arable land is presently under cultivation. While not an easy process, new lands can be brought into production with time.

Most of the new lands are in the Casamance and Eastern Senegal Regions. These regions are relatively remote and will require development of infrastructure as they are settled. Improved production technology should be introduced along with settlement.

The Senegal River Region offers potential for increased production and is relatively accessible. However, increased productivity of this region depends upon development of irrigation.

In the short run, food production can be increased through greater yields on existing croplands. Senegal has made significant progress in this area between 1973 and 1975. Greater use of improved production practices on currently cultivated land can further increase the productivity of Senegalese agriculture.

Adoption of fertilizer involves more than just the ability to accurately recommend and supply fertilizer. A stable price relationship between the value of yield gain and cost of fertilizer application must provide an economic incentive to the farmer. Even when this relationship appears to be economically favorable, the farmer may still be reluctant to adopt fertilizer. Extension education and fertilizer response demonstrations are important in assisting him to more accurately evaluate the benefits and risks of fertilizer use.

The following project recommendations are suggested to accelerate food production through the use of fertilizer in Senegal.

Soil Fertility Project

Senegal has a strong agronomic research program, but it is oriented toward controlled research on experiment stations or fields. This does not represent the level of crop production technology available to the mass of farmers in Senegal. Recently, extension and joint research-extension programs have been initiated in the peanut basin which should greatly improve crop response data at the farm level.

A soil fertility project is proposed for the Casamance and Eastern Senegal Regions. It should be incorporated by or have close liaison with current and future crop production and integrated agricultural development projects. In addition, the current soil fertility work in the peanut basin might be reoriented to also include K and PR response trials.

The Soil Fertility Project has the following objectives: (1) obtain agronomic and economic crop response data for fertilizer nutrients for "on-farm" conditions; (2) train Senegalese crop production specialists; and (3) demonstrate good crop production techniques to farmers. The term of the project is 5 years. Project team members would work closely with existing research and extension organizations. A detailed description of the proposed project is contained in appendix II.

Public Policy Studies on Price Stabilization and Equalization

Fertilizer use is highly dependent upon the relationship between the cost of fertilizer and crop prices.

IFDC recommends that alternate public policies on price support and cost subsidization be studied to determine their effects on fertilizer adoption, food production, and overall economic development. IFDC recommends that one expatriate economist work with Senegalese economists from the appropriate planning organization to carry out the study. The term of this project is 6 months. See appendix II for additional detail.

Estimated Budgets--Recommended Projects

The estimated foreign exchange requirements for the budgets for the recommended projects are:

Project	Budget
Soil Fertility	$825,000
Public Policy	31,000
	$856,000

REFERENCES

1. A Framework for Evaluating Long-Term Strategies for the Development of the Sahel-Sudan Region, Center for Policy Alternatives, Massachusetts Institute of Technology, 1974.

2. Indications of Market Size for 132 Countries, Business International, 1976.

3. Foreign Economic Trends and Their Implications for the United States, FET 76-022, U.S. Dept. of State and Dept. of Comm., Washington, D.C., 1976.

4. Etude Prospective pour le Developpement Agricole des Pays de la Zone Sahelienne 1975-1990, FAO, Rome, 1976.

5. Trade Yearbooks, FAO, Rome, 1972-1974.

6. The Economy of Senegal, Report No. 212 SE, IBRD, 1973.

7. Senegal: Tradition, Diversification, and Economic Development, EC-1-166, IBRD, 1974.

8. Production Yearbooks, FAO, Rome, 1972-1974.

9. Senegal Agricultural Sector Survey (Draft), Volume II Annex, Regional Projects Department, Western Africa Regional Office, IBRD, 1975.

10. Agri-Afrique, Ediafric-la Documentation Africaine, Paris, 1975.

11. General Critique on the Problem of Mineral Fertilizer in the Groundnut Basin, National Center for Agronomic Research - Senegalese Institute for Agricultural Research, Bambey, Republic of Senegal, 1975.

