INTERNATIONAL DEVELOPMENT RESEARCH CENTRE

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INTRODUCTION

The Agriculture, Food and Nutrition Sciences Division (AFNS) is one of the five Divisions of the International Development Research Centre (IDRC), the other four being Information Sciences, Population and Health Sciences, Publications, and Social Sciences and Human Resources. Each of the program divisions seeks to encourage and develop research and training capabilities within institutions and among scientists in the developing world.

The AFNS Division does not normally carry out research programs as such on its own behalf. In some cases, however, outside scientific expertise has been requested by developing country Institutions to help them develop specific parts of their programs and assist in training local scientific personnel. The papers compiled in this document are progress reports on the work in which 12 such field staff personnel are involved working within programs funded by IDRC but administed and directed by the grantee institutions. All of the programs are concerned with providing the small farmer with improved opportunities usually, but not always, through new technology which will fit in with his current cropping systems.

The subject matter covered by the papers is quite diverse and the projects themselves are located on four continents. Despite this diversity the ultimate objective of all the programs is to improve the wellbeing of rural people in some way. Very generally the programs can be divided into two categories. The first is related to developing improved agricultural technology through activities such as plant breeding, agronomic research and studies of plant interactions in multiple cropping situations. Associated with these activities is a research project on post-harvest grain preservation and processing to find ways of reducing the quite substantial losses which are common during storage and processing in developing countries.

A second group of papers is concerned with concepts and techniques related to determining how current farming systems operate, defining their parameters and finding out what farmers want and need. This information is important as a basis for orienting more specialized research on technology improvement and for identifying limiting constraints whose removal would allow for improved wellbeing for rural people. The first of these five papers details an approach being developed by the International Rice Research Institute in Southeast Asia as a means of assuring the relevance of its Rice-based Multiple Cropping Systems research program. The last four papers form a unit since all four authors work in collaboration in the same program in Colombia but present their research findings from slightly different academic points of view. Conclusions are still tentative but nevertheless some very important and extremely interesting concepts and programming techniques are evolving which have profound implications for agricultural research and rural development programs. At issue is the fundamental question of how agricultural research and development programming priorities are determined by executing agencies, both national and international, and the implicit assumptions on which programs aimed at helping rural people are based.

AFNS trusts that these presentations in the form of progress reports on research activities underway and supported by IDRC will be of interest to the invitees to this Symposium.

5.

THE SMALL FARMER AND SORGHUM IMPROVEMENT IN ETHIOPIA

By

K. Riley

Presented at

IDRC Field Staff Symposium
November 20, 1974
Ottawa, Canada

THE IMPORTANCE OF SORGHUM

Ethiopia is a remote and rather aloof country in the north-east corner of Africa, isolated from her African neighbours by deserts on three sides, and separated from the Miolalle East by the Red Sea. The high Central Plateau runs north and south like a broad bumpy backbone down the length of the country at an altitude of two to three thousand metres. A second, smaller rib, called the Chercher Highlands, comes from the eastern Horn of Africa and would merge with the Central Plateau if it were not for the Rift Valley, which begins in the Danakil depression and runs southward into East Africa, splitting the Central Plateau from the Chercher Highlands.

Sorghum is found in scattered pockets along both east and west edges of the Central Plateau up to an altitude of 2,400 metres and extends into the low hotter areas towards the Sudanese border in the west. The most concentrated area of sorghum is throughout the Chercher Highlands. The distribution of sorghum production is shown in Figure 1.

In the highland areas, long maturing, tall types are grown, which may take half a year to flower, and often reach a height of four metres. In the lowlands, faster maturing, shorter types are grown during the short rainy season.

Estimates of sorghum production in Ethiopia range from one million tons to 1.4 million tons per year (Stanley 1971). The sorghum crop occupies about 1.5 million hectares which is 18% of

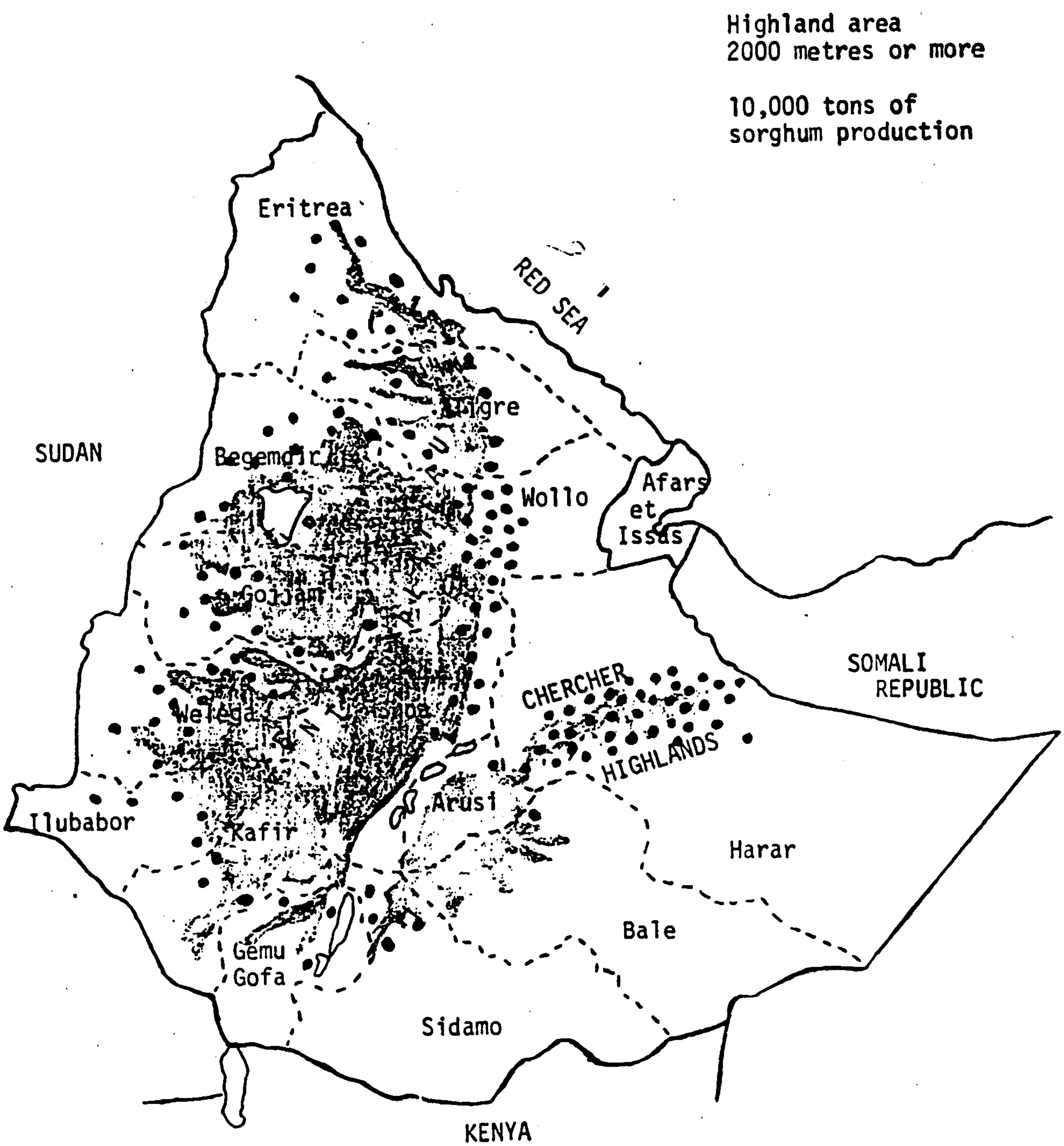

Fig. 1 Sorghum Production in Ethiopia 1967
Adapted From: The Rural Economy of Ethiopia
by S. Stanley, 1971

the land devoted to food crops. (Statistical Abstracts 1970-1971. As shown in Table 1, combined sorghum and millet production ranks second only to teff, Eragrostis teff, a small grained, low yielding cereal which is generally grown at higher altitudes than sorghum.

Table 1. PRODUCTION OF MAJOR FOOD CROPS IN ETHIOPIA 1966-1967

Crop	Area (thousands of hectares)	Production (thousands of metric tons)
Teff	2,008.7	1,149.2
Sorghum & Millet*	1,759.0	1,441.0
Barley	1,480.8	1,328.9
Maize	1,119.3	1,099.3
Wheat	660.0	478.9
Pulses	823.7	584.0
Enset (false banana)	190.8	449.0

*Millet is mostly grown in the North, in Eritrea Province.

Source: Stanford Research Institute (S.R.I.) Report #10, 1969.
Statistical Abstracts, 1966-67.

National sorghum yields between 1961-1965 are reported to be 6.1 quintals per hectare (S.R.I. Report #10, 1969). The statistical abstracts 1966-67 put the figure at 8.4 quintals per hectare. Provincial yields, shown in Table 2 range from 14.3 quintals per hectare in

Shoa Province, down to 4.6 quintals per hectare in Eritrea. Sorghum is most widely grown in the Chercher Highlands of Harar Province where 44% of the food crop area is planted to sorghum.

Table 2. PROVINCIAL YIELDS AND IMPORTANCE OF SORGHUM 1966-1967

Province	% of Crop Area Devoted to Sorghum	Yield (Quintals per hectare)
Arusi	3.0	8.1
Bale	2.4	8.5
Begemdir	15.0	7.9
Eritrea	5.0	4.6
Gemu Gofa	19.9	5.9
Gojjam	13.0	7.5
Harar	44.0	10.0
Ilubabor	27.0	7.7
Kafir	12.5	6.7
Shoa	7.0	14.3
Sidamo	14.3	7.3
Tigre	21.0	6.7
Welega	17.9	9.5
Wollo	15.0	11.5

Source: Stanley 1971.

The importance of sorghum in an area is also affected by tribal preference. The Amhara people who live in Shoa and Gojjam, place a very high value on teff, however, the Galla or Kotu people who predominate the Chercher Highlands value sorghum very highly and it usually sells for a higher price in the markets in this area. The Somali people who live further east in Harar Province are able to grow sorghum, but they reportedly sell it all and buy maize instead.

THE SORGHUM FARMER IN HARAR PROVINCE

Since I am most familiar with the area in the centre of the Chercher Highlands where the Alemaya College of Agriculture is located, I will concentrate on describing sorghum farming in this area.

The average size of a farm in Harar is roughly estimated at one hectare. Fifty-one percent of the farmers are tenants (Stanley, 1971). Sorghum is exclusively a small farmers' crop, 90% of the crop in the Alemaya area was found to be consumed on the farm without entering a commercial market (Birke, 1974).

The land is usually cultivated just before the onset of the rains in March. Often a digging stick is used. This is a stick tipped with a 10 cm. wide iron blade, with a round stone like a donut fastened to the top to add weight. The wealthier small farmers use oxen and a single furrow wooden plow which scratches a furrow about

40 cm. wide. Sorghum is usually planted after the first cultivation, as soon as the rains begin. Sometimes the seed is simply spread on the unplowed land and the seed is turned in with the first plowing. Much less care is taken in preparing a seed bed for sorghum or maize, than for the smaller seeded grains. Subsequent cultivations are carried out with a seemingly back-breaking instrument called a Kota hoe, or possibly the oxen and plow are driven through the field, weeding and thinning at the same time. Manure is very occasionally applied, but it is more often saved for lining grain storage pits or bins. Plant populations of sorghum in the Alemaya area were found to range from 28,000 to 31,000 plants per hectare (Bedane, 1973).

Sorghum is sometimes planted alone but often in mixtures with maize. If the rains are heavy and concentrated, then the maize will yield better, but if the rainy season is erratic with drought periods, the sorghum, with its better drought tolerance is more likely to give the farmer a crop. Legumes are often intercropped with sorghum. Cowpeas, peanuts, and haricot or field beans are the most common. Sorghum is also grown as an intercrop with chat (Catha edulis) a perennial bush. The leaves of the chat bush contain amphetamines. They are picked in the same manner as tea, but are sold fresh and chewed as a stimulant.

The long maturing Harar sorghums emerge and begin growth during the "small rains" which most often fall in April and May. A dry spell may occur in June or July, then the second "big rains" are expected. Flowering of the sorghum occurs in early September, and the rains often stop about the end of September. Harvesting takes place in November and December. Thus the long maturing sorghums take the entire rainy season to develop. These sorghums are also adapted to cool night temperatures. During flowering in September, night temperatures can be expected to dip down to 5^{o}C., but climb to 20-25^{o}C. during the day. Low altitude sorghums produce very little viable pollen under these conditions, but the cool tolerant sorghums produce copious pollen and good seed set.

The sorghum plant is used for many purposes. After flowering, its leaves are often stripped and fed to cattle. The stems of some types are sweet and are chewed like sugar cane. Other stems are extremely hard and woody and are used for building fences or for walls or roofs of houses. Since most trees in the Chercher Highlands have been chopped down, sorghum stalks are probably the main fuel used for cooking.

The grain is usually milled whole into a fine flour. Small, diesel powered grinding mills are common, but the mortar and pestle is still used. The flour is mixed with water and allowed to stand for three days to be fermented by air-borne yeasts. The dough, about the consistency of pancake batter is poured onto a hot, flat griddle and quickly cooked. The resulting enjera is the staple food of most Ethiopians. Enjera is also made from teff and barley. The sorghums which are preferred for enjera are tight-headed durras with corneous endosperms with light amber or light red to orange seed coats.

Sorghums with high tannins in the seed have dark red seed coats and dark sub seed coat-layers. These sorghums are usually used for making beer.

CONSTRAINTS TO HIGHER PRODUCTION

By world standards, yields of sorghum in Ethiopia are low, as is shown in Table 3.

Table 3. YIELDS OF SORGHUM IN ETHIOPIA AND OTHER COUNTRIES 1961-1965
(Average per hectare yields in quintals)

Country	Yield	Country	Yield
Ethiopia	6.1	Turkey	12.8
Iran	10.6	Taiwan	10.6
India	4.3	Japan	15.7
Kenya	9.1*	United States	28.3

*Only 1963
Source: S.R.I. Report #10, 1969.

What are the constraints that limit higher production?

Rainfall over the sorghum growing areas is very erratic. An example is the annual rainfall at Alemaya College, shown in Figure 2, which can range from 502 to 1261 millimeters. Moreover, the rainfall in the Alemaya area is known to be more dependable than in many other areas. The monthly distribution is shown in Figure 3. Although there are two rather indistinct wet periods, in April and again in August, the pattern fluctuates from year to year, and a dry spell may come during a critical period following emergence or flowering. The long term varieties which the farmers grow during the rainy period will usually make a crop, but in terms of grain yield per day, they are poor producers.

