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Crop Improvement in Eastern and Southern Africa

Research Objectives and On-Farm Testing

A regional workshop held in Nairobi, Kenya, 20-22 July 1983

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Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa, Canada

Kirkby, R.A.

IDRC. East Africa Regional Office, Nairobi KE

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Crop Improvement in Eastern and Southern Africa:

Research Objectives and On-Farm Testing

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Editor: Roger A. Kirkby

RÉSUMÉ

Un atelier a réuni un petit groupe représentatif de scientifiques travaillant à des programmes d'amélioration des cultures alimentaires en Afrique orientale et australe, pour discuter de la planification, de la conduite et de l'élaboration de ces programmes. Le débat a porté surtout sur les aspects méthodologiques, communs à la majorité des cultures réalisées par les petits fermiers et les plus susceptibles de permettre l'utilisation des résultats de la recherche.

On s'intéresse donc ici aux cultures locales et aux pratiques culturales, à l'organisation de l'aide institutionnelle pour améliorer les cultures, aux objectifs particuliers des programmes et au mode d'établissement de ces objectifs, enfin aux méthodes d'évaluation employées pour formuler une nouvelle recommandation sur les travaux de vulgarisation. On résume aussi la séance de discussion qui a porté sur l'organisation des programmes d'amélioration des cultures, l'établissement des objectifs techniques, l'application des critères de sélection, la méthodologie pour les essais tous terrains et sur les fermes et, enfin, l'orientation de la recherche.

RESUMEN

Este seminario reunió un pequeño grupo representativo de científicos que trabajan en programas de mejoramiento de cultivos alimenticios en Africa oriental y meridional con el ánimo de discutir la planificación, la ejecución y el desarrollo de tales programas. El énfasis de la discusión recayó en aquellos aspectos metodológicos, comunes a la mayoría de los cultivos sembrados por los pequeños agricultores, que tienen la probabilidad de influir más en que los resultados de la investigación sean utilizados por el agricultor.

Entre estos trabajos se encuentran breves recuentos de las variedades locales y las prácticas de cultivo empleadas actualmente, la organización institucional para el fitomejoramiento, los objetivos específicos de los programas y su sistema de establecimiento, así como los procedimientos de evaluación empleados para llegar a las nuevas recomendaciones para los trabajos de extensión. También se incluye en este volumen un resumen de la sesión de discusión sobre la organización de los programas de fitomejoramiento, la fijación de los objetivos técnicos y la aplicación de los criterios de selección y la metodología para las pruebas tanto en fincas como en localización múltiple. Varios temas de política fueron identificados.

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GRAIN LEGUMES AND OILSEEDS

REVIVING GROUNDNUT PRODUCTION IN MOZAMBIQUE

A.D. Malithano, K.V. Ramanaiah, and S.B. Chilengue

Groundnut Improvement Project, University Eduardo Mondlane, Maputo, Mazambique

Groundnuts are extensively grown in Mozambique as a food as well as a cash crop. They are produced mainly by small-scale farmers on small plots of land. The agricultural surveys conducted annually from 1961-1970 placed groundnuts, in 1970, as the fifth most important crop in the country, occupying 9% (254 000 ha) of the total area under cultivation. The surveys also showed that 99% of the total area under groundnuts was cultivated by small-scale farmers (Missão de inquérito agricola de Moçambique 1970). Estimates in 1980 showed that 5% of the cultivated area was under groundnuts and the production was 90 000 t, giving an average yield of 450 kg/ha. This shows that, within 10 years, the area under groundnuts was reduced by half. This progressive decrease in groundnut production is associated with several limiting factors, especially droughts and seed shortages, so that today both the area under groundnuts and yields are severely reduced. Some areas that used to grow groundnuts have ceased to produce the crop. This is causing great concern both to the government and the public, so much so that a concerted effort is now being made to revive the production of groundnuts.