12. Evolution et Perspectives du Secteur Rural dans le Cadre de la Preparation du Ve Plan Quadriennal - Document de Travail, Ministere du Plan et de la Cooperation, Republique du Senegal, 1976.

13. Ramond, C., et Y. Gorgeu, Analyse des Rendements Parcellaires en Milieu Paysan Resultats Obtenus Pendant la Campagne 1971, Centre National de Recherches Agronomiques, Bambey, Senegal, 1973.

14. Ramond, C., M. Fall, et T. M. Diop, Main d'Oeuvre et Moyens de Production en Terre, Materiel et Cheptel de Traction des Terroirs de Got - Ndiamsil Sessene - Layobe (Enquete 1975), Centre National de Recherches Agronomiques, Bambey, Senegal, 1976.

15. Gillier, P., et Prevot, P., Fumures Minerales de l'Arachide au Senegal. Bull. Res. Counc. of Israel. 8D: 131-150. 1960.

16. FAO Fertilizer Programme, The First Decade, FAO, Rome, 1974.

17. Freedom from Hunger Campaign - Fertilizer Programme, West Africa, FAO, Rome, 1970.

18. Siband, P., and Diatta, S., Contribution a l'Etude de la Fertilisation du Riz Pluvial en Casamance. IRAT. 1974.

19. A Review of the Use of Rock Phosphate as Fertilizers in Francophone West Africa. Samaru Misc. Paper 43. 10 pages. IAR, Zaria, Nigeria, 1973.

20. PHOSPAL Field Trials. 19 pages. Societe Senegalaise des Phosphates de Thies and Societe d'Etudes et d'Applications des Minerais de Thies. Paris, France, undated.

21. Gora Beye. Etude Comparative de Differents Engrais Phosphates pour la Fumure Phosphatee du Riz en Sols de Riziere Tres Acides de Basse Casamance. L'Agronomie Tropicale 28:935-944. 1973.

22. Tintignac, J. P. L'Emploi des Phosphates de Thies dans la Production d'Arachide au Senegal. Oleagineux 21:525-530, 1966.

23. Gautreau, J. Influence de Regime des Eaux sur l'Efficacite des Engrais dans la Culture de l'Arachide au Senegal. Oleagineux. 21:217-222, 1966.

24. Charreau, C. Soils of Tropical Dry and Dry-Wet Climatic Areas of West Africa and Their Use and Management (draft). Agron. Mimeo 74-26. Dept. of Agron., Cornell Univ., Ithaca, N. Y. 1974.

25. Etude de l'Evolution de l'Emploi et des Effets des Facteurs de Production Mis en Place Pendant les Dix Dernieres Annees - Republique du Senegal, Ministere des Affaires Etrangeres, Direction de l'Aide au Developpement, Paris, France, 1972.

APPENDIX

APPENDIX I

FERTILIZER RAW MATERIAL DEPOSITS AND LITERATURE REFERENCES

References	Composition of Samples	Location	Other Information
Reference 1	Al phosphate	At Mibaye, east of Taiba	
	Lateritic phosphate	At Mekhe between Sam and Ker-Male north of Thies	Thickness of seam 4 m at Mekhe, 5-6 m at Tiare. Area approx. 500 km^2.
Reference 2 and Reference 4	"Very rich phosphate"	Keur Yakhandiaye and nearby.	
References 3, 4, and 6	These references describe the Thies phosphate presently extracted at Pallo. There is also aluminum phosphate at Ouobine.	85 km from Dakar	Overburden 2-3 m. Open-pit mining of seam 17 m thick average. Reserves 50 million mt.[a] In 1975, 250,000 mt calcined and ground to produce PHOSPAL.[b] Operating company is Societe Senegalaise des Phosphates de Thies.
Reference 6	Phosphate beds P_2O_5 11-35%	Many locations East and South of Thies.	40-50% of various borings for water encountered phosphate beds at depths of 40-100 m.
Reference 10	1.3-10.2% P_2O_5	Zinguinchor	Deposit found at 232 m during boring for water.
Explanatory note to Carte Geologique Senegal BRGM 1962	10-12% P_2O_5	Kanel, Guiers, Casamance	

[a] Ind. et Trav. d'Outremer Jan. 1976, p. 57, says reserves now estimated at 150 million mt.
[b] The grinding is done mainly in France.