Another problem with the late types is frost. Last year, an exceptionally early frost occurred in early October, with a temperature of -2°C. at the College. Probably over a thousand hectares of sorghum was killed in the Chercher Highlands during the early stages of grain filling. Although this frost was the worst in memory, it was only 2 to 3 weeks earlier than usual. and there is no reason that it will not occur again.

In lower areas, down the edges of the escarpments the rainfall period is usually shorter and lighter. Rainfall can really only be expected during the peak months of April and in July or August. In these areas the farmers still plant much the same types of long maturing tall sorghums, hoping for the exceptional year that will give them a crop. In the Dire Dawa area at 1200 metres, the sorghum will likely make a crop this year, but the rains have been very heavy and well timed. For the previous four years, no crop had been harvested. The situation was similar in many of last year's famine areas in Wollo Province.

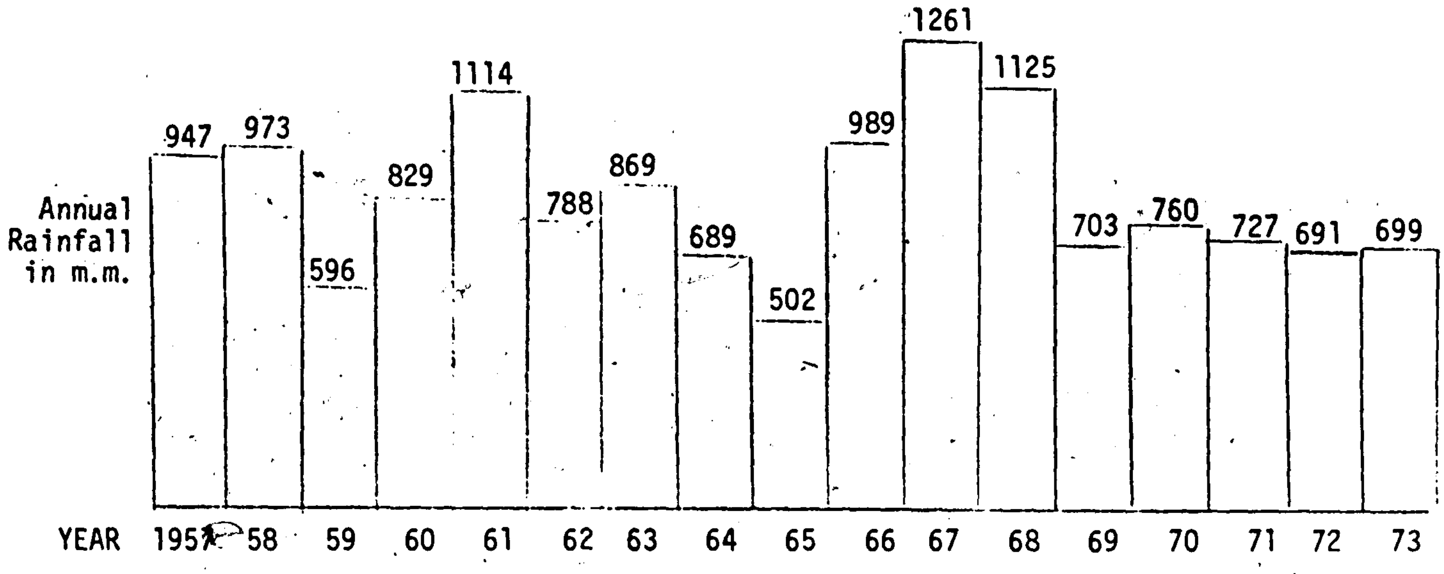

FIG. 2. ANNUAL RAINFALL AT ALEMAYA COLLEGE FOR FOURTEEN YEARS. (Altitude 2000 metres).

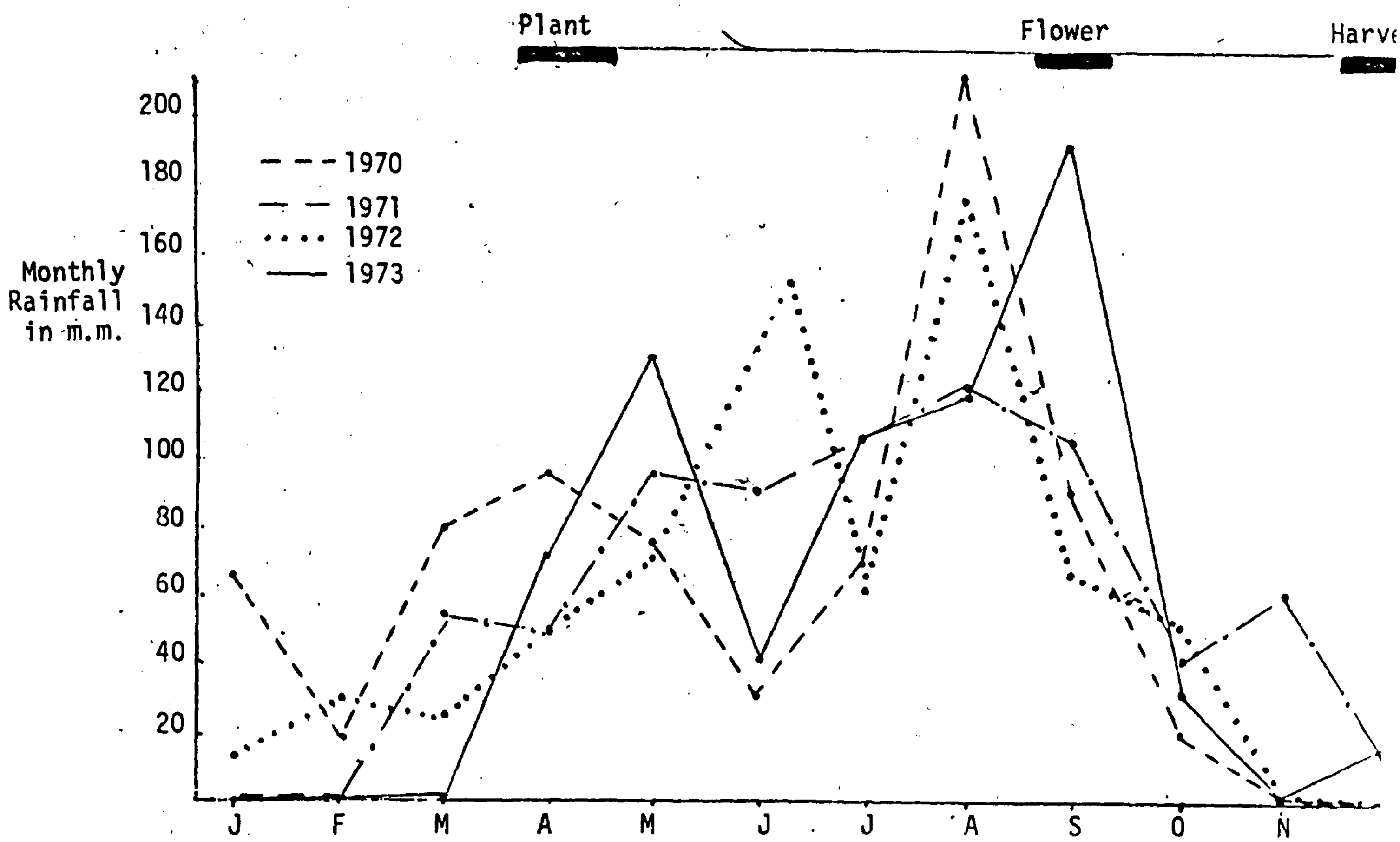

FIG. 3. MONTHLY RAINFALL FOR THE LAST FOUR YEARS AT ALEMAYA COLLEGE AND NORMAL PLANTING, FLOWERING AND HARVESTING TIMES FOR FARMER'S SORGHUM.

Cultivation by hand methods or by a wooden plow is slow and exhausting work. Often a farmer is not ready to plant at the onset of the rains. Also, wooden plows do not destroy weeds or prepare the seed bed well.

In many areas farmers have grown sorghum continuously for perhaps hundreds of years, taking all stover off the field--even roots are pulled up for fuel. The level of organic matter has become very low and the moisture holding capacity and fertility of the soil is reduced. The rain that does fall is allowed to run off. Water or erosion control measures are practically non-existent. The rapidly expanding population has pushed cultivation onto steep hillsides and forests, which once served as natural reservoirs for water, have now been largely cut down. The hillsides are quickly evolving. In lower areas, the unchecked water is making huge gullies through the sorghum fields, reducing the area that the farmer can cultivate.

The prevalent system of land tenure also discourages higher production. Rents which range from 30 to 75% of the farmer's crop are taken by the landlord, the church or the state. This system should now change for the better, but land ownership is incredibly complicated and land reform will take time. Table 4 shows the percentage of farmers who rent their land, and the cropped area per holding in most provinces.

Table 4. PERCENT TENANCY AND CROPPED AREA PER HOLDING (IN HECTARES) BY PROVINCE

Province	Percent Tenancy	Cropped Area per Holding	Province	Percent Tenancy	Cropped Area per Holding
Shoa	60	1.67	Harar	51	-
Arussi	48	-	Gemu Gofa	45	0.54
Wollo	17	0.97	Kafir	60.5	0.90
Begemdir	12	-	Ilubabor	74	0.69
Gojjam	16	1.15	Welega	56.5	1.14
Tigre	16	1.27			

Source: Stanley 1971.

Birds are a serious problem in many areas. They may pick out the pistil at flowering or take the soft grain as it reaches the dough stage. Yellow weavers and sparrows are the most persistent, and doves and pigeons take their toll. Quelea birds, a type of migrating weavers will occasionally descend on a crop in the thousands. In order to scare the birds, farmers build platforms so that they can stand and look over the crop. During grain filling, the farmer and all members of his family take turns at bird scaring. Many a budding David, a sling in his hand can be seen standing above the crop. He loads the sling with a piece of earth, spins it around his head, then fires at the birds with a loud crack and a yell.

Other problems which discourage higher production are concerned with the marketing economy. Feeder roads are very poor or non-existent. The farmer must bring excess sorghum and other crops to market on his wife's back or by donkey. The markets only serve a small area and prices fluctuate tremendously during the year. Because of poor storage facilities, the farmer often brings his excess to market immediately after harvest, flooding the market and forcing prices down. Storage is either in a dung-lined hole in the earth, or in a small above-ground bin. Storage life is reported to be about four months.

These problems must be overcome before the farmer has the incentive to produce more.

THE SORGHUM IMPROVEMENT PROGRAM

The sorghum project, based at Alemaya College can be divided into three areas: 1) Collection of Ethiopian sorghums; 2) Intercrossing of Ethiopian and foreign sorghums; and, 3) Agronomy trials and variety testing.

Ethiopia is acknowledged as a major centre of diversity of sorghum. Collection trips have been made, and 3,000 entries have been collected over the years. More systematic collecting methods are now being planned to gather as much information as possible about each type of sorghum in an area. It is hoped to collect the diversity of Ethiopian types before improved varieties with narrow bases of genetic diversity replace local types.

This collection will be valuable in identifying superior types which are adapted to a given area. The first released variety called Alemaya 70, was selected from the germplasm collection. It is earlier and yields significantly more than farmer's varieties. The collection should also be useful in locating specific desirable genes. For example, the high lysine, hl gene was located at Purdue University in an entry from the Ethiopian collection. This gene triples the biological value of sorghum when fed to rats (Singh and Axtell, 1973). Subsequently, over 200 heads of high lysine suspects were collected in Wollo Province where the high lysine mutant apparently originated and where the high lysine types are grown to a limited extent. The head rows of these collections are showing considerable variability for seed plumpness, earliness and plant and head type. One problem with the high lysine types is that they have a seed with a dented endosperm, and their seed weight is only about half that of normal sorghums, consequently yield is reduced. When sufficient high lysine material has been multiplied, it is planned to conduct feeding experiments with children. We feel that a possible immediate use could be as a feeding supplement for weaning children of farm families.

Our breeding program is also based on the germplasm collection. The breeding program has two parts. First, by making specific crosses between Ethiopian and American, Indian, and East and West African material, we hope to bring back to Ethiopia favorable genetic combinations which have been assembled elsewhere over a long period of time. The parents include short early maturing types, hard seeded types that store well, bird resistant types - either with high tannin, covered glumes or tight, pendant heads; large seeded types, locally adapted types with good enjera quality, as well as the high lysine mutant. Two hectares of F_2'S from last years crosses between Ethiopian and foreign material are now reaching maturity and are being selected for advance breeding.

The second part of the crossing program involves combining 170 selected lines, which are mainly of Ethiopian origin, into a genetic male sterile base to produce randomly mating populations. It is hoped that linked groups of genes can be broken up and re-assembled through a recurrent selection procedure at a number of sites, so that the best yielding, most adaptable, insect and disease resistant and high quality combination can be picked out. We are also crossing out selected lines to four cytoplasmic male steriles, in order to conduct test crosses of hybrid performance.

Once an entry has been selected, it is then yield tested, first in a pre-national yield trial, then in the national yield trial (NYT). We presently have fifteen entries at seventeen locations in the NYT. We are planning to split our yield testing program into two parts. One for high altitude testing, and the other, which is just getting started, for testing varieties with potential in low altitude areas. For low altitude areas, we are now looking at varieties which can be planted and will mature either in the "small rains" or in the "big rains". This requires a very fast variety of 60 days or less to flowering. There are very few entries of this sort in the Ethiopian Gemplasm collection. Less than 1% of the collection flowered in 60 days or less and only 15% flowered in 90 days or less (Gehrekidan, 1973). It would appear that Ethiopia, for all her wealth of diversity of sorghums, may need to use foreign material to bring in sufficient earliness. We now have five early selections in the NYT which flower in 100 days or less. Four of these are introductions. I feel that the introduction of fast maturing varieties into low altitude areas, is a relatively simple and urgent priority.

Advanced selections are also evaluated for enjera-making quality. A woman prepares enjera from each entry using local methods. The enjera evaluation is quite complex, and is based on a panel assessment of such characteristics as stickiness, pliability when curled in the fingers, the number and size of the "eyes" or gas bubbles, colour, taste and keeping quality of the enjera after 3 days of storage. Also the number of enjeras that can be made from one kilogram of flour is noted. We find that a close correlation exists between light amber corneous seed and good enjera quality. Seeds with high tannin or chalky seed coats with a dark sub-seed coat layer make poor or unacceptable enjeras.

High tannin in the grain however, is probably the most effective type of bird resistance. But it has been shown that tannins bind up the protein in the seed and make it nutritionally unavailable (Cummings and Axtell, 1973). A test is being used at Purdue called the vanillin hydrochloric acid test which can pick out grains which have high tannins during grain filling but the level drops as the seed nears maturity. Furthermore, on a recent collection trip we collected a high tannin type which the farmer assured us made good enjera. Thus it may be possible to select types which have good bird resistance, but do not bind up protein and also make good enjera.