Working within the national strategy for increasing food production, the Groundnut Improvement Project started a modest research program in 1976, concentrating mainly on germ-plasm collection, multiplication, maintenance, and evaluation. The work of the project became more effective and gained momentum when the International Development Research Centre (IDRC) started giving financial support to groundnut research in 1980, making it possible for the project to work on other important aspects of groundnut research and production. In addition to research, the project is involved in training national scientists, field assistants, and labourers. To transfer its research findings to the farmers, extension is also becoming an integral part of the activities of the project. In this paper, an attempt will be made to give an overall picture of groundnut production and research in Mozambique and the role the project is playing in reviving groundnut production.

PRODUCTION AND YIELD

The major groundnut-growing areas in Mozambique are located in the provinces of Nampula, Zambézia, and Cabo Delgado in the north and Inhambane, Gaza, and Maputo in the south. Figure 1 shows that the

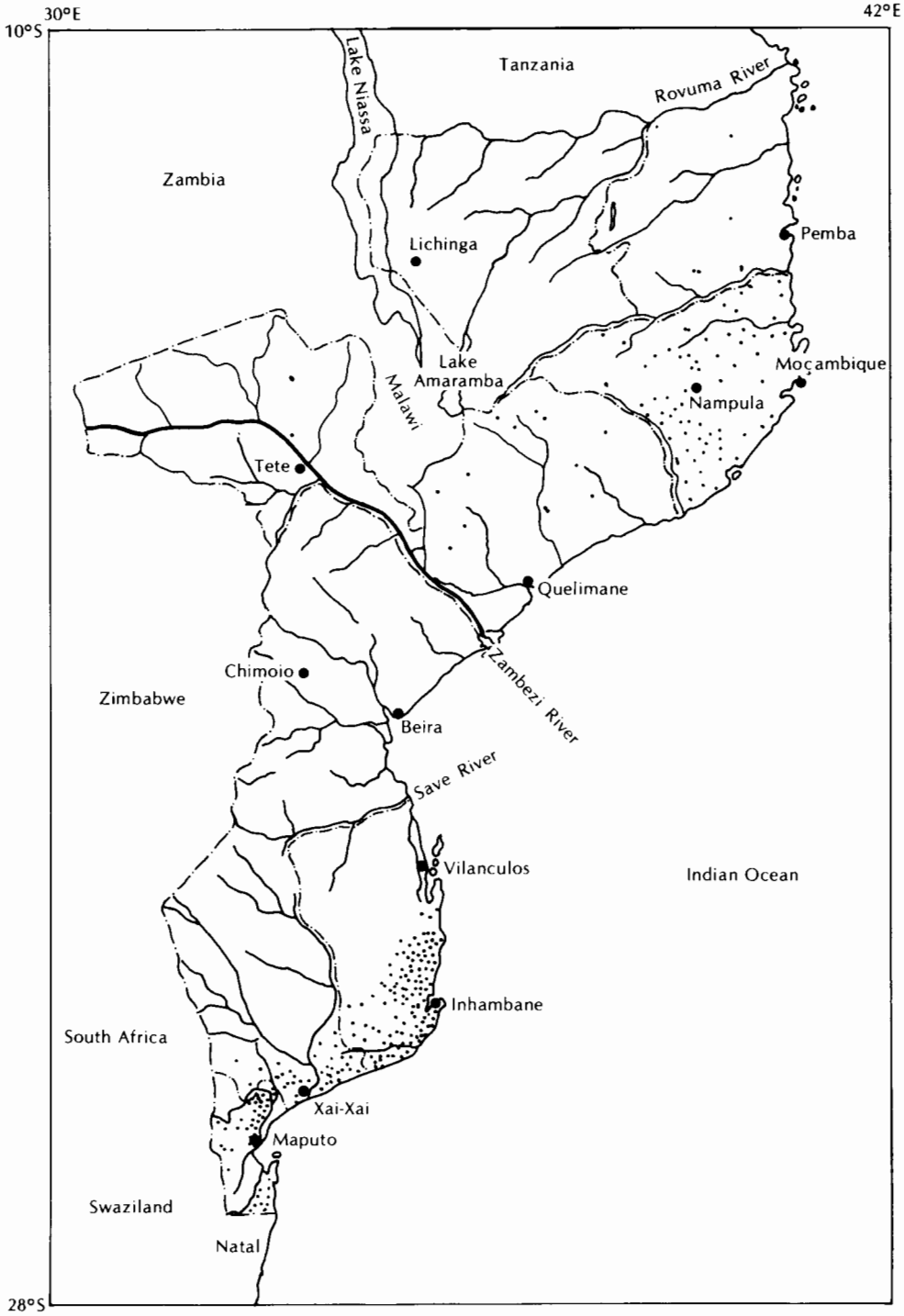

Fig. 1. Major areas of groundnut production.