References	Composition of Samples	Location	Other Information
Reference 7	High P_2O_5 aluminous rock	Pallo	Gives a mineralogical study of these large deposits indicating the presence of crandallite and wavellite, etc. and a defined series of clays.
Reference 6 p. 202-3	Pyrites in marls	Kaffrine N'Diouma Gainta	In one location at 85 m and in another at 230 m.
References 4 and 6	Many observations are reported of lignite, bituminous marls and limestones, in one case with pyrites.	Kedougou, Moukmouk, Ouakam, etc.	Usually encountered when boring for water. About 60 m deep and of great thickness.
Private communication	Oil in limestone	Thienaba (North of Thies)	
Reference 6 p. 183-4	Brines	N'Guermalal, Coki, Joal	
Above, Ref. 6	Brines	East of Lake Guiers	
Mem. BRGM 1967, 41, 32	Natron waters	North Senegal between meridians 15° 45' and 16° 45'.	
Industries et Travaux d'Outremer, Sept. 1975, pp. 739-40.	Phosphate rock (Private sources say not	Tobene near Lake Guiers	Reserves 90 million mt. A projected new mine will give 2 million mt product/year. Companies involved are from Senegal, Morocco, and France. A phosphate-oil exchange with Iran is being studied.

1. Senegal. A. Gorodiski. Rapp. a. Serv. geol. Afr. occid. Fr., 1948, pp 34-37. (In French) Phosphates, pp 36-37.

2. Senegal. A. Gorodiski. Rapp. a. Serv. geol. Afr. occid. Fr., 1949, pp 26-29. (In French) Phosphates, pp 27-29.

3. Note petrographique sur le phosphate de chaux de Lam-Lam (A.O.F.). L. Visse. C.r. somm. Seanc. Soc. geol. Fr., 1949, No. 11-12, pp 251-253. (In French).

4. Les ressources minieres de l'Afrique occidentale. M.G. Arnaud. Bull. No. 8., Dir. Mines Afr. occid. Fr., 1945. 100 pp, figs., refs., maps. (In French) Phosphates, pp 50-54, 85-92.

5. Sur les phosphates alumineux de la region de Thies (Senegal). L. Capdecomme. C.r. hebd. Seanc. Acad. Sci., Paris. 1952, Vol. 235, No. 2, pp 187-189, ref. (In French).

6. Contributions a la straitigraphie et a la paleontologie de la partie ouest de Senegal (Cretace et Tertiaire). F. Tessier. Bull. No. 14. Dir. Mines Afr. occid. Fr., 1952, Vol. 1. 267 pp, figs., photos, refs., maps. (In French) Phosphates, pp 93-94, 110-120, 147-151.

7. Etude mineralogique des gites de phosphates alumineux de la region de Thies (Senegal). L. Capdecomme. C.r. 19me Congr. geol. int., 1952, Sect. 11, Pt. 11, pp 103-117, fig., refs. (Algiers: 1953). (In French).

8. L'emploi des phosphates de Thies dans l'agriculture Senegalaise. S. Bouyer. C.r. 2me Conf. interafr. Sols. Leopoldville, 1954, Vol. 2, pp 1395-1414. (In French).

9. Sur la radioactivite des phosphates de la region de Thies (Senegal). L. Capdecomme and R. Pulou. C.r. hebd. Seanc. Acad. Sci., Paris, 1954, Vol. 239, No. 3, pp 288-290, refs. (In French).

10. Miocene et indices phosphates de Cassamance (Senegal). A. Gorodiski. C.r. somm. Seanc. Soc. geol. Fr., 1958, No. 13, pp 293-297, refs. (In French).