In our agronomy trials, we are investigating the best populations to use at a cool site with erratic rains, at a hot site and at Alemaya which is cool with a long rainy season. Three types of varieties are used, a long, medium and short maturing type. We find that ideal populations run from 66,000 to over 100,000 plants which is 2 to 3 times the population in farmers' fields.

We have also planted an intercropping trial using two commonly grown legumes-haricot beans and cowpeas, in alternating rows with tall, medium and short sorghums. The yields will be evaluated on an economic basis. We are finding that we still have a lot to learn about adjusting the rates and dates of planting of the legume.

In another experiment, our entomologist is putting seeds of our selections into bottles, adding weevils and allowing them to stand until well infested. Then counts are made to try and determine which seed types are weevil resistant.

ACCEPTANCE BY THE FARMERS

Every year we provide the national extension service, called EPID, with 2-3 quintals of our best 3 or 4 varieties, which are grown in about 50 demonstration sites. EPID began functioning 4 years ago, working only with small farmers who had 5 hectares of land or less. They now have a good network of agents and demonstration fields throughout the country.

As yet the acreage under improved varieties of sorghum is insignificant. Nor is there any organized seed multiplication set up. At present, the college can produce only about 50 quintals of seed. From there, individual farmers multiply the seed themselves. Government seed farms are being set up, but they have not yet produced any seed.

In an attempt to get a closer understanding of the problems in accepting a new variety by the farmers, a number of demonstration sites have been set up on farmers fields near the college. Three improved varieties and the farmers seed are planted at the correct populations, in rows which are opened with the farmers plow, and with recommended rates of fertilizer (100 Kg of phosphorus and 100 Kg of Nitrogen per hectare). The plots have been very impressive with 2-3 times the farmer's yield obtained by using improved practices. However, the farmers acceptance is disappointing. One farmer who had impressive demonstrations on his land for two years, has reverted back to his old system. When asked why, he simply said he didn't have time to plant the way the college had done. Another farmer looked at the seeds of a short, erect high yielding sorghum which we were going to plant as a demonstration on his land. He would not allow us to plant that variety because he said that his neighbours would scorn him when they saw that kind of sorghum growing on his land.

However, improved technology is catching on. Harar Awraja is the district surrounding the College with a population of half a million people and about 80,000 farms. In this Awraja, the extension agency has sold the following amounts of fertilizer (urea and diamonium phosphate) from five outlets, as shown in Table 5. I am grateful to Ato Mohammed, the EPID agent at Bati for giving me these figures.

Table 5. FERTILIZER SALES AND NUMBER OF APPLICANTS IN HARAR AWRAJA

Year	Number of Quintals Sold	Number of Applicants
1971	100	98
1972	997	875
1973	1,247	1,245
1974	3,000 (Est.)	2,500 (Est.)

It would appear that about 1% of the farmers in this area are now using fertilizer. With the average size of farm at one hectare, it would appear that the farmer who uses fertilizer applies about one quintal per hectare.

Superior varieties can be selected and bred to meet a number of different specifications, and their superiority can be demonstrated. But the change needed in adopting these new varieties, along with the new technology lies in the mind of the farmer. For him, it is a major revolution to change from the methods he has known for generations past, and to accept the risks and responsibilities of adopting something that will cause changes in his life that he cannot foresee. For adopting a new technology requires an evaluation and acceptance of a new way, which for better or worse will shove him into a greater awareness of the world and his own position in it.

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SORGHUM BREEDING IN SENEGAL

By

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Presented at

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SORGHUM BREEDING AND INTERCROPPING IN SENEGAL

Historical and Background Information

Work on sorghum breeding started in Senegal in about 1950. Up until 1962, it consisted essentially in exploring for and collecting local material. Selection was then applied between and within the families composing this material. The difficulty encountered in having the consumer to accept the taste of a new variety, even a productive one was cited as the reason for limiting the breeding work to mere selection within the local material. By 1962-1963, there was a new exploration for local varieties, but improving genetically those varieties was then also envisaged.

Later, selection work on the local material was done as preliminary steps, preceding its hybridization with dwarf early sorghum varieties introduced from the USA. The dwarf male sterile CK 60 was often the female parent in those crosses and the African lines were used as male parents. A few hundred lines were obtained in the process, of which about forty were retained.

In that period, some hybrids were also introduced from the U.S. They were found of no use in Senegal because of poor grain quality. In the U.S. these hybrids were produced to be used as animal feed and not as human food, whereas in Senegal the sorghum grain is entirely destined for human consumption. They also lacked the resistance to certain parasites found in most local strains.

Consequently, the production of African male steriles was considered. This was very promising since testing of 73 African lines at Bambey in 1960-61 revealed that 23 of them were of the B-type (non-restorer) and the other 50 of the R-type (restorer of fertility). The techniques used were:

1) to cross the American dwarf male sterile (CK 60) with the R-type African lines, thus obtaining the fertile F1's.

2) these were to be backcrossed repeatedly with the dwarf male sterile in order to produce some African dwarf lines, fertile but with the corresponding male-sterile cytoplasm (B-lines).

3) the F1's were also to be backcrossed several times with the African parents, thus producing the African male-steriles. They were expected to be tall (A-lines).

About a hundred early and late African varieties were used in this hybrid production program. CK 60 was again the male sterile parent. Some fifteen were B-lines.

It was reported that wind pollinization became the major problem; since relative humidity is very high during the flowering months, pollen movement was impaired and consequently seed setting was very poor.

Another series of crosses involving CK 60 and some sixty-five late and very late varieties were made in 1964. Only the dwarf male sterile were retained. They were either ½ of 3/4 Bassi tourka (a R-type local line, race guinea).

In 1967, more male steriles were brought, this time, from the US via Montpellier. Two of them, without brown subcoat (MSCK 612, MS 172) are still readily used. Later in 1972, another two male steriles (MS 607, MS 615) were also included in the program.

The production of experimental hybrids is today an important part of the breeding program and it is hoped that hybrids made with male steriles produced at Bambey will replace those made with merican male steriles by 1976.

Parallel with these activities towards producing African male sterile and hybrid sorghums, pedigree and mass selection in local populations and segregating generations of crosses between them and introduced material have never ceased.

In 1960, the variety SH 60 was selected out from the local population Congossane (SH= selection Harlan). Now, two strains of that variety exist at Bambey, one with and one without brown subcoat. It is a tall late variety with good grain quality. A cross male in the dry-season of 1966-67 between a local variety and a variety introduced from Niger lead to the variety IRAT CE90 now in seed multiplication for distribution to the farmers in a northern part of Senegal. It is a good grain variety with a growth cycle of 100 days. It has been found outside Senegal intermediate in its reaction to drought and grain molds. Another variety (51-69) introduced from Tehad was found very productive in yield trials in the southern part of Senegal. Unfortunately, this variety was later rejected by the farmers for being too late (145 days).

MARATHEE who has been the sorghum breeder from 1970-1973 sought to explain the little success obtained in the crosses. According to him the varieties used were poor genitors and the objectives very different from the present ones. He noted as an example that reducing the size of the plant was judged important only in 1964. In his opinion, members of the races candatum and Kafir are better genitors than those of the bicolor and guinea races. The latter were more often used in those crosses.

Present General Selection Objectives

1. Reduction of Plant Height

In general, the local varieties are ~~4~~ to 5 m tall. The grain straw ratio is very low as the yield per plant is low. Today the limits are put at 1,50 m for the early varieties (90 days) and 2 m for the late varieties (120 days).

2. Good Grain Qualities

This has always been an objective in sorghum breeding in Senegal since the grain is used for human consumption. The grain should be white or light yellow, corneous, without brown subcoat and with no anthocyanic spots.

3. Good Adaptation

Soil and climate in Senegal present some peculiar characteristics that the plant breeder should reckon with. The amount of clay in the soil is often very low. Soon after the start of the rainy season there is a period of nitrification as a result of the renewal of microbial activity in the soil. The plant breeder should allow the plant to take advantage of that.

The rainfall is often irregular. Rain may start one month later or stop one month earlier and also it may fail to come at all for some time during the season. Thus, some kind of drought resistance is necessary.

The wind may be a factor. In particular, a hot and dry wind sucks away the water from the plant and causes it to break or crack. Heat resistance may also be useful.

4. Disease Resistance

Almost no sorghum disease is economically important in Senegal. However through repeated introductions and because of some specific objectives (grain molds), this situation might change in the future. Spots of Anthracnosis, Ramulispora and Gleocercospora can be seen year after year and Macrophomina may be a problem in dry conditions.

5. Insect Resistance

Many species of insects visit the sorghum head from flowering to harvest. However only contarinia is known to have the potential for becoming economically important. The plant itself may be attacked by stem borer. Sorghum shoot fly is being watched, since some transplanted segregating material show signs of discovery resistance in the field this year.

Special Objectives

1. Increasing the Yield Level

All reports show that the average sorghum yield obtained in Senegal seldom surpasses 12 quintals per hectare. This is very low. The minimum yield should be around 30 quintals/ha and this can be reached without going to hybrid production. Improved cultural practices and a variety with average yield potential would permit to attain at least that level.

2. Reduction of Growth Cycle

Rainfall in Senegal increases in intensity as in duration from North to South. Early and late sorghum are accordingly distributed throughout the country. Local varieties are often late and photosensitive, reacting as a short day plant. Photosensitivity is an obstacle in the reduction of the growth cycle. So, non-photosensitive material is prefered in the crossing program.

2.a. A 90-day Sorghum Variety

In the crop rotation system being offered to the farmer in the main sorghum growing area of Senegal, sorghum precedes peanuts. Timing considerations in the calendar of agricultural activities lead to the conclusion that this sorghum should have a 90-day growth cycle. It will thus be harvested early enough to allow the utilization of the last rains for plowing the fields in an early preparation for the next year crop : peanuts. This sorghum will certainly have to mature under rain, thus creating ideal conditions for grain molds development.

2.b. Grain Molds Resistance

The program of grain molds resistance took birth from the preceeding constraint of the inclusion of 90-day varieties in a normally 120-day rainy season region. It appears to be a difficult problem since the fungi involved seem to be numerous and they attack at different stages of seed development. However, there is a slight possibility that harvest can be done early enough so that great damage to the grain be avoided.

A rapid screening procedure is being worked out to facilitate the selection of grain mold-resistant lines.

2.c. A 120-day Sorghum Variety

The main sorghum area has a urgent need for a 120-day variety. The variety 51-69 that was proposed for this region should be replaced because it's too late. There is evidence that sorghum is loosing ground in some places of the area because of the lack of a suitable variety. 51-69 outyields all the local varieties, but it is late and photosensitive. It matures always at the end of the season, its harvest being possible only when there is already a great amount of field work to be done.

3. Response to Nitrogen Application

An improved variety should have a good response to nitrogen fertilization. However organic nitrogen may be important as,if not more important than mineral nitrogen. This is now under study. Also timing of fertilizer application might need new consideration.

Personnel

There are two sorghum breeders in Senegal, working in collaboration but on separate programs. One is provided by IRAT and the other by IDRC. The IDRC sorghum breeder is being entrusted with those special objectives for the main sorghum area of Senegal.

The IRAT sorghum breeder is serving a region north of the sorghum area where pearl millet is the main cereal crop. They have each a local staff that is recruited mostly with a certain level of secondary education, and no education in agricultural sciences. They receive their training on the job, and thus time is very much needed to build competence.

Approaches (IDRC Program)

At this early stage of the program, the main concern is yield. However, none of the other objectives are neglected.

Yield is seen in two different ways : yield per plant and yield per unit of area.

In breeding for high yield per plant, the emphasis is placed on head dimensions, length and girth, given that yield is positively correlated with head size. The population density anticipated is about 100,000 plants per ha. The plant can thus be as tall as 2 m depending on its growth cycle. It shall have 12-16 developed leaves, if possible erect leaves, short internodes and a sturdy stem. The root system, although it will not be investigated, should be good enough to prevent lodging under windy conditions. It may have early synchronous or late tillering because it probably won't be mechanically harvested.

High yield per unit of area is often best obtained through breeding for tolerance to high density. The ideotype becomes then a short-statured plant that can be sown in close spacing, thus allowing a population density of 200,000 plant per hectare or more. The plant should have small, erect leaves, short internodes and synchronous tillering, that may or may not be profuse. The height shall not exceed 150 centimeters. The harvest is intended to be mechanical as probably will be all other cultural practices under intensive agriculture. Its response to nitrogen fertilisation should be very good.

In both cases, some level of disease and insect resistance is required and in particular some drought resistance capability.

Methodology

A. Introductions

A trip has been made to ICRISAT, in India at a time when a great deal of sorghum was in the field. About a 1000 lines were requested and some of them are already in the field at Bambey. Some introduction for grain-mold resistance were also brought in from Nigeria and US.

B. Observation Plots

About twenty of the good grain varieties used in crosses at Bambey since 1950 were sown and observed in the field last year.

In the off-season, about one fifth of the good grain varieties of the Bambey collection was chosen randomly to be planted in observation plots. The observations show that there is a large amount of variability available in the Bambey material. However, some lines look so much alike, although coming from different sources, that one is inclined to think that they are identical.

Hybridization

Based on these observations made and other recorded information on those varieties, a choice was made of the lines to be used in the crossing program. A diallel was contemplated at first, but it was soon discovered that the material did not suit such purpose. The resulting F2's from these crosses are undergoing selection this year.

Then, varieties with good contrasting head characteristics were crossed together depending on their height and flowering time. Priority was given to short or medium height plants with an average flowering time of 50-60 days. Thus, segregation for height and duration of the growth cycle is not taken for granted since the parents so chosen can have the same height and maturity genes.

Selection

Effort is made particularly toward selecting plants with good head characteristics in a wide range of flowering times (45 to 85 days). It is known that seed weight is a component of seed yield. It is further assumed that the length of the grain filling period correlates positively with seed weight. So, different grain filling periods could lead to different levels of yield for the same seed number and dimensions.

Exceptionally transgressed specimens are also retained for later use. Selection is not done for disease or insect resistance, but heavily attacked plants are routinely discarded.

Use of the Selected Material

The selective pressure applied varies from 0-12,5%. The chosen heads are classified under three broad categories : the elite, the A-group and the B-group plants.

The elite plants are those that fit either of the two ideotypes described above. They are judged differently for yield potential depending on which ideotype they approach. For yield on a per plant basis, a yardstick of 50 grams of dry seed is used, or in certain cases the yield of the best parent is the indicator. Judging on a per area basis, the plant should have 2 or 3 synchronous tillers and a total seed yield of 30 grams or higher. These elite plants go through fixation (self pollinization) reaching eventually drought resistance test, grain molds resistance screening and fertilizer - density - yield trials.