coastal zone of Mozambique produces the bulk of the crop. It is also in this zone that the population density is the highest. It would appear that the demographic distribution and socioeconomic structure of the regions of the country influence, to a large extent, the production of groundnuts.

Traditional farming, involving very little investment, is practiced by all small-scale farmers in Mozambique. They form the largest group of farmers and it is this sector of agriculture that has been the most involved in groundnut production, both before and after independence. In traditional systems of farming, shifting cultivation (where land is available) and intercropping are generally practiced. Groundnuts are almost invariably intercropped with other crops, cassava and maize being the most popular. At present, there are no groundnut varieties recommended for use by the farmers, who grow landraces and keep part of their produce as seed for the next season. In the north, where the potential for groundnut production in terms of suitable soils and agroclimatic conditions is very high, the crop is grown mainly for cash as an oilseed crop and only small quantities are consumed as food. As such, there is a tendency for the farmers to give groundnuts second-class treatment in relation to the main staples of sorghum and cassava. Even so, the north is still the major producer of groundnuts.

Groundnuts are grown in the southern region both as a pulse food crop and for domestic cooking oil. They constitute one of the most important staples and are consumed, whenever available, daily in one form or another. However, the potential for groundnut production, as well as for other crops, is not as high as in the north due to the erratic rainfall pattern that can result in drought or flooding. In general, moisture loss due to evapotranspiration amounts to twice the total rainfall received (Carvalho 1969). Also, the soils where groundnuts are grown are predominantly sandy and poor in mineral nutrients and organic matter. Soil exhaustion due to continuous cropping is evident in many areas. Thus, although groundnut hectarage in the south is high, the yield per hectare is lower than in the north. Groundnuts are traditionally not grown in the central region, although the potential to do so exists.

In recent years, groundnut production in the south has been greatly reduced due to a lack of seed for planting. The scarcity of seed has been caused by consecutive droughts that, in 1982, culminated in one of the worst droughts in over 50 years, resulting in complete crop losses in some districts. In trying to beat the drought, farmers planted whenever it rained; but in all cases the crops dried up and, therefore, the farmers lost what little seed they had kept. Food shortages have been serious and farmers have been forced to eat their seed reserves. Thus, even if the rainfall should return to normal again, the farmers have practically no seed to plant and, therefore, no groundnuts to produce. Unless measures are taken to supply farmers with seed, groundnut shortages in the south will continue to be a serious problem.

Local Varieties

In the north, where the rainy season is prolonged, farmers grow mainly long-season populations of the Virginia type, comprising both

runner and bunch types. These are more suitable for that agroecological zone than the short-season populations because the former are dormant whereas the latter are not. Short-season populations of the Spanish type are also grown, mixed with the Virginia types or separately. The mixture of long- and short-season groundnuts causes difficulties and loss in yield at harvest because harvesting the earlier Spanish type causes damage to the long-season types; if the short-season types are not harvested once mature, they start germinating in the field. The more common practice is to grow these two types of groundnuts separately, which permits the farmers to grow two crops per year of the early-maturing type.