11. Les phosphates de Taiba. V. Dmitrieff. Travaux, 1959, No. 298, pp 449-453, photos. (In French. English abstract. p 449).

12. Contribution a l'etude des phosphates alumineux de la region de Thies (Senegal). E. Latrilhe. Bull. No. 25. Serv. Geol. Prospect. min. Afr. occid. Fr., 1959. 84 pp, figs., photos, refs. (In French).

13. Abbau und Aufbereitung der Phosphatlagerstatten in Florida und im Senegal. G. Quittkat. Z. Erzbergb. Mettallhattwes., 1960, Vol. 13, No. 3, pp 101-109, figs., photos., maps. (In German).

14. Aptitude a l'enrichissement du minerai de phosphate de Taiba (Concentration aptitude of Taiba phosphate ore). M. Prioux. Pap. No. E/CONF. 39/A/122. U.N. Conf. Appl. Sci. Technol. Benefit less Dev. Areas, 1962. 5 pp (In French).

15. La sedimentation et l'alteration lateritique des formations phosphatees du gisement de Taiba (Republique du Senegal). M. Slansky, A. Lallemand and G. Millot. Bull. Serv. Carte geol. Als. Lorr., 1964, Vol. 17, Pt. 4, pp 311-324, figs., refs. (In French. English abstract, p 323).

16. The Taiba phosphate rock mine. Phosphorus & Potassium, 1970, No. 49, pp 26-30, figs., photos.

APPENDIX II

RECOMMENDED PROJECTS

SOIL FERTILITY PROJECT IN SENEGAL

Fiscal year proposed for financing: FY 1978

Priority and Relevance

A goal of AID support in West Africa is to assist in increasing food production, particularly to restore balance between production and demand. Major emphasis is being placed on this goal by AID through support of Semi-Arid Food Grain Research and Development (SAFGRAD) and country and sectional crop production and/or integrated rural development projects.

Requirements for millet, sorghum, and rice, primary food crops, are projected to increase 118,000 and 258,000 mt by 1980 and 1985 over 1975 food requirements. To help meet these needs, basic and applied research and extension programs are being expanded to develop and distribute drought tolerant varieties adapted to the soil and climatic conditions, to study cropping systems suitable to the area, and to generally increase use of improved crop production technology, particularly in the peanut basin. These programs are much needed and will bring about increased crop production. Senegal also needs to expand crop production in the Casamance and Eastern Senegal Regions.

Farm level information is scarce for cereal response to fertilizer. Limited data indicate on-farm response to low levels of application may be from 7 to 15 kg of grain/kg of N plus P_2O_5 in the peanut basin. Even less information is available for on-farm crop response to K although trials and demonstrations have been initiated.

Many trials have been conducted with PR, both Taiba and PHOSPAL. However, available data did not permit an evaluation of the economics of use of PR in comparison with soluble P fertilizers. To maximize the response to fertilizer, improved production practices at the farm level must be implemented. Little is known about farmer attitudes toward acceptance of improved cultural practices. The lack of widespread acceptance in many cases may be due to the lack of farmer knowledge, bottlenecks in the delivery system for inputs, limited availability of credit at economical interest rates, inadequate input/output price relationships, and unstable market demand.

Description of Project

This project would implement a soil fertility program in the Casamance and Eastern Senegal Regions consisting of two "action" components followed by a project evaluation. The term of the project is 5 years. It would be implemented within the framework of existing institutions responsible for agricultural research and extension.

The objectives of the soil fertility project are:

1. Define the nature of response of food crops to fertilizer in various soil and climatic conditions at the farm level;

2. Quantify the value of indigenous PR for food crop production in relation to soluble P fertilizer and other widely used PR under varying soil and climatic conditions;

3. Train nationals in improved crop production practices, methods of conducting and analyzing trials and demonstrations, and using results with farmers;

4. Demonstrate to farmers the value of improved crop production practices; and

5. Relate levels of inputs of a crop production program to outputs, changes in attitudes, and changes in practices.

This project proposes that one crop production specialist be assigned to work in each of two regions. Each crop specialist would have four assistants (nationals) that would be trained to carry on the work themselves. One or two additional new assistants would be added each year.