The A-group plants have compact and medium size heads. They have broad and erect leaves. The stem is sturdy. They may or may not have tillers or stem ramifications.

The B-group plants have long and loose heads. They have numerous small leaves. They may or may not have synchronous tillers.

These two groups will be intercrossed using A-group plants as female parents. An effort will be made so that at least one parent has tillers. It is expected that these crosses will lead to the selection of more elite plants.

As far as possible at least one of the parents in a cross is known or believed to have some level of grain molds resistance, or drought resistance or both.

So, awaiting a rapid drought resistance screening procedure from the work of Dr. P.M. Saint-Clair at Laval University and a quick grain molds resistance test from Dr. J.C. Girard at Bambey, the focus is now on high yield for several flowering times.

<u>Future Prospects</u>

Eventually after exploring some of the additive genetic variability that is presently available, a hybrid program will be started where the same basic ideas of the present selection work will be applied.

<u>Areas of Research</u>

- Genetics of the rhythm of growth as related to yield.
- Genetics of the life duration of the leaves in its relation to yield and drought resistance.
- Relation between head shape and yield.

A REGIONAL CROP RESEARCH AND TRAINING PROGRAM

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INTRODUCTION

In countries of the Middle East and North Africa, where traditional agriculture is still widely practiced, there exists a considerable potential for agricultural improvement. The region, which extends from $5^{O}N$ to $40^{O}N$ is dominated by a semi-arid temperate climate and two main systems of farming are of importance within region; a relatively intensive irrigated agriculture, and a less intensive rain fed agriculture.

In response to the need for increased agricultural research within the region, the Arid Lands Agricultural Development Programme (A.L.A.D.) was started in 1968 by the Ford Foundation with the three primary aims of:

a) Increasing agricultural productivity in the region;

b) Building national capabilities in the region to sustain increasing productivity; and,

c) Strengthen linkages among national agricultural scientists between them and centres of agricultural excellence located elsewhere.

The region covered by A.L.A.D. activities includes about 18 countries (Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, Ethiopia, Jordan, Lebanon, Cyprus, Turkey, Syria, Iraq, Saudi Arabia, Yemen, Iran, Afghanistan and Pakistan) and the regional research base is centred in Lebanon. Two special country programmes have also been established to complement the central programme, one in Iran for research under cold-rainfed conditions and the other in Egypt, primarily for research on irrigated agriculture.

Research under the A.L.A.D. programme initially concentrated on sheep and forage production and on wheat and maize development in conjunction with the CIMMYT programme in Mexico. The research has since broadened in scope, however, and now includes programmes on farm mechanization and gourds, on rice (in cooperation with I.R.R.I.), potatoes (in cooperation with C.I.P.) and in 1971 Dr. L. House of the Rockefeller Foundation joined the A.L.A.D. staff to explore the potential of sorghum, millets and food legumes in the Middle East. In 1973 the funding of this programme was taken over by the I.D.R.C.

THE SORGHUM, MILLETS AND FOOD LEGUME PROGRAMME

The production of sorghum, millets and food legumes varies considerably throughout the region (Table 1) and although the total production is small in comparison with wheat and barley, they constitute an important factor in the diets of many people in the region. Relatively little research work has so far been undertaken on these crops and in general it has taken second place to research on wheat and barley. The current protein shortage, however, has helped to stimulate many governments to take an interest in the food legumes and there is also a growing interest in improving sorghum and millets, both for seed for human consumption and as a forage.

The main aim of the regional programme is to help initiate or strengthen the national research programmes on these crops and it is hoped to achieve this through several lines of approach which can be summarized briefly as follows:

1) The training of research workers in the theory and techniques of crop improvement and management.
2) The extablishing of a framework within the region to allow the interchange of personnel, ideas and materials, with particular emphasis on providing facilities for off-season nurseries.
3) Enlarging the germplasm base of the crops through collecting within the region and introducing exotic material from other parts of the world.
4) The distribution of germplasm collections through the region for screening and evaluation in the various countries.
5) The establishing of breeding programmes at the regional base in Lebanon to provide segregating and advanced material for selection and evaluation in the region.
6) The undertaking of certain basic research, chiefly on agronomic practices and cropping systems.

Basic research and breeding work are currently being undertaken on sorghum, pearl millet and chickpeas at the International Center for Research in the Semi-Arid Tropics (I.C.R.S.A.T.) in India, and links between the A.L.A.D. programme and the I.C.R.I.S.A.T.

programmes have already been established and it is intended to develop these further in the future.

TRAINING

In many countries of the region the lack of trained scientists is a major barrier to crop improvement work. Research capabilities vary considerably throughout the region though even in those countries with a comparatively high level of academic training, there frequently still exists a need for people with practical skills who are capable of running effective field trials. It is felt that if the regional programmes is to succeed in its aims, then a body of trained scientists should be built up in the region who would be responsible for the national breeding efforts and who would work in close cooperation with the regional programme.

In view of the widely differing academic backgrounds and the need for training of a very practical nature, it has been decided to conduct courses which are primarily field-oriented and in which the theory of breeding takes second place to the practical aspects.

In accordance with these aims the first sorghum and millets training course was held in 1973 and was attended by twelve students from seven countries. This year two courses were conducted, a seven months course in sorghum and millets attended by ten students from seven countries and a five months course in food legumes, which was attended by sixteen students from ten countries. The courses were designed to coincide with the growing periods of the respective crops so that all aspects of breeding programmes could be studied from land and seed preparation through to harvesting.

A considerable amount of time was devoted to such topics as mechanization, land preparation, irrigation, planting plans, planting methods, crop protection, crossing techniques, breeding methods, note taking, harvesting and seed storage. A certain amount of theory was also covered and included an introduction to genetics and statistics, morphology, taxonomy and physiology.

The lectures were held almost entirely in English and a working knowledge of the language was made a condition for attendance on the course. In spite of this requirement, however, language did prove to be a limitation and a certain amount of help had to be given in Arabic to some of the students.

Generally, it is felt that these courses were of considerable value, though obviously this can only be judged from the performance of the trainees in the future.

THE FOOD LEGUME PROGRAMME

This programme aims primarily at the improvement of the three crops, chickpeas (*Cicer arietinum*), broadbeans (*Cicia faba*), and lentils (*Lens culinaris*). The main objective in the breeding of all three is increasing yield, although other factors such as harvestability, disease resistance, and nutrition are of importance.

In view of the generally rather narrow gene base available to breeders in their local varieties, a major effort has been put into obtaining, maintaining and distributing germplasm through the region. In 1972 and 1973, Dr. House contacted a number of breeders throughout the world and assembled initial germplasm collections, and expeditions were made to Syria, Iraq and Jordan to collect native landraces. This year, a five week expedition was mounted in Afghanistan, at the request of the Afghanistan Government, to collect food legumes. As a result of this expedition nearly 900 samples were obtained including seeds of chickpeas, broadbeans, lentils, beans, peas, cowpeas and mungbeans. A few pearl millet samples were also obtained.

The germplasm collections currently maintained in Lebanon comprise nearly 2,800 entries of chickpeas, 600 entries of broadbeans and 2,000 entries of lentils. These collections were screened in Egypt, Sudan, Tunisia and Lebanon in 1973 and on the basis of these trials a regional nursery of chickpeas, comprising 168 entries, was sent to twelve countries in the region for evaluation this last year. On the basis of further screening of the germplasm collections, regional nurseries of chickpeas, broadbeans and lentils will be distributed through the region for evaluation this coming year.

Little actual breeding work has been undertaken yet, although last season a number of genotypes were identified which are suitable for inclusion as parents in a breeding programme. Twelve lines of of chickpeas have been sent to I.C.R.I.S.A.T. for crossing in their crossing block this season, and the F1 seed resulting from this programme will be evaluated in Lebanon next year. It is also planned to make crosses in lentils this winter in a glass house in Lebanon. Lines of broadbeans have been identified for including in several composites to be established next year. These lines will be grown in cages into which it is planned to release bees at flowering time, so as to make the maximum use of cross-pollination in the crop.

A major contribution which can be made by the programme to breeding in the region is through the organizing of off-season nurseries, enabling breeders in many of the countries to grow more generations per year. A high altitude site in Lebanon is currently being evaluated as an off-season location, and it is hoped that this will allow two generations to be grown per year in that country. The transfer of material between countries will also enable further generations to be grown each year, e.g. seed from the Egyptian programme can be planted in Lebanon during the summer, and the next generation can be returned to Egypt in time for normal planting. It may be possible, in some instances to grow three generations per year.

Legumes are very susceptable to a wide range of disease, and the broadbeans in particular can be very greatly affected. The prevalent diseases vary throughout the region, e.g. powdery mildew and viruses are the most important ones in Sudan, whereas chocolate spot and rust are more serious in Egypt. Dr. C. Bernier from the

University of Manitoba spent several weeks in the region this year, as a consultant to the programme, and he was able to locate areas in which the disease risks were particularly high. It is intended that in the future, nurseries will be grown in these locations in order to screen for resistance to the important diseases. The disease factor is an important consideration in the movement of seed through the region, and special care has to be taken to ensure that new diseases are not introduced to countries where they are at present unknown.

Other important areas of research which are currently being investigated are the control of the parasitic weed, broomrape (*Orobanche spp.*) through chemical means, and some initial work has been undertaken on various agronomic factors.

It is envisaged that in the future the work will be expanded to include nutrition, (e.g. the identification of lines with a high percentage of protein and methionine in the seed) and nitrogen fixation.

SORGHUM AND MILLETS PROGRAMME

The world collection and other entries of sorghum and several entries of the millets have been procured and were sown for seed increase and preliminary evaluation. Entries came from many sources and these are indicated in Table 2.

Preliminary screening tests furnish valuable information on flowering behaviour, vigor, growth and adaptation. For example, many introduced types of sorghum and millets flower late or fail to flower altogether in Lebanon. The expression proso, common, foxtail and barnyard millets has been very good indicating their adaptation to the region. These crops are, therefore, being further evaluated to see how they could fit in a productive and profitable cropping system. Poor adaptability has been noted for finger millet and common millet. Most of the finger millet entries failed to germinate and those that did germinate exhibited extremely poor development; the common millet was observed to germinate but grew very slowly and died before producing heads. These preliminary tests thus enable suitable entries to be identified for the regional nurseries and hence contribute to a regional improvement program. A regional nursery is being grown in Turkey (three locations), Egypt (three locations), Sudan (one location), Ethiopia (one location), Yemen (three locations), Saudi Arabia (two locations), Iran (two locations). Other countries including Syria, Iraq, Pakistan and Afghanistan have shown considerable interests in these crops and the programme will be expanded to include these countries as well. A sudangrass nursery and a dual purpose or silage ~~type~~ sorghum nursery have been distributed in the region.

Based on regional notes on plant height, flowering date, vigor and other characteristics, entries showing a broad regional adaptation are selected. These selections are then used to build composites and organize crossing blocks. For sorghum, three broad based and eleven narrow based composites have been made. One broad based composite of pearl millet has been made up of selected B-lines (maintainer lines of cytoplasmic male - sterile type used as seed parents in sorghum hybrids).

In the crossing block, the B-lines are being crossed and backcrossed to selected male-steriles arising from an ms_7 composite made in India, using an ms_7 source from Nigeria. All other sorghum composites are being crossed and backcrossed to early and late male sterile selections arising from an ms_3 composite made in India based on composites from Uganda. It is planned to distribute these basic composites to interested programs in the region for selection in their environmental conditions. Other operations in the sorghum hybridization program include crossing local varieties from Sudan, Egypt, Yemen, and Ethiopia to short early exotics and backcrossing the F2 plants of these crosses to short exotics. The objective here is to produce short early adapted varieties. Many of the current varieties grown in the region tend to be very tall and rather late. Another procedure carried out in the sorghum crossing block is to cross high lysine source to local types, regional selected entries which have been introduced, selected B-lines, cold and drought tolerance entries and other exotics in order to upgrade the lysine content of these types.

At the present time, the pearl millet germplasm is being evaluated and regionally adapted types are being identified in order to build up composites and organize a crossing program for both grain and forage types.

Nurseries are grown in Lebanon to identify cold tolerance in the seedling stage and drought tolerant types of sorghum and millet.

Sorghum and millets do have considerable potential in the Middle East and North African region. An important aspect of the cultivation of these full season summer cereals will be as part of the cropping system. In hot areas, they can be grown following wheat which is harvested April-May; hence, with identification of short duration varieties and suitable sowing dates it would be possible to fit these crops in a relay cropping system or a rotation cropping scheme. In many countries intensive efforts are made to improve and increase meat production and summer fodder crops such as sudangrass and forage type sorghum and millet are expected to play an important role in the development of a viable livestock and poultry industry in the region. In some countries such as Egypt, Sudan Pakistan, Yemen and certain parts of Saudi Arabia, these cereals are a staple food and tremendous opportunities for improvement of these crops exist also in other countries where they are less familiar and they have a considerable potential as a feed grain if not as a staple food. It is hoped that the present research programme will stimulate and expand production of these crops and hence increase agricultural productivity in the region.

INSTITUTIONAL LINKS

The Agricultural Research Institute (A.R.I.) of the Government of Lebanon has supported A.L.A.D.'s crop improvement research by providing land, labour, staff and office facilities. Their support has helped tremedously in the expansion of the programme through the region. The Government Agricultural Departments of the countries in the region are also cooperating by providing land, labour and other facilities. U.S.A.I.D. and F.A.O. have financially supported young argiculturalists during their training programme in Lebanon. Strong links have been developed between the sorghum, millets and chickpea programmes and the respective programmes at I.C.R.S.A.T. It is possible that in the future these programmes in the Middle East may become outreach programmes from I.C.R.S.A.T.

The American University of Beirut (A.U.B.), under a grant from the I.D.R.C. is expected to play an important role in investigating the cooking and nutritional quality of these crops, and will also research methods of processing.

The A.L.A.D. programme is currently in a state of flux as the possibility now exists of the development of an International Centre for the Middle East. If and when such an institute is formed it is probable that the sorghum millets and food legume programmes will be considerably expanded.