In the south, the duration of the rainfall is short and intermittent and short-season landraces are normally grown. The most popular populations grown by the farmers are Bebiano Branco and Bebiano Encarnado, characterized by cream to light-brown seeds and red seeds respectively. They are both short-season erect types and mature at the same time. At planting, farmers mix red and cream seeds in varying proportions depending on their liking. The preference is for a higher proportion of Bebiano Encarnado because this gives better taste to food than Bebiano Branco. However, according to their observations, Bebiano Encarnado is more susceptible to drought and lower yielding than Bebiano Branco. Variety trials show that Bebiano Branco yields better than Bebiano Encarnado (Table 1). The project is applying mass- and single-plant selection methods to improve this population and to recommend the improved version for immediate use by farmers. The project has also recommended that only short-season varieties and populations be developed for the south and long-season varieties and populations in the north, although short-season varieties can also be grown in the north. Research results indicate that the yield of long-season varieties in the south is very low compared with their performance in the north, where short-season varieties also produce quite high yields (Tables 1-3). At the present level of traditional farming in Mozambique, population improvement using mass selection or the modified pedigree method of selection using single seed descent (SSD) and the development of multiline varieties appears to be in line with the farmers' needs. Such varieties will be more easily accepted by the farmer and their purity maintained than varieties originating from a single pure line, which will be blended by farmers to satisfy their needs. The farmers are aware of the genetic variability in the populations that they grow. They recognize various genotypes with respect to seed colour, plant habit, and maturity. At shelling, various seed types are separated according to size and colour; but at sowing the population is deliberately reconstituted in definite proportions according to the farmer's liking, with an awareness of the fact that such a blend provides security against disease and drought and, at the same time, satisfies food preferences. Varietal purity is not of concern to the farmer. Therefore, breeding methods should aim at developing varieties with a high frequency of genes for yield without impoverishing the genetic variability in the variety. Multiline varieties composed of superior lines tested for disease and drought resistance, quality, and yield might be the answer in Mozambique. Multiline varieties composed of agronomically similar but genetically dissimilar pure lines have been proposed for self-pollinated crops (Browning and Frey 1969; Frey et al. 1971; Schilling et al. 1983). Some varieties developed through mass selection are being evaluated together with the others. Improved populations of Bebiano Branco will be tested in farmers' fields in "on-farm experiments" that have already been initiated.

Table 1. Yield of shelled groundnuts at Nhacoongo, 1980.[a]

Cultivar	Origin	Plant habit	Maturity	Shelled groundnuts (kg/ha)	Duncan test[b]
Bebiano Branco	Mozambique	Erect	Early	262	a
Tamnut	USA	Erect	Early	219	ab
55.137	Senegal	Erect	Early	212	ab
Malimba	Malawi	Erect	Early	210	ab
Bebiano Encarnado	Mozambique	Erect	Early	182	bc
Starr	USA	Erect	Early	155	bc
73.30	Senegal	Erect	Early	137	c
RMP-12	Senegal	Bunch	Medium	87	--
69-101	Senegal	Bunch	Medium	78	--
57-422	Senegal	Bunch	Late	60	--
Florunner (Senegal)	Senegal	Prostrate	Late	59	--
73.33	Senegal	Erect	Early	48	--
Mwitunde	Malawi	Bunch	Late	31	--
Manipintar	Malawi	Prostrate	Late	18	--

[a] The experiment was conducted in the southern part of the country.

[b] Cultivars ascribed the same letter are not significantly different in yield at the 5% level of probability.

Table 2. Yield of unshelled groundnuts at Namialo, 1981.[a]

Variety	Yield (kg/ha)	Duncan test (0.05)
57-422[b]	3611	a
Florunner	3333	ab
RMP-12[b]	3259	ab
Early Runner	2963	abc
59-127[b]	2796	bcd
69-101	2333	cd
Napalala	2278	cd
Manipintar	2206	d
Senegal[b]	1556	e
Local	1500	e

[a] This experiment was conducted in the northern part of the country.

[b] Obtained from Senegal.

Table 3. Yield of unshelled groundnuts at Namialo, 1982.[a]

Variety	Yield (kg/ha)	Duncan test (0.05)
Senegal	1340	a
Jonca[b]	1230	ab
Tamnut[b]	1060	bc
57-422	1060	bc
Starr[b]	900	cd
Maquilovilha	880	cd
Local	660	de
AC 207	600	e

[a] This experiment was conducted in the northern part of the country.
[b] Short-season varieties.