Specialists would be assigned for 2 and 3 years and rotation would be staggered to permit continuity. The first coordinator's term would be for 3 years. The specialists must have training and experience to conduct professional levels of work and must be able to effectively converse in French. Specialists should arrive in Senegal in January or February to give time for familiarization and planning before their first crop season. Upon arrival, the specialists would familiarize themselves with existing research data and crop production programs, and make detailed plans for the coming season in consultation with researchers and project management.

Each crop specialist would be responsible for conducting 30 to 40 crop production trials or demonstrations of a design suitable to measure the effect of individual plant nutrients (N, P, K, S), crop variety, plant population, timing of planting and harvesting, soil preparation, and incorporation of residue or manure application. Long-term experiments would be established to determine the effect of crop rotations and the value of residual fertilizer.

Individual trials with PR would be conducted for 3 to 5 years to determine the immediate as well as residual effect. The trials would include equivalent rates of P_2O_5 applied as TSP and PR and the lowest rates of PR with supplemental TSP. In all trials and demonstrations, soil samples would be obtained and analyzed for attempts at correlation of yield response and levels of soil test P and possibly other characteristics. Arrangements would be made for proper analysis of samples at research station laboratories. Rainfall (quantity and distribution) would be recorded at or near each location. Data would receive statistical and economic analyses, and practical farm budgets for various cropping and economic situations would be developed.

A graduate student would conduct adoption studies of changes resulting from the crop production program. This study would include documenting at the village level such things as: kinds and number of farmer contacts; availability of credit and other inputs; input and output prices; price fluctuations; availability of markets; acceptance and implementation of new practices; and effect of these on production, labor requirements, and economic well-being. The study would attempt to define the relative importance of various inputs of a crop production program upon the diffusion, acceptance, and implementation of improved cropping practices.

Training sessions would be conducted with assistants covering how and why various things are done. In addition, training sessions would be held with each cooperating farmer before trials are established, during the growing season, during harvest, and after harvest.

AID and Other Relevant Experiences

AID has funded many applied research, crop production, and extension training projects. The soil fertility project has particular relevance to the SAFGRAD project since it contains an action program to strengthen national institutions and to provide immediate benefits to Senegalese farmers.

Beneficiary

Principal beneficiaries of the project are Senegalese farmers. Through better defined crop response data and better informed extension advisors, farmers are more likely to increase crop yields and produce more for the time spent for production.

Feasibility Issues

Indications of cereal response to fertilizer are 7 to 15 kg of grain/kg of nutrient, with 40 to 50 kg of applied nutrient/ha. Present farmer price for 50 kg of each urea and DAP (55 kg of nutrients) in Senegal is about 2,000 F CFA. If a response of 10 kg of grain/kg of nutrient is obtained, the yield increase is 550 kg/ha. Using 37 F CFA/kg as the grain price, the value of the increased yield is 20,350 F CFA/ha or 18,350 F CFA/ha above fertilizer cost.

On a national basis, fertilizing 10,000 ha of millet or sorghum would require 550 mt of nutrients and result in 5,500 mt of additional grain. Estimated economic farmgate value of sorghum based upon world prices, margins, and freight is 23,500 F CFA/mt which gives an economic farmgate value of 129 million F CFA for the additional grain produced from 550 mt of nutrients. These nutrients supplied as urea and DAP would cost 41.9 million F CFA delivered to Dakar (based upon world prices plus freight). Using the same rate for domestic freight and margins as for grain, these add 7.5 million F CFA for a total cost of 49.4 million F CFA for the fertilizer delivered to farms. Therefore, each million F CFA spent on fertilizer can yield grain to replace 2.6 million F CFA in grain imports. Applying a portion of the fertilizer for rice will result in even greater benefits.