Table 1. Production Acreage and Yield Statistics for Various N.E. Countries

Area	Sorghum			Millet		
	Area ha.x 1000	Production tonsx1000	Yield kg/ha. x 100	Area ha.x 1000	Production tonsx1000	Yield kg/ha. x 100
Alegeria	3	3	10.0	-	-	-
Cyprus	-	-	-	-	-	-
Egypt	210	897	42.7	-	-	-
Iran	12	12	10.0	18	19	10.6
Iraq	3	3	10.7	2	2	7.8
Jordan	1	1	13.0	-	-	-
Lebanon	1	1	6.0	-	-	-
Libya	1	5	7.1	1	5	7.1
Morocco	60	60	10.0	7	6	8.6
Pakistan	560	330	5.9	760	360	4.7
Saudi Arabia	50	52	10.4	16	16	9.7
Sudan	1950	1500	7.7	700	450	6.4
Syria	12.5	10	8.0	12.5	10	8.0
Tunisia	12	4	3.3	-	-	-
Turkey	-	-	-	34	40	11.8
Yemen	135	275	14.9	135	275	14.9
Total	3009	3148	-	1685	1179	-

Table 1. (Contd.)

Area	Broadbeans			Lentils			Chickpeas		
	Area ha.x 1000	Production tonsx1000	Yield kg/ha. x 100	Area ha.x 1000	Production tonsx1000	Yield kg/ha. x 100	Area ha.x 1000	Production tonsx1000	Yield kg/ha. x 100
Algeria	23	16	7.0	23	9	3.9	35	18	5.1
Cyprus	2	2	8.8	-	-	-	-	-	-
Egypt	135	269	21.9	20	39	19.3	3	6	17.4
Iran	-	-	-	55	37	6.7	95	45	4.7
Iraq	15	12	8.0	6	4	6.2	5	3	6.0
Jordan	2	4	17.5	22	22	10.0	2	1	5.0
Lebanon	1	1	11.0	3	2	5.6	2	1	5.0
Libya	4	1	3.0	-	-	-	-	-	-
Morocco	180	190	10.6	35	22	6.1	120	100	8.3
Pakistan	-	-	-	140	70	5.0	959	480	5.0
Saudi Arabia	-	-	-	-	-	-	-	-	-
Sudan	8	13	16.3	-	-	-	2	2	10.3
Syria	7	10	13.6	129	87	6.8	29	24	8.1
Tunisia	50	24	4.7	3	1	3.7	26	13	5.0
Turkey	30	43	14.3	103	105	10.2	100	120	12.0
Yemen	-	-	-	-	-	-	-	-	-
Total	457	608	-	539	398	-	1378	813	-

Table 2. Sorghum

Acc. No. NES	Source
2-103	Fed/Stat. USDA Mayaguex, Puerto Rico.
153	EAAFRO, Sorghum Section, Serere, Uganda.
261-600	Dept. of Agron., Purdue Univ. Indiana USA.
624, 628, 2734-	Batan, Mexico
2736, 2832-2843	" "
629-866	Mayaguez, Puerto Rico thru India.
867-873, 1386	Oklahoma A&M Stillwater, Okla., USA thru India.
874-879,	Imperial Valley Station, Univ. of Calif.,USA
2824-2829	" " " thru India
880-1380, 2963,3087	USDA-Texas AES Conversion program thru Inida.
1381-83, 1387	Dekalb Ag. Research, Lubbock, Texas, USA thru India
1389-1881	Texas AES, Lubbock, Texas, USA thru India.
1972-2569	" " " " thru Thailand
1882-1971	Kasetsart Univ., Farm Swan, Thailand.
2570-2707	All India Coordinated Sorghum Program, Yemmiganur, A.P.
2737-2791, 2912-2914,	All India Coordinated Sorghum Program, Hyderabad, A.P.
2929-2962	" "
2792-2802	Punjab, India.
2803-2833	Iowa State Univ. Ames, Iowa, USA.
2844-2851	Northrup King, USA.
2852-2855	Univ. of Kansas - Manhattan, Kansas, USA
2856,2857	Kasserine & Beja respectively, Tunisia.
2858-2874	Univ. of Nebraska, North Platte, Neb., USA.
2875-2890	Pioneer Seed Co., Plainview, Texas, U.S.A.
2891-2911	Univ. of New Mexico, Clovis, N.Mexico, USA.
2920	Meridian, Mississippi, USA.
2921-2924	Univ. of Neb. Lincoln, Neb. USA.
3088-3197	Accessions, American University of Beirut.
3198-3281	CIMMYT, Mexico.

Cytoplasmic male-steriles from USA; All India Coordinated, Sorghum Program, Coimbatore, Tamil Nadu; EAAFRO, Serere, Uganda; and from Samaru, Nigeria.

3854-3953	Ethiopia

In addition, the world collection comprising about 6500 entries originated from the following countries:

Afghanistan	Kenya	South Africa
Botswana	Mali	Swaziland
Chad	Mexico	Sudan
Ethiopia	Nigeria	Tanzania
India	Rhodesia	Uganda
Japan	Senegal	U.S.A.

Table 2. (Contd.) Pearl Millet

Acc. No. NEP	Source
7-994	All India Coordinated Program, Coimbatore, India.
1014-1032	India thru Thailand
1033-1041	All India Coordinated Program, Hyderabad, India.
1042-1051	Coastal Plains, AES, Tifton, Georgia, USA
1052-1053	" " " " " thru Accessions, American University of Beirut.
IP	
2650-2790	Bambey Senegal

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NESe	Foxtail Millet
1-6	Colorado, Nebraska, Minnesota, USA
7-121	AES Akron, Colorado, USA.
ISe	
462, 474, 79	Iowa
297, 358, 389	India
480, 700, 710	China

12 entries of ISe from All India Coordianted Millets Program

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NEPm	Proso
1-12	Mitchell, Nebraska; St. Paul, Minn., Akron, Colorado, USA.
13-227	AES Akron, Colorado, USA

9 entries of IPm from Mitchell, Nebraska, USA.

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Also included in the collection are 255 entries of Common millet (Panicum miliare) 663 entries of Finger millet (Eleucine corocona) 32 entries of Barnyard millet (Echinochloa spp.) and about 200 entries of Sudangrass (Sorghum sudanense)

SUMMARY

Sorghum, millets and food legumes are important in the Middle East and North Africa, but to date relatively little research work has been undertaken on these crops. In 1973, I.D.R.C. funded a regional programme for research and training on these crops, to be based with the A.L.A.D. programme in Lebanon. Two training courses have so far been held on sorghum and millets, and one on food legumes. The training is essentially of a practical nature, with the aim of building up a body of scientists with the region, capable of carrying out effective field experimentation.

A major part of regional activities so far has been in obtaining and distributing germplasm, to provide breeders with a greater range of genetic material for selection.

Collections of chickpeas, broadbeans and lentils have been made and evaluated in several countries. Some breeding work has been started and a few basic agronomy trials have been undertaken. Diseases are of major importance, especially in broadbeans, and steps have been taken to locate suitable sites for growing disease resitance screening nurseries.

Large collections of sorghum and millets have been evaluated, and regional nurseries have been screened for both grain and forage production. Several sorghum composites have been formed and crosses have been made in an effort to incorporate genes for high lysine into locally adapted genotypes. Pearl millet germplasm has also been

evaluated for both grain and forage and lines have been identified for the formation of composites. Several other species of millet have been screened of which proso, foxtail and barnyard millets show the greatest adaptation to the region.

INTERCROPPING RESEARCH AND THE SMALL FARMER IN TANZANIA

By

R.C. Finlay

Presented at

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ABSTRACT

A study was initiated in 1973 by African Scientists at the University of Dar es Salaam to study and improve systems involving mixed cropping, under a grant provided by IDRC.

The objectives are: to increase the total yield of sorghum, millet and other subsistence cereal grains and grain legumes by systematic intercropping; to test sorghum and millet varieties and determine those best suited to intercropping; to select varieties for resistance to the major pests affecting cowpeas and other food legumes; and to determine the best conditions of crop protection - insect, disease and weed control.

The project should make a real contribution towards the improvement of rural agriculture in Tanzania. Not only will newly developed varieties and recommendations assist production and raise nutrition levels, but the project will help increase the practical experience and knowledge of the Faculty staff and students. Close contacts and cooperation with the local farming community and the new international centres, such as ICRISAT and IITA, as well as other quality research institutes linked through the project, should involve a total team effort.

In preparing young scientists for a practical field such as agriculture and since applied agricultural research must be field-oriented, their association with and participation in a well-defined, well-implemented and dynamic program are essential.

A study was initiated in 1973 by African Scientists, at the University of Dar es Salaam to study and improve farming systems involving mixed cropping.

Intercropping or mixed cropping is the most common form of cropping system found in Tanzania (3,4). Probably the most important legume grown in Africa is cowpeas (2), particularly in low altitude, low rainfall areas and provides food for millions of people. In Africa, 98% of cowpeas grown are intercropped (2). In areas such as West Africa cowpeas are mainly grown with millet and sorghum (1).

A study (10) conducted in Northern Nigeria showed that, in general, the profitability of crop mixtures over sole crops was about 60%. This particular study was conducted on locally grown annual crops under indigenous technological conditions.

Despite the popularity of this cropping system among peasant farmers, there is little quantitative information available on the comparative merits of intercropping and monoculture in Tanzania (6). Experiments which have been conducted so far show that in most cases higher yields can be obtained from intercropping (3, 4, 5, 7, 14, 15, 16).

As a cultural practice, the reasons for its popularity by small farmers in tropical environments are as follows:

1) flexability - sowing and planting dates can be arranged so as to optimize labour requirements during cultivation and harvesting (12).

2) higher yields per unit area of land - higher output and profit maximization (1, 3, 4, 5, 7, 10, 13, 14, 15, 16).

3) maximize resources on a given area of land (8, 10, 12). - maximizes the returns from the most limiting factors (shortages) - can be considered as a space and time dimension;

   a) space - vertical and horizontal arrangement of stems, leaves and roots - land area, light, etc.

   b) time - water, nutrients, temperature, labour, crop cover etc.

4) minimize risk and insure against insects, disease, weather, price fluctuations etc. - a cropping system which utilizes an ecological balance between a farmer and his environment (9).

5) benefit of soil conservation by utilizing ground cover to protect the soild from water and erosion - in Texas it has been shown that soybean yields can increase 20-25% with maize acting as a wind break (13).

6) higher retention of soil fertility (a type of crop rotation) - nitrogen fixation from legumes - adaptation of planting to changing soil conditions - root excretions, mycrorrhiza, root feeding at different levels and over different periods of time (7).

7) weed control - cowpeas and other fast growing crops can act as a smother crop - crop competition is the cheapest and most useful method small farmers can use to control weeds.

8) food supply - nutritional reasons, continuous supply of varied foods over several months - frequency of consumption depends partially on storage which is generally a problem (12).
9) sustenance income from companion crops.
10) traditional popularity - the system works, normal practice by farmers equipped with hand tools which limit both land and labour.

The chief disadvantage of an intercropping system is mechanical harvesting. Evans (3) working in Tanzania wrote, "Unless sound evidence is obtained that production from pure stands is appreciably higher than that from mixed cropping and that there are advantages such as reduced labour input, pest and disease control, and convenience, it will not be possible to introduce rotational systems of agriculture based on pure stands as long as the hoe remains the most important agricultural implement".

Scientists at the Faculty of Agriculture in Morogoro under the direction of the Dean of the Faculty and the Head of the Department of Crop Science and Production set out the objectives - to increase the total yield of sorghum, millet and other subsistence cereal grains and grain legumes by systematic intercropping; to test sorghum and millet varieties and to determine those best suited to intercropping; to select varieties for resistance to the major pests affecting cowpeas and other food legumes; and to determine the best conditions of crop protection - insects, disease and weed control.

With the objectives defined, a research approach was worked out. It was decided that the project would have a central theme of crop improvement through plant breeding, in addition to crop production studies (agronomy) and crop protection. Agronomy studies under different fertility levels and rainfall regimes were to be conducted by the Department of Agricultural Chemistry and Soil Science once the breeders had established which germplasm should be studied. Three main recommendations are required from our agronomy studies -

1) economic fertilizer rates;
2) time of fertilizer application; and,
3) method of fertilizer application, i.e. broadcast or placement.

The most important fertilizers are phosphate and nitrogen. Utilizing nitrogen fixation in an intercropping system makes phosphate, perhaps, the most important element, and response curves will have to be worked out. Thus, the first two years have involved variety testing and germplasm evaluation by entomologist Professor H.Y. Kayumbo, plant pathologist Dr. C.L. Keswani and the breeders headed by Dr. John Monyo, Head of the Crop Science and Production Department. The IDRC grant provides support for two research fellows and three graduate research workers. Therefore, the development and availability of research material for graduate student projects within the framework of the program are of prime importance.

From the variety testing and germplasm evaluation phase of the project the next step was to set up a crop improvement program at

Morogoro and at the same time move the project into direct contact with the local farming community in different regions of Tanzania. This second phase of the project should involve the departments of Rural Economy and Extension, and Agricultural Engineering and Land Planning. This will involve the economics of production systems and extension together with cultivation, threshing, milling and storage systems.

The third and final phase of the project should be an evaluation of the program. Are we using the latest methods in our breeding, agronomy and plant protection programs? Are the young scientists and recommendations developed through the program relevant to the country's needs? Is our research effort applied directly to the improvement of local crop production and nutrition? If we are developing an improved farm technology how can this information be quickly disseminated to and adopted by the farming community? This last step involves knowing what the farmers are doing now. In Sukumaland, Western Tanzania, the principal crops grown are sorghum, millet, maize, rice, groundnuts, Bambarra groundnuts, cowpeas, mung beans, chickpeas, cassava, sweet potatoes, cotton and sisal. Cereals and legumes are most often grown in mixtures and these crops are frequently interplanted with cassava. Sowing and planting dates are arranged so as to optimize labour requirements rather than crop yields (11).

In the first two years of the program variety testing was carried out on sorghum, bulrush millet and finger millet, bred by the East African Community at the Serere Research Station, Uganda. The best new cultivars are now part of the intercropping program.

Co-operation with IITA has begun with the exchange of legume material. Close contacts and cooperation with the new international research centres such as ICRISAT should involve a total team effort, in which Morogoro and the project could act as a link with the local farming community.

Eighteen varieties (differing in morphology) of cowpeas and soybeans were intercropped during the first year with maize, sorghum and millet. This also included monoculture checks to provide the answer to two main questions:

1. Is the material available for monoculture systems from our research institutions suitable for intercropping?
2. Will varieties of legumes keep their yield ranking under cereal crops (as morphologically and physiologically diverse as a tall full season maize variety, a dwarf sorghum variety and a bulrush millet variety) and under monoculture conditions in both good and poor environments?

The cowpea varieties in the intercropping experiment are divided into high and low yielding cultivars of the following groups: (1) prostrate, (2) semi-upright, and, (3) upright varieties all within the present range of our germplasm and were grown under insecticide spray and non sprayed conditions.