Farmers' Agronomic Practices

There is no definite seed rate used by the farmers. Depending upon the availability of seed at planting time, the seed rates for pure or mixed cropping may vary from 40-80 kg/ha. In the south, where seed shortage is very serious, farmers use less seed per hectare than in the north. In general, plant density is very low. Research results showed that erect varieties planted at high seed rates gave the highest yields. However, at a high plant population, the yield per plant and return on seed is lower than when plants are spaced far apart. Therefore, a high seed rate recommendation giving a high plant density may be an economic proposition for the state farms and private enterprises but not for the small-scale farmers who have difficulties obtaining sufficient seed to plant. Varieties that perform well at low plant densities should be identified and recommended for use by the small-scale farmer.

Groundnuts and all other crops are planted on the flat, even if the topography of the land warrants the making of bunds and ridges. Soil erosion is, therefore, a serious problem, especially in the north. Planting is always delayed and farmers recognize the loss in yield when groundnuts are planted late. However, they plant most land late because hoe cultivation is a slow process and, consequently, all other operations on the farm are delayed. The family labour force is commonly employed; although in the south, some farmers supplement this with animal traction. Rotation of crops and fertilizer application are not practiced but land may be left fallow for some time to allow it to recuperate.

INSTITUTIONAL ORGANIZATION

The Faculty of Agronomy and Forestry, University Eduardo Mondlane, was given full responsibility by the Ministry of Agriculture, through the National Institute of Agricultural Research (INIA), to carry out all research on groundnuts at the national

level. There is, therefore, an intimate relationship between the Faculty of Agronomy and Forestry and INIA. Except for cotton, sugarcane, tea, and cashew, INIA is responsible for the organization, administration, and management of agricultural research on all other crops in the country.

Because groundnut production in Mozambique is linked with small-scale farmers, strong ties have been developed with national organizations that cater to this group, such as Zonas Verdes (Green Belt) and Cooperatives and Regional Centres of Extension and Development (CRED). An intimate relationship has also been developed with individual farmers. The project has close links with the National Agricultural Directorate (UDA), which is responsible for state farms.

Because seed multiplication is especially important for groundnuts in Mozambique, the project is working very closely with the National Seed Company in giving technical advice on seed multiplication, treatment, certification, and distribution. It is with the collaboration of the National Seed Company that the project is improving Bebiano Branco, a local landrace, using the mass-selection method. The improved version of the population is being multiplied and will be supplied to the farmers as seed.

The relationship between the project and the above-mentioned organizations is mutual. For instance, the Faculty of Agronomy and Forestry does not have research farms; instead, these are provided by the organizations free in exchange for the scientific and technical advice given to them by the project and with the understanding that research results are of direct benefit to them.

The project collaborates very closely with Food and Agriculture Organization of the United Nations (FAO) and International Fund for Agricultural Development (IFAD) scientists working in Mozambique or there on short visits. Research on biological nitrogen fixation has been conducted by the project with FAO assistance.

Strong links have been developed with adjacent groundnut research programs in Zimbabwe, Zambia, Malawi, and Tanzania. There is now a reciprocal flow of research information, germ plasm, and exchange study visits. Farther afield, the project has a very close relationship with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which supplies exotic germ plasm. A joint project/ICRISAT local germ-plasm collection expedition was carried out in 1981 in northern Mozambique. ICRISAT has trained two technicians involved in the project and a third technician is currently taking part in an international course there.

IDRC recruited a senior scientist who, in collaboration with an agronomist, is carrying out research on groundnuts. As well, the researchers are teaching in their respective fields of specialization. This arrangement satisfies the additional objective of involving faculty staff and students in interdisciplinary agricultural research. Thus, apart from the plant breeder and agronomist, a plant pathologist is actively involved in groundnut research and scientific advice and assistance is obtained from other members of staff specialized in experimentation, chemistry, entomology, soil science, and rural development.

PROGRAM OBJECTIVES

The objectives of the project have two main components: (1) research in various aspects of groundnuts so that there will be an increase in production, and (2) training of Mozambican counterparts, field technicians, and workers so that research on this crop will be sustained.