Other Donor Coordination

International Bank for Reconstruction and Development (IBRD), Fonds Europeen de Developpement (FED), Fonds d'Aide et de Cooperation (FAC), United Nations Development Program (UNDP), and AID are presently funding crop production projects and/or research and extension activities. The Federal Republic of Germany, Canadian International Development Association (CIDA), and Ford Foundation may be interested in funding for this type of project.

Financial Plan

The annual foreign exchange cost of the project is estimated to be $165,000 or $825,000 for a 5-year period. In addition, the GOS would be expected to supply the assistants and field hands for the work as well as office space. It is estimated that about 60% of the salaries budgeted in the first year for technical services would be needed in the first year since they will not be in the field a full year. However, support costs will be highest the first year.

Estimated Foreign Exchange Support for Five-Year Project

Technical Services	
Crop Production Specialists - 2 at $45,000 x 5	$450,000
Support	250,000
	$700,000
Graduate Student Stipend - 1 at $3,000 x 2	6,000
Support - $17,000 x 2	34,000
Travel - $5,000 x 2	10,000
	$ 50,000
Commodities	20,000
Travel for Specialists, Workshops, Printing and Logistic Support	55,000
Grant Total	$825,000

Implementation Plan

A contractual agreement will be made with GOS. The project would be administered by a project coordinator probably placed in the administration of the Ministry of Rural Development. Very close collaboration would be needed with the project managements of Region Administrations.

Project Development Schedule

Departure, Project Design Team	July 1, 1977
Project Committee Review, Project Paper	September 1, 1977
Review/Approval of Project Paper	November 1, 1977
Project Staff Arrive in Senegal	January 1, 1978

STUDY OF PUBLIC POLICIES ON PRICE STABILIZATION AND EQUALIZATION

Fiscal year proposed for financing: 1977

Priority and Relevance

Fertilizer use level is highly dependent upon the cost:price relationship between fertilizer and a crop although other factors influence fertilizer use. Farmers tend to maximize net returns and do not use fertilizer if returns do not cover the cost plus risks involved.

Generally, a kg of nutrient can be expected to give 8 to 10 kg of cereal grain. At current world prices for grain and fertilizer nutrients, imports of grain would cost 2.5 to 3 times the cost of fertilizer to produce the grain in Senegal. Any in-depth analysis would require consideration of many other factors.

Description of Project

This study would describe alternative public policies on price stabilization and equalization; subsidies for crops, fertilizers, and other related inputs; their implementation; effects upon fertilizer use; and the effects on the economy of the country sectors and regions. It would furnish guidelines for establishing policies related to fertilizer use which could effectively meet government goals. The study would require one expatriate economist working with one or more economists from the national planning agency. The study would be completed in 6 months.

AID and Other Relevant Experiences

The nature of other studies in this area financed by AID is unknown.

Beneficiary

Agricultural development would benefit rural and urban sectors. Increasing self-sufficiency in food through appropriate agricultural price and incentive policies would substantially strengthen Senegal's international positions by helping to correct current balance of payment problems.

Feasibility Issues

Given the varying cost:price ratios over the years it would seem worthy of establishing guidelines for policy in establishing prices of agricultural inputs and crops.

Other Donor Coordination

Unknown.

Financial Plan

The foreign exchange cost of the study is estimated to be $31,000. In addition, the local government would be expected to supply one or two local economists to work on the project.

Estimated Foreign Exchange Support for the Study

Technical Services

Economist - 1 at $30,000 x 0.5	$15,000
Support	10,000
Travel	5,000
Publication	1,000
	$31,000

Implementation Plan

A contractual agreement would be made with the GOS. The study would be undertaken with the national planning agency. It would require cooperation and assistance from Ministry of Rural Development, Office of Price Equalization and Stabilization, and organizations marketing agricultural inputs and outputs (ONCAD).

Project Development Schedule

Visit to the country for project negotiation	July 1, 1977
Visit to field for data gathering (2 months)	September 1, 1977
Completion of study	March 1, 1978

Technical Bulletin IFDC–T-4
April 1977

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER FLORENCE, ALABAMA, U.S.A. 35630