A cowpea variety was also conducted in 1973, as were population experiments involving sorghum, maize, cowpeas, and soybeans in an attempt to standardize spacings. But these were not successful.

The practical benefits of using Sorghum Population Breeding Methods also began in this first year of the program. The breeding systems under investigation are half-sib selection, plant-row selection and S_1 testing within one sorghum population using the Coes genetic male-sterile ms_3.

The legume improvement program involving cowpea and soybean seed increase bulks along with limited sesame breeding completed the 1973 program.

During the past season, 1974, the field program included the large cowpea and soybean intercropping experiments and the following:-

1) <u>Need of Inoculation Maize-Soybean Intercropping Experiment:-</u>

It is hoped to develop a design and treatment series which can be taken to the villages, to test our best strain of <u>Rhizobia</u> under intercropped and monoculture conditions, which could act as demonstration wherever well grown. The design works on confounding and involves 16 treatments per replication with 2 replications at each location. Dr. Chowdhury of the Soil Science Department is a soil microbiologist and handles the legume inoculation work.

2) <u>Maize-Legume Population Intercropping and Intercropping Systems Experiments</u>

These experiments had 16 and 20 different treatment populations and combinations respectively of millet, sorghum and maize with cowpeas and soybeans in an attempt to standarize our spacings.

3) <u>Maize Breeding - Legume Intercropping Experiment</u>

This involved a screening of 21 cultivars and populations of maize of different maturity periods and morphological types over one variety of soybean and one variety of cowpea. We are looking for an intercropping type of cereal plant. A formula is being developed in combining the cereal, millet-sorghum-maize, with the legumes cowpeas-soybeans-pigeonpeas-greengrams, and the oil crops, sesame and sunflower, for selection purposes.

New recurrent selection schemes for sorghum, millet and maize in combination with cowpeas, soybeans and pigeon peas in conjunction with sesame and sunflower are now under consideration for development in the Morogoro Intercropping Program under phase two.

Under the legume improvement program 170 lines and varieties of cowpeas and 26 greengram varieties from the Tanzanian collection were examined this past season in a large screening trial by Professor Kayumbo for insect damage, Dr. Keswani for disease infestation and Mr. Doto, a Tutorial Assistant in Crop Science, for agronomical characteristics. We hope to improve the technique which involves one portion of a long row sprayed with insecticide, one portion intercropped and one portion left as monoculture. As major pests affecting cowpeas at Morogoro consist mainly of leaf eating beetles and sucking bugs which damage the pods, this screening approach was highly effective. An interesting observation was the disease score, which gave different readings under sprayed and non-sprayed conditions. A satisfactory crop production system must include control measures for insects, pathogens and, perhaps most important, weeds.

As one of the major objectives of the project was to help increase the practical experience and knowledge of the Faculty staff and students, their participation in the program is essential. This past season several staff members took an active part in the field program; seven final year students conducted their special research projects on the intercropping material. Field practicals in the intercropping research areas were held during July and early August with the Faculty students from each year. Discussions and working sessions were conducted by Dr. Monyo and some members of his staff.

It is hoped, in the future, that not only will the Faculty staff and students be involved in the program, but also a strong cadet field staff can and will be trained both for the research program and for extension-research service in the villages. It is possible to train these agricultural workers directly in crop production practices while bulking new varieties for release to farmers. This offers a complete package as well as a direct communication system which must be set-up if we are to be successful at transferring modern technology into a traditional African husbandry system.

Two factors are important:-

a) the project must have a direct commitment to and involvement in agricultural crop production in Tanzania;

b) the development of young men and women for agricultural careers involves equipping them to recognize the principles involved and providing the training ability to translate findings into practical solutions. In preparing young scientists for a practical field such as agriculture and since applied agricultural research must be field oriented, their association with and participation in a well-defined, well-implemented and dynamic program is an essential mixture.

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THE DEVELOPMENT OF A CROPPING SYSTEMS RESEARCH PROGRAM IN THAILAND

By

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Agriculture in South East Asia is small farm agriculture. To a very great extent it is based upon a single crop per year, a limitation imposed by the length of the period when water is in adequate supply. Recognizing the need for a better understanding of cropping systems in this region, several institutions are in the process of developing research programs with this fundamental objective. This has been fostered by a group at the International Rice Research Institute in the Philippines, where a considerable amount of basic work has been done on the nature of Asian cropping systems. The IRRI group has encouraged other institutions to develop related programs.

In Thailand the lowlying Central Plains cover approximately 5.8 million hectares. Rice is the traditional crop of this region, but on the higher areas where flooding is not a problem, sugarcane and other upland crops are grown. The majority of farming in this region is rainfed, with the cropping period beginning in May or June and ending in November or December.

There is great need to extend this cropping period. New irrigation networks are being developed, but while more than 50% of the land is irrigable, it is probable that irrigation will reach only half of this irrigable area. There will be problems also in reducing the seasonality of water availability throughout the irrigation system. At present there is promised water supply during the rainy season only. While this reduces the risk of crop loss from variable rainfall, it does little to extend the cropping period.

As at least 50%, and perhaps as many as 75%, of the farmers of the Central Plains will remain totally dependent upon rainfall for their agricultural productivity, there has been evident need to initiate a research program to determine optimum cropping patterns for this area. The rainfed 'multiple cropping' program at Kasetsart University was one of the first to be initiated in conjunction with the IRRI program.

Although the oldest established University with a Faculty of Agriculture in Thailand, Kasetsart has had little experience in research. Until recently, teaching was its only function. Throughout all disciplines the research base is very thin, and in many areas has been developed with little regard to native problems. In consequence, Kasetsart has not had a major input into either of the two major crops of the Central Plains. The rice crop has been the focus of the different agencies of the Ministry of Agriculture, whereas cane has been the concern of private industry. If Kasetsart is to build research skills capable of serving the farm community, it is evident that the University must have contact of some sort with this community in order to develop an understanding of farm problems. The cropping systems program has been designed in such a way as to promote this contact. The objectives of the program are, briefly:

1) To develop rainfed cropping systems of higher productivity, and giving greater net income, than those in present use.

2) To encourage Kasetsart University personnel to take an active interest in the problems of farming communities.
3) To develop institutions within Kasetsart that can originate small farm research technology.
4) To act as an outlet for concepts and information developed at IRRI in the Philippines, and at ICRISAT in India.

There is a range of agricultural and food scientists involved in the program, which is now in its second year. Although the major activities relate directly to agriculture, a small component of the program is designed to examine the food habits and preferences of the Central Plains people.

CROPPING PATTERNS

The present cropping patterns found on the Central Plains are very distinct: either a single crop of rice or sugar cane each year. Elevation is a major factor which determines which of these crops is grown on a particular piece of land, but the range in elevation is little more than two metres, so that the division into 'cane-land' or 'rice-land' is not distinct. Whether the cane spreads into rice-land, or the rice into cane-land, appears to depend upon the price of the product and the relationship between the farmer and his buyer. Cane follows a three-year cycle, the first crop followed by two ratoons, and the cane farmer is very much dependent upon a middleman merchant for his supplies and his market. As the rice farmer is more independent, the change from rice to cane is an easier one than from cane to rice.

There are two possible means by which the present cropping patterns can be improved: improvement of existing practices, and introduction of new ones. In terms of major improvement the second approach appears to hold more promise. A single rice crop presently makes inefficient use of one season's rainfall. The rains are spread over a five-month period, with the majority falling in September and October. Few farmers are ready to plant at the beginning of the rainy season, because the initial cultivations are not started until after the rains have begun. One or two months of the rains may thus be lost to crops. Similarly, in sugar cane, the season of the first planting is one in which the land and rains are not fully utilized. Wide row spacing, and the slow rate of elongation of the cane buds means that complete crop cover is not achieved until about three months after planting.

In our preliminary studies of possible cropping patterns for this region, we have accepted that rice or cane must remain an integral part of any pattern. There is considerable potential however, to improve on these patterns within existing farming conditions. Figure I. shows the patterns that are currently being tested. In both rice and sugar cane it is possible to squeeze another crop into the rainy season. In the case of rice, this involves sequential cropping, with the

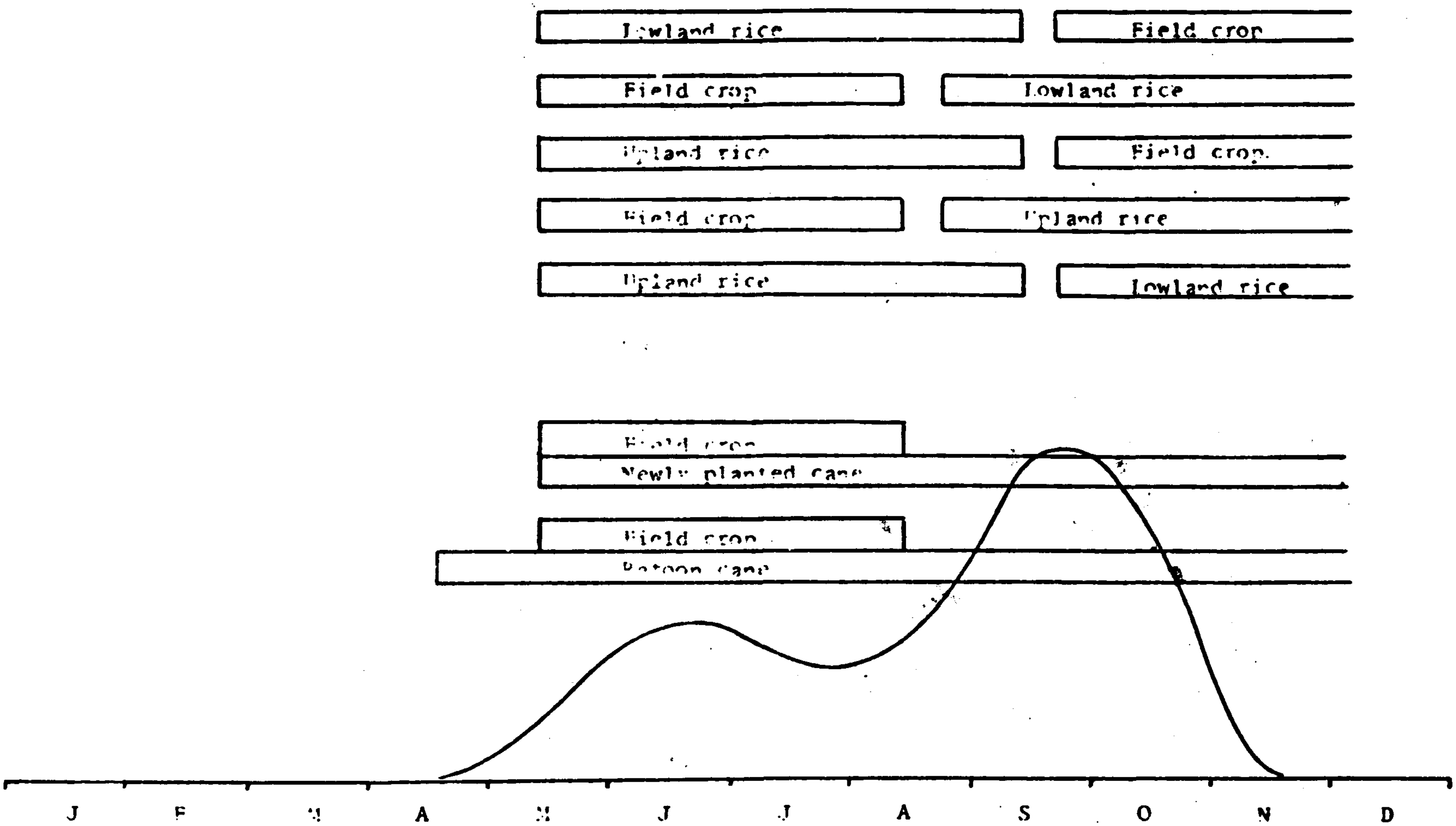

Fig. 1. Cropping patterns presently under study. Diagram includes a curve showing approximate distribution of rainfall during rainy season. Average annual precipitation in Central Plains is approximately 1500mm.

additional crop being grown before or after rice. With sugar cane this involves intercropping, but there is the limitation that this may be possible only in the seeding year. The ratoon crop sprouts earlier and grows faster than a new planting, and this, in combination with the mulch of trash from the previous harvest may eliminate the possibility of intercropping in the ratoon.

TECHNOLOGY

In this program, there are two levels of technology to be considered. There is the technology that exists at the farm level, the means by which the farmer accomplishes his objectives. There is also the technology that exists at the University level, the tools and techniques by which the University conducts research aimed at developing the farm level technology. The farm level technology is a proven technology, as it is farm-developed to utilize the resources available to the individual farmer. It is a product of conceptual thinking and practical management. No University technology can hope to have much inpact on farm-level technology unless the research workers apply it within the same conceptual framework that exists at the farm level.

There is, of course, no single technological approach to be developed, because every farmer is different and operates within different conditions. Differing technology at the farm level requires different approaches at the research level. However, there is need to develop a 'technology of understanding', a means by which a researcher can comprehend the conceptual basis of a particular farm enterprise. Only then will a skill develop in being able to distinguish between the conceptual thinking of different farmers.

The rice farmer has a particular technology developed to fit his own conditions. To say that a rice farmer can grow an upland crop after rice because his soil has sufficient residual moisture is to totally ignore his technological capabilities. He could grow the upland crop if he was aware of how he could adapt his system to the necessary technological change in switching from lowland to upland culture in the same season. If it was left to the farmer to determine the nature of this change, he would base it upon his conceptual 'picture' of his production system. He may consider adapting this change if he felt that it fitted and would benefit his system. The researcher tends to assume that such a change is obviously desirable just as it stands, and that therefore, the farmer should adapt it for this reason. He fails totally to acknowledge that the farmer has a better understanding of the complete system than he, the researcher, has.

The Kasetsart program, in the process of creating a research methodology applicable to small farm problems, has to pass through the development of a 'technology of understanding' phase. This requires continual village and farm level contact with rural people in some very simple research situations. There is no feeling as yet that on-farm research is any different from on-station research. The unpredictability of the farm situation requires, however, that if any worthwhile results are to be obtained, whether they come directly from an experiment or indirectly through conversation with a farmer, only one or two variables should be studied and in simple tests. It needs to be understood that in this context more useful information will come probably from less complex experimentation. In the coming year of the Kasetsart program, a single crop will be used as the basis for a farm-level research study, and in very specific research situations.

CONCEPTS

Distinct from a cropping pattern is a cropping system. The pattern is a simple description of what crops are being grown; the system is a description of the resources used by the farmer and the constraints upon him when he grows a particular pattern. The cropping system is a subdivision of the farming system, though by no means a discrete part of it.