Field surveys have been conducted by the project in all the major groundnut-growing areas. These have shown that there are several factors that limit groundnut production in Mozambique, such as a lack of farm implements and fertilizers; untimely planting, weeding, and harvesting; low plant density; and a lack of improved and high-yielding varieties resistant to diseases and insects. Every effort, therefore, is being made to revive and increase groundnut production through research aimed at identifying high-yielding varieties adapted to different agroecological zones. Such varieties should also be compatible with the present farming systems and trials are being conducted to encompass all aspects of the cultural practices employed by the farmers. To satisfy immediate needs, the project is screening a large number of varieties to identify those that are potentially high yielding. These varieties are then multiplied in collaboration with the National Seed Company and distributed to farmers as a stopgap measure until plant breeding can produce better varieties. An increase in groundnut production will greatly improve the level of nutrition of the rural and urban population. It will also mean that the country can export some of the produce to increase its foreign-exchange earnings.

The shortage of trained personnel is a serious problem in Mozambique. The project, therefore, attaches great importance to training national counterparts, field assistants, and workers. This will guarantee the continuity of the research work already initiated. Three graduates have worked in the project during the last year of their BSc course in agriculture. One of them will be working on a permanent basis in groundnut research and production. At the moment, the project is training two undergraduates in their third year of the BSc course. The aim is to give the candidates some experience in organizing and conducting research.

The project takes on a number of undergraduate students for special training in the field of agriculture under the university's extracurricular program.

A great deal of success has been achieved in training field assistants. These assistants receive their instructions from the project adviser and the agronomist. After sufficient exposure to the basic principles of agricultural science and research, they are recommended to participate in the international courses organized by ICRISAT. The project also organizes various forms of training for field workers in the project, members of farm cooperatives, and individual farmers. The underlying objectives of the training are to integrate theory with practice by stimulating students, lecturers, and assistants of the faculty to engage in agricultural research aimed at solving some of the basic problems farmers face in agricultural production. The project is also serving as the nucleus of the future postgraduate school and, at the same time, it is strengthening the national research capabilities through the exposure, guidance, and supervision of the students that pass through its program of work.

EVALUATION METHODS

The project has collected, maintained, and conserved a valuable germ plasm composed of exotic and local material. However, genetic resource conservation is only justified if such material can be utilized in crop improvement and crop production. Thus, systematic and quick methods of evaluation of the germ plasm so that promising material can be identified in a minimum of time and with a minimum of effort and cost should be devised. Through a multidisciplinary approach, in collaboration with an agronomist, a plant breeder, a pathologist, and a statistician, the groundnut germ plasm is evaluated in three stages.

Preliminary Evaluation of the Germ Plasm

The project has over 350 acquisitions and all of them have been evaluated for important agronomic and morphological characteristics such as yield, number of pods/plant, seed size and number of seeds/pod, shelling percentage, germination, flowering, vegetative cycle, pod maturity, and dormancy.

A description of plant morphology and habit has been made. This information is useful in deciding spacing within and between lines. Some of these varieties, pure lines, and segregating materials have been found to be high yielding and resistant to diseases such as rust and leaf spots.

Most of the germ plasm was bulked from a single plant or a few seeds so that there were delays of 2-3 years between the time that the line was acquired and the time that it was first tested. A preliminary observation nursery is used as an early testing technique of new material. However, there needs to be a balance between aiming for very early testing, through small unreplicated plots, and for gaining more reliable information from larger, replicated plots. A multilocation preliminary observation nursery is preferred because some acquisitions perform differently in different locations, e.g., material from Senegal proved to be excellent in the north but inferior in the south (Tables 1,2). If we had discarded this material in 1980, when it was first tested in the south, we might have lost the best material, so far obtained, for the north. It is, therefore, necessary to make a compromise between a screening method that is fast and one that is efficient enough to pick up superior material without expending too much energy and time.

Variety Yield Trials

The entries that performed well in the preliminary observation nursery are further tested in replicated multilocation variety trials. Data collected over 1 year are sufficient for a decision to be made on whether or not a variety should be tested further if the trial was truly multilocational; otherwise, more time is needed to obtain definite information about the performance of the varieties. Some of the varieties that had sufficient quantities of seed were evaluated directly in the variety yield trials. In these trials, no fertilizers were applied because this is how the farmers will eventually grow the crop. Through these experiments, varieties such as 57-422 and RMP-12 were recommended for the north and Bebiano Branco

and Valencia were recommended for the south. The recommendation was based mainly on the yield potential rather than on disease resistance, so that even if a variety was susceptible to disease, but the disease did not appreciably decrease yield, the variety was considered to be superior.