While it is fairly easy to formulate a cropping pattern, it becomes very much more difficult to determine whether such a pattern could become the basis of a farmer's cropping system. Input from the farmer will be essential if such an analysis is to be achieved.

While one thrust of the Kasetsart program has been a consideration of cropping patterns, the development of a small farm research technology has required that another thrust should be the development of farmer/researcher communication channels. Only after this can a cropping pattern be developed into a cropping system. The development of these channels is the crux of the program, and it is here that there has been the least success.

Though Kasetsart has considerable human resources, these people do not have a training that is designed to help them perceive and solve the problems of their own culture. In turn, the extension activities of the University are aimed at training extensionists rather than promoting information flow from other sources to the farmer. Thus, the University is two steps away from the farmer, and has no means at all of promoting any feedback that would enable it to evaluate its programs. From the limited contact that this program has had with the farming community, it is clearly apparent that the Thai farmer is amenable to, and appreciative of, new ideas and information. The problem remains, however, to encourage people to see and understand this, and then to use this as the motive force in the development of a conceptual understanding of the small farmer.

It is essential to encourage, in the people working with small farmers, an understanding of the concepts that the farmer themselves use as the operational base of their own production system. For the majority of agricultural workers this requires re-education, for they see the small farmer as the lowest agricultural level, who can go nowhere but 'up' and 'up' normally implies a shift away from his present production system. This re-education is a slow process, and though it may be encouraged through training courses (IRRI now offers a five-month training course in cropping systems designed for people involved in national programs), it can be achieved only through continual contact with the farmer himself. This requires a considerable amount of effort that many people are not willing to spend, because they do not consider it worthwhile. A major problem in the Kasetsart program has been to set up a group/individual/farmer information channel, where an individual is asked by a working group to find out some farm-level information. The lack of an interdisciplinary understanding results in the individual not recognizing that the group is the necessary working level, and consequently he feels that he does not have any responsibility towards it. This does not encourage any use of systems concepts in developing a farm-level research technology.

The Kasetsart program has resources that have not been generally available to the University in the past. An overall lack of appreciation of the nature of the research involved in the development of cropping systems, combined with inflexibility in the working approach to the program's problems has resulted in poor management of the resources available to the program. However, in the same way that the program hopes to encourage an understanding of small-farmer concepts, so a suitable management structure must evolve as the program proceeds. A research worker cannot hope to have skills without experience. However, he must recognize that these skills should be modified through experience. If the program can develop its own methodology through continual evaluation of its experiences, then it has a chance of success. This requires a degree of humility that many of the participants are not yet willing to show.

Ultimately, it will be necessary to develop a linkage between the University and the Ministry of Agriculture. Although the University should be able to develop a small-scale capability through this program, it is the Ministry that has the resources to develop it across a large area. The Ministry already has a network of agricultural officers throughout the Central Plains. And although there are within-Ministry problems with regard to information flow, it is unlikely that a better basis for program expansion could be found. The University/Ministry link will be a difficult one to foster, because the most desirable contact is between the field workers of the two institutions. This will have to be established on an 'official' basis, through the various institutional channels, and this is a slow process. It will take a long time for an University/Ministry interaction to develop.

Although many problems in a program of this nature are country-specific, the Asian network that is slowly developing around cropping systems research promises to be of considerable benefit to the participants in country programs, because the wider insight gained by an appreciation of the different problems of another program with similar objectives can only be of advantage to the individual in his own program. The development of concepts with and between programs offers the research worker a good opportunity of improving his services to the farming community, and of providing the Asian small farmer with the resources he needs in a rapidly changing agricultural region.

POST-HARVEST GRAIN PRESERVATION AND PROCESSING

By

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INTRODUCTION

To meet our global requirements for food one must advocate a systems approach; not just to crop production; not just to post-harvest technology but to the entire spectrum of the food chain. Others have covered the production aspects of agriculture in the tropics and now I would like to present to you the post-harvest technology program at Bambey.

The program is divided into three broad areas: drying, storage and processing. Both theoretical and experimental techniques are used to study drying and storage. The work in processing is, at the moment, purely experimental. Through adequate theoretical models one can predict fairly well what may happen under given experimental conditions. Such models used in simultation can be a saving of both time and money. The unfortunate part is that computer facilities are limited where the work is likely to take place. Thus arrangements have to be made with some external university with adequate facilities.

In this project most of the variables in drying and storage are well defined. One can measure temperature, wind velocity and solar radiation. Knowing the physical properties of the grain in question, one can calculate heat losses or heat gain. One can then simulate drying and storage systems with reasonable accuracy. This gives us an adequate screening device for our experiments since any situation which appears useless in the simulation will probably behave likewise in real-life. Thus that trial need not be included in the experiment.

To work in a milieu near that of the village farmer we have planted 2.5 hectares of sorghum. This should provide material to test drying techniques and subsequent storage and processing trials. Since the history of the crop is known, one can use the grain for chemical analyses. The entire post-harvest system can be followed using this crop.

SOLAR RADIATION AND THE PROJECT

The greatest factor influencing both good drying and good storage is the amount of incident solar radiation. In drying we want as much radiation as possible, in storage the reverse is true.

At the equator the radiation component striking a vertical wall facing south is nearly zero for some portion of the year. For this reason many of the buildings in the tropics are constructed with the long walls facing south or north. As one moves northward or southward to higher or lower latitudes this vertical component can be minimized by constructing a suitable overhanging roof. Maximum solar radiation in the tropics is received by a horizontal plane. Thus one must take into account these two factors as well as wind velocity and direction and a large surface area to volume ratio. Trials are being carried out this fall using these different factors.

DRYING

Drying is dependent upon the equilibrium moisture content (e.m.c.) of the grain which is a function of the relative humidity (R.H.) and temperature. By use of controlled environment chambers or by means of saturated salt solutions, e.m.c. curves can be obtained for different grains. However this type of apparatus has not been available. Instead theoretical methods were obtained to calculate these curves for the common crops. The curves were calculated for 77F and since the yearly mean temperature at Bambey is 80F. the fit is quite good.

To study the rate of drying in threshed grains a factorial experiment was set up to measure temperature under different orientation, inclination angles, materials and paint color. The results of this trial should be available next October.

Drying trials are conducted for two reasons: first moisture content works in parallel with temperature to cause grain losses or spoilage; secondly, in commercial aspects water can be extremely expensive. Let us assume that Senegal produces 500 thousand tons of grain per year. If an additional 2% water is found in the grain, 10,000 tons of excess water would be bought or sold each year. Depending on whether one is buying or selling this may be something to enjoy or something to dread. I think it may be worth investigating the possibility of introducing moisture content into a grading system.

Even two classes, dry and tough, could be set up so that the farmer is paid more to sell dry grain.

THRESHING

Good drying is necessary for good threshing. The power and machinery section at CNRA has constructed a millet thresher which has been tried for millet and found successful. Last fall, sorghum was tried for the first time and damaged kernels ranged between 7-35% depending on cylinder speed and setting. The machine was further adjusted to reduce this loss but the farmer contacted for the test decided that 4 francs per kilo was too expensive. As a result further tests are to be made this fall. The grain from these tests will be stored under different conditions for a period of six months, at which time all samples will be analyzed for germination percentage and free fatty acid content. Initial tests on the grain will also be carried out.

STORAGE

Storage of grain can be successfully carried out if one can meet three requirements:

1. keep the grain temperatures below or above that required

by the insect species that may be present;

2. keep the grain dry; and,
3. avoid large temperature gradients at any point within the grain store.

Generally factor 2 can be resolved by keeping the grain within a rainproof structure. To meet the other two requirements one must control the environment external to the grain bulk. This is partially accomplished by shading of bins to protect the bin against direct solar radiation.

Studies are carried out primarily on local structures. In use at the station we have bins of the type used in Senegal, Nigeria and Togo. As time goes on we hope to include nearly all the different structures used in West Africa and compare them under the same conditions. These studies are multivariate in nature with the following factors being studied: temperature, germination, moisture content, microflora, 100 kernel weight, ash content, fat acidity, weight of dust, percent of infested kernels and number and stages of insects of major species per given weight of grain. Results from this study should be available next year.

In order for work to be meaningful it must be carried out under conditions that can occur in the farmer's life. As such I am slightly hesitant to suggest anything to the farmer which he cannot afford. We have therefore set up an experiment using chemical and physical methods of insect control in the local Senegalese bins.

Using three bins filled with threshed grain, one was filled with sorghum and admixed with bromophos, the second is admixed with millet and the third is a millet control since millet is harder to infest than sorghum. Results are not yet available.

Studies are also being carried out on the IRAT concrete bins. These have been advocated strongly and are now undergoing a two-year test using sorghum. Tests were made using phosphine, bromophos, lindane and no insecticide. At the same time different methods to control solar radiation were tried out. This included straw roofs, straw walls one metre away from the bin and an underground bin.

Using the methods developed as part of my thesis at the University of Manitoba, one can simulate many of the temperature conditions within the different bin types provided that one can obtain the necessary input data such as monthly mean temperature, wind velocity and latitude. Then by knowing initial conditions and thermal properties of the grain one can solve the Fourier heat transfer equation by the finite-difference method. This technique is useful since one can simulate the temperature distribution in a bin before it actually happens, thus allowing a warning against possible problems. The other use is to screen out bins which obviously do not meet the requirements. Thus this simulation can save a great deal of research time and money.

Further work at the station will involve tests using plastic bags, ferro-cement, oil drums and other methods already tried out in other tropical areas.

EDUCATION AND EXTENSION

All of these ideas innovated at the research level would be a waste of time if not tested under real-life situations. The research part of this project is easy but one wonders whether or not that is also true about extension and education. The extension aspect of all these trials will be carried out at two levels: first a village near Bambey and second at the "experimental units", an outreach station of C.N.R.A.

GRAIN PROCESSING

At present much of the grain processing for immediate consumption is done by the Senegalese housewife. It takes approximately six hours to prepare the evening meal, a dish called couscous. The grain is wetted for decortication then washed and dried and pounded into flour. Since the final product is quite damp, the product must be used immediately if it is not to be attacked by molds.

We now have completed trials on mechanical decortication and milling and find the product well accepted by our sample of Senegalese housewives. They like it because the flour is dry. It presents a problem because it takes longer to ferment. However, we plan to introduce the mechanical methods at the experimental units within the next few months. The extra time gained by this innovation will provide the housewife with time to make articles for sale. This money can be used to pay for her processing of grain and the rest can be used for other necessities. You may see the overlap between this program and that of the Household Sciences. The final aspect of this program is to coordinate the different stages of this network such that there are no bottlenecks.

CONCLUSION

You have just heard a brief exposé of our post-harvest technology program at Bambey. I hope that you can take home some of the thoughts on our systems approach to drying, threshing, storage and processing. I will welcome any questions or suggestions you may have.

A PHILOSOPHY OF SURVEYING CROPPING SYSTEMS IN SOUTHEAST ASIA

By

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Presented at

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INTRODUCTION

The objective of a survey of cropping systems is to define and, where possible, quantify major factors interacting with cropping systems. This information is needed to help understand the cropping systems in practice so research on new technology can be designed to meet the needs of the total farm system and not just one enterprise or one part of one enterprise. The objective of this paper is to begin developing a philosophy of surveying cropping systems. Philosophy here is defined as a system of principles for guidance in practical affairs. A more mundane title might be, "Some principles for surveying cropping systems".

Before delineating the philosophy that has developed in our work we should begin by stating some of the assumptions made at the very beginning of the work.

ASSUMPTIONS

1. With the given level of technology and resources available to him the farmer is near his optimum if he has had sufficient time to develop a stable system since the last major change in his technology.
2. The farmer is using his resources to meet his needs. The cropping systems and the other enterprises found on a farm are only a means to an end.

3. Any program which involves give-aways or great subsidies will not get a clear picture of the farmer's decision making and resource utilization.
4. Field experimentation is needed to back up and clarify survey data.
5. Field experiments should be built on farm level management in the farmer's environment if they are to complement survey data.
6. The farmer has a limited range of decision making. Many decisions are made by the community or other groups over which he has limited or no control.
7. The researcher is there to learn. He must develop the idea that the farmer is the teacher if a true understanding of the cropping system is to be attained.
8. Farmers cooperate with research agencies on the basis of the quality of the people sent out from the agency and not from a feeling that they will obtain a lot of useful information from the agency.
9. The farmer is marketing his products as well as he can so the study will stop at farm gate price.

These assumptions may not all be valid in a very detailed study but have not caused us serious problems. Assumption 9 would be the first assumption to be removed in a more detailed study.

FRAMEWORK

In setting out to gather data on cropping systems, it is important that a framework be available into which to fit the data and to help in planning the form the data should take. In the initial study of cropping systems, a very simple framework with only five major parts was developed (Fig. 1). These parts were environment, resources, enterprises, market, and needs. This framwork was built on the assumption that the farm operation is a process by which the farmer transfers resources into products which can be used to meet his needs.

Environment

The environment is the first part of the framework for studying cropping systems. Environment is divided into five major areas: physical, economic, social, biological and political. Each of these environmental factors can have a direct effect on the cropping systems (the resources available to the farmer) or an indirect effect on other enterprises. In surveying a cropping system it is not possible to quantify or even define each of the many variables found within any one of the environments. It is important to define those which are outstanding for that cropping system or which are having major effect in the cropping system. Several examples will help explain this. An example of an environmental factor having a direct effect on a cropping system is land reform as it is now practiced in the Philippines. Large landowners are forcing the tenants to put their rice and vegetable land into sugarcane to keep it out of land reform. Thus, political decision making is having a direct effect on a cropping system. Another example of environment with inflation and a lack of fertilizer at the same time. The farmers are planning to plant more legumes than they have done previously as a direct result. We cannot cover every factor in the environment; rather there should be a framework to look at the environment and to check which factors are associated with a particular cropping system. IRRI is currently sponsoring a set of studies on agro-climatic environments in Southeast Asia to start defining climate and soils for cropping systems.

Resources

Resources in this framework are those factors currently used by the farmer which interact in the processes associated with his cropping system. We study these in more detail and spend more energy on defining and, wherever possible, quantifying. The resources we look at initially are land, water, solar energy, labor, management ability, technical knowledge, power available, cash, non-farm inputs available, credit, and perhaps markets. Each of these resources, with the exception of markets, has been defined and methods found to quantify most of them. Markets are not usually considered a resource, but for a farmer considering what crops he can grow in his cropping system, a good market would be looked on as a resource.

In considering land, we quantify its chemical properties such as the pH, the nutrients available and possibly its cation exchange capacity. We define and, if possible, quantify its physical properties such as the texture of the soil, water movement in the soil, lower plastic limit, depth of soil and finally, the topography. We also quantify the area available and the ease of access to it.

The next factor is water. We quantify rainfall patterns and water tables.

The number of weeks or months with a rainfall averaging over 200 mm per month has been used as a standard associated with rice cropping systems.[1] The depth to the watertable at different times of the growing season also appears to be associated with certain cropping systems found in drier regions.

In solar energy we quantify the daylength and the solar radiation pattern over the year. In certain areas temperature becomes a significant variable. In most of the rice growing areas of Southeast Asia, temperature is not a significant variable.

In considering labor as a resource, we first quantify that available and then define the ability and finally the cost of the labor. It is becoming clear that ability is far more important than is generally taken into account. Many cropping systems are designed to make use of children in activities such as picking vegetables on a regular daily basis or in a continuous cropping program where little hard work is involved at any one point. Young people have the ability to do concentrated light work for short periods. The farmer has to consider hiring outside people in terms of cost and availability. It is a major factor in cropping systems which may have significant labor peaks. Management ability is one of the hardest factors to measure. A preliminary study has indicated that certain factors can be associated with specific cropping systems.

Certain abilities and attitudes are significantly different for farmers in different cropping systems.[2] Farmers who have high managment ability can generally manage more sophisticated cropping systems and are willing to include crops which have a higher management requirement if there is a high potential income. If a more detailed analysis of management is required, management ability may be divided into economic management, biological management and social management.

Another factor closely associated with the farmers' ability is his technical knowledge. Technical knowledge is not easy to measure. Many farmers know many ways to increase yields but do not practice them because they do not pay. Farmers with more assets can also take more risks than a poor farmer. Thus, current practices are not a measure of a farmer's technical knowledge. Some preliminary studies have shown that a better understanding of technical knowledge can be gained if it is divided into biological knowledge, economic knowledge and knowledge of physical factors. Most farmers in Southeast Asia have a high degree of competence in biological knowledge.

They do understand interactions among plants and animals. Interactions between plants in many current cropping systems are based on a superior knowledge of the biological interactions found in the fields.

Power is another resource which has a great effect on cropping systems. There are four main sources of power available to a farmer: hand labor, animal power, internal combustion engines and electrical power. For most of Southeast Asia electrical power is not a significant factor in the cropping systems. Mechanical power is limited to the very few large farmers who are not within our primary target group of farmers. Animal power is used by about eighty percent of the farms under two hectares in Southeast Asia. The power source available to the farmer must be defined and quantified as the farmer with only hand labor available will try and develop a cropping system which requires only 1 land preparation per year and usually the land preparation is at a period when there is no immediate rush. A farmer with animal power can have a little more flexibility in his cropping system allowing some land preparation in the middle of the growing season. Once the farmer uses mechanical power he has greater flexibility. However, because of the increasing initial cost of each of these power sources, they require an increasing area to use them efficiently.

The cash that the farmer has available to carry on his farming operations must be quantified over the whole year. The farmer with very little operating cash usually has a low risk cropping system.[3] The cash that the farmer has available also affects the type of cropping patter he uses.

The market inputs available to a farmer are usually measured both in quantity and quality. In many areas in Southeast Asia the inputs needed by the farmer are only available in limited quantity and often their quality is below standard. We have found examples of ammonium chloride being sold in urea bags.

Credit is another important resource for any farmer and is usually quantified at the same time as cash as the two are closely interrelated. The credit is usually quantified on the basis of amount borrowed, length of loan, the interests paid and the collateral required. In considering credit, the difficulty of getting a loan must be considered. A small farmer requesting a small loan may have more difficulty at regualr banking facilities than someone requesting a large amount. In looking at cropping systems we must quantify the type of credit facilities available.

The final resource we consider in our cropping systems study is markets. When defining and quantifying markets we have the cost of marketing the product, the information which the market supplies to the farmer, the faith the farmer has in the market, the facilities available, and the quantity that the market is willing to handle. This final point is quite important for a farmer starting a new cropping system in his area. If marketing facilities will only handle large scale quantities of a product at a certain time of the year, it is virtually impossible for a farmer to test the new product or a change in his cropping system. This has been a constant stumbling block in introducing new cropping systems in different parts of Southeast Asia, particularly those with a new crop or a crop with some characteristics which differ from the normal.

Enterprises

Although we are primarily concerned with cropping systems, we must be aware of where the farmer is allocating his resources and the interaction between enterprises, particularly as the other enterprises interact with the cropping systems. An analysis which does not take into account these other enterprises quite often leads to a conclusion that a farmer is not allocating his resources in an efficient manner; yet when the total system is considered the farmer is doing a very fine job of allocating his resources given the circumstances he is facing and his total needs.

Our framework requires the farmer to allocate his resources into five possible enterprises. These are: direct resource marketing, family production, community stability, livestock production and cropping systems. It is also quite possible that he does not use the resource or uses only a portion of it. In our studies to the present time we have been primarily interested in where the resources were being allocated and limited information, except for labor, has been gathered on the resources left idle.

Resource marketing refers to the farmer selling any of the resources, or utilizing any of the resources on the farm to directly meet his needs or meet his needs through the market. This enterprise is usually easy to quantify as money is usually received for the resource. One of the prime examples of this type of enterprise is the farmer who spends part of his labor in off-farm employment. Another example of resource marketing is the farmer who hires out his tractor or his carabao to a neighbor.

Family production is not usually considered a farm enterprise but it has been found useful to look at the family as an enterprise which requires certain resources. These resources are not available to the other enterprises. Our framework, then, can clearly show the resources used directly by the family. The two resources used most by the family are cash and labor, which can be measured quantitatively in total amount and distribution over time.

Community stability is another enterprise where the farmer must allocate certain of his resources. If we look at community stability as an enterprise utilizing resources, it helps to understand the allocation of resources made by the farmer and the potential for a new technology which may be introduced. Examples of resources being used in community stability are cash to pay taxes, labor put into community projects, and cash given to various community projects. Cash and labor are the main resources so quantitative data is relatively easy to obtain.

Livestock production is an important enterprise on many Southeast Asian rice farms. First and of prime importance, is the power source. A water buffalo or a cow is used by most farmers in Southeast Asia to do the land preparation and other heavy cultivation. These are easy to quantify in number and value. The farmer must keep in mind the food requirements of this power source, designing his cropping system in such a way that the animal can do the work when it is needed. This means that food must be available prior to and during the heavy initial cultivation. Also enough food must be available through the dry season for the power source to eat. A profile of feed used can usually be quantified. In addition to the power source, many farmers have other livestock which are sold in the market place or used for home consumption. Thus, a cropping system may be designed so the products from the cropping system are fed directly into the livestock system and do not enter the market place. In analyzing the cropping system alone, it may appear that the crops grown are not coming near reaching an economic optimum. If we have specific data on the return of the crops marketed through a livestock enterprise, it may be that the total system is very efficient. The by-products from the livestock can go back to the fields to increase fertility for the cropping systems. This has not yet been a major factor in any of our analysis. The livestock enterprise also acts as a reserve for the farmer. If his crops fail or he needs a lot of money at any one time to meet a family crisis, livestock give an added economic stability to the farmer.

Cropping systems are the main methods that small farmers throughout Southeast Asia use to turn their resources into products which meet their needs. When surveying cropping systems, we break these systems into cropping patterns; that is, the crops grown on each piece of land over a one year period. Within a cropping pattern we then look at the sequence of crops and find if there is any intercropping, any interplanting, or relay interplanting. In looking at these cropping patterns it is important that we not only know the sequence but also the duration of each crop and any special management characteristics which it may require. Varieties can be a very important factor. Resistance to disease, resistance to insects, ability to withstand adverse water conditions, the ability to withstand typhoons, early seedling vigor, ability to withstand high population densities, height and shade characteristics and the harvesting characteristics of the plant may all be important. Harvesting characteristics are turning out to be quite an important factor. A simple example is the position of the pods on cowpea; those with pods scattered all along the main stem require about 50 percent more harvest time than do those with all the pods located at the very top, where they are easily picked. There is also the quality of the finished product. Does it receive a high market value and is it one that the consumer or the farmer would like to eat? The understanding of cultivar selection is of great importance. A general discussion with farmers about their crops to generally define the crops will usually give enough data. But once any special characteristic is found, quantitative data are required.

Weeds are a continual problem and cause a loss of income for all farmers. Understanding the weed management practices carried out by the farmers is most important. This includes not only what the farmer is currently doing, but what his previous crops have been and his previous management so that an understanding of the interaction between the crops, the weeds, the cultivation and herbicides, if any are understood. Looking at one crop and the weed management practices applied to it does not give a clear understanding of weed management when we are looking at an area where different crops are grown in sequence.

Insect management is also something which must be studied as a total management system. It is important not only to study the insect on the crop being grown, but the crops surrounding it. The interaction of cultivar resistance, cultural practices, time of planting, off-season insect control practices, and the actual control of insects on the crops while growing are all factors to consider when collecting data.

Disease management, although important, appears to be tied very tightly to cultivar selection at the present time, and with the exception of a few management practices, there appears to be little that we can study directly. The most effective method at the present time appears to be using farmer recall to obtain estimates of the degree of disease damage and frequency.

Soil management can be divided into two main areas: physical and chemical management. In understanding the physical management of thw soil, we must first define the soil with the usual soil classification techniques. In addition, it appears that some measure of the soils wet plowing characteristics is needed. Lower plastic limit may be one possibility. Some measure of the speed with which the farmer can continue cultivating or plowing his land after heavy rain is definitely needed to get an indication of the turn-around time we may expect in the wet season. Also, some measures are needed of the amount of work required to take the soil from a puddled to a friable upland condition. Until more scientific methods have been worked out and adapted to field conditions we have been using number of days from a heavy rain to the first plowing as some indication of the measures mentioned above. The chemical management of the soil is usually directly related to the farmer trying to increase the fertility of the soil with nitrogen, phosphorus and potash. A few areas may also include liming or the use of micro-nutrients, but this is rare among small farmers in Southeast Asia. The data required for chemical management of soil is quantity, timing, and cost of fertilizer used.

Water management is an area for which it is difficult to get data, but it is quite important. In water management we are looking at holding the rainfall which comes to the field and the movement of water from one field to the next. The holding of the rainfall which falls on the field is dependent on the physical management of the soil. Of course, it is also tied very closely to the topography as is the movement of water from one field to the next. Up to the present we have done little work in this field. It is expected the water management team being established by IRRI will supply the guidelines on data needed and a methodology to obtain it.

Markets

In looking at the markets in relation to cropping systems we have chosen to take markets as given. Price fluctuations over the year are taken into consideration, but only as they show up in the farmers' data as prices received minus transportation cost to the market place. It is felt at this time that the research should concentrate on understanding what is happening on the farm; more detailed studies of marketing can be undertaken in the future.

Needs

For the purposes of studying cropping system the farmers' needs can be divided into seven major categories.

The first is food. His food needs are made up of carbohydrates and protein, which are basic. He also is concerned with taste, variety and the social acceptance of what he is eating. The first two items, carbohydrates and protein, are essential and must be met either through the crops grown or through the market place. Any change in the cropping system which brings about a major change in the amount of protein or cartohydrates produced must take into consideration where the replacement will come from. To date no relationship has been found between cropping system and eating habits. Taste is something which has to be taken as given and simply stated that the farmer likes or does not like a certain crop or a certain variety. Rice is one of the best examples of this. Although the carbohydrate and protein content may be exactly the same, different varieties of rice meet varying degrees of acceptance, in different areas of Southeast Asia. There are also the socially acceptable crops in certain areas; sweet potatoes are considered a very poor man's food and any one who can possibly avoid it does not regularly use sweet potatoes in his diet. In other areas other crops are considered socially inferior or not good for certain people at certain times in their lives. The cropping system researchers must take these needs and values into account when they are considering what to grow and the sequence to grow them.

Consumer items are the farmers' next large group of needs. These have all one characteristic in common; they all require cash to obtain them. They include housing, clothing, entertainment, transportation, reading materials, and things to make life generally more enjoyable (food is considered separately). In quantifying consumer items there are two factors to consider: total cash required and the distribution of cash requirement over time. The farmer's cash requirement do not usually coincide with the cash made available from his cropping system. The further apart these two are, the more difficulties the farmer is likely to experience. Credit will become more important for consumption.

Another need of the farmer is social acceptance. He must be doing things which are acceptable to his family, his friends, the community and the nation. The national does have a desire for him to grow those crops which are needed most to meet either the existing food requirements or export demand. The community is a little more critical in its acceptance of the farmer's cropping system. If he is totally out of sequence with the rest of the community it may lead to some disharmony within the community particularly his immediate neighbors. It becomes more critical that his cropping system coincides with theirs. The family must approve the crops, the sequence, the way the farmer is producing them, the amount of labor that they are required to put in, and the products that he gets from his cropping systems. This need of social acceptance, although real, is very hard to measure. It can only be defined when some change is made or anticipated by checking if the people in the community will generally accept the idea and more important if the farmer and his family find it acceptable.

<u>Stability of the Above</u>

The farmer requires that each of the needs mentioned above be met this year and in the future. The farmer is not interested in carrying out an activity which, although meeting his needs at the present, has a high possibility of ruining his chances of meeting his needs in the future. The most obvious example is the farmer who would sell his land, although meeting all of these needs at the present time, the probability of meeting his needs in the future are very slim. The farmer facing a variety of risks and uncertainties due to nature wants to develop a system which has built in stability.

Socio-economic stability is also important for the farmer. It is one of his needs, and to meet this need he pays his taxes and is a conscientious member of his community. The money paid for this can be measured.

The final need is one which is the basis for farmers trying to improve their systems, testing of new enterprises and making them interested in research and new technology, this is the need to increase his level of well being. The farmer is interested in more food, better education, more consumer items for his family and greater stability both in socio-economic aspects and in the meeting of his immediate physiological needs. Although this need is almost impossible to define quantitatively, certain general patterns emerge when the farmer wants more to eat or more law and order. In our studies certain groups wanted more social improvement, others wanted more infrastructure development (particularly in the way of roads so that they can have more and cheaper products), others mention more law and order. So each has an existing level of needs and an increasing desire for some aspects of the above needs.

Agronomic Experiments

Survey of farmers and their farms covering social, economic and physical factors is not sufficient to understand cropping systems. In addition, agronomic experiments in the locations where the survey is being conducted are required. A range of simple single factor treatments added to a farmer's field is sufficient to give an idea of which factors may be constraints. It is very simple to add 100 kilos per hectare of phosphorus or potassium to a farmer's field and measure the result to find if phosphorus or potash is really a limiting factor. It is very simple to go in and keep several small plots weed free in farmer's fields to find the potential for increased weed management practices. The same method, although not as accurate, holds for