Advanced Variety Yield Trials

The best varieties in the variety yield trials are further evaluated under the "farming systems approach." They are tested under different levels of fertilizers and intercropped with other crops. Data showed that some varieties gave high yields at high levels of fertilizer application and others at low levels of fertilizer application. With multilocation variety trials, varieties that respond to high levels of fertilizer application have been identified. Such varieties will be recommended for state farmers and cooperatives. Those varieties that are high yielding but that do not respond well to high levels of fertilizer application will be recommended for use by small-scale farmers. On-farm experiments showed that, under dryland farming, 3500 kg/ha of groundnuts were obtained when 40 kg/ha of P_2O_5 were applied, whereas the control gave 1000 kg/ha. These trials were conducted on farmers' fields and on land belonging to members of the cooperatives who collaborated and participated in running the trials. In one area in the south a positive response to zinc sulphate was obtained, especially if this fertilizer was applied together with phosphatic fertilizers.

Considering the magnitude and popularity of intercropping in Mozambique, varieties are evaluated under this practice so that specific information may be obtained on the type of species that may be intercropped, plant density, and the date of planting of each crop in the mixture. This is especially important in view of the fact that, at present, a lot of effort is being made to breed more productive varieties of all the major crops grown in Mozambique. Any such improved varieties placed in the hands of the small-scale farmer will be intercropped and the assumption that the best cultivars selected in a monoculture will also be optimal in a mixed-cropping system needs to be verified.

SUMMARY OF METHODOLOGICAL ISSUES

The government is placing great importance on small-scale farmers because they produce most of the food consumed in the country. In order that information on better crop production methods reaches the farmers, extension services through demonstrations, radio, and pamphlets are being organized. This means that the project has to examine more closely its objectives and research methodology to accommodate the official recommendations of rural development. Because groundnuts are almost entirely grown by small-scale farmers, the project's direct involvement in transforming subsistence farming into economic and increased crop production is quite evident.

So far, emphasis in research has been given to identifying and recommending high-yielding and, preferably, multiline varieties of groundnuts so that the immediate food requirements of the country and food preferences of the people are satisfied. Therefore, breeding

objectives should aim at improving populations rather than releasing pure-line varieties. When there is an abundance of groundnuts, the farmers will become market-oriented and quality becomes an important factor. The breeding objectives will then have to change accordingly to suit such a demand. Farmers should be taught to use haulms profitably as livestock feed so that they may benefit from increased yields of milk. So far, farmers do not feed their livestock with groundnut fodder. Because animal traction is being strongly recommended as a cheap source of energy for the small-scale farmer, the project's identification of varieties whose foliage remains green at harvest is serving the dual purpose for the farmer of providing groundnuts as well as fodder.

Although intercropping is a popular practice, rotation is not common. There are several benefits associated with rotation and our future program should study this practice more closely and find a compromise between it and intercropping. When crops are rotated, fertilizer application is straightforward and easier than with intercropping. Some studies should be conducted on how to apply fertilizers to two different crops growing adjacent to each other in a mixture.

Although small-scale farmers do not use fertilizers, our program has a large component of fertilizer trials. Some of these trials have been carried out on farmers' fields in on-farm trials. After seeing a tremendous increase in crop yields, farmers are keenly interested in adopting this practice. Thus, our objective is not only improving existing practices but also innovating and introducing new ideas and technology.

The project has created and maintained close relationships with small-scale farmers so that, to many farmers, the project is synonymous with the Faculty of Agronomy. The project works closely with them from land preparation and planting through to harvesting. In this way, the project has managed to win the confidence of the farmers and they now turn to us for advice on their farm work. The project intends to intensify and improve this relationship because the whole objective of the groundnut improvement project is to help small-scale farmers raise their standard of living through increased food production and the economic benefits accruing from the sale of their produce.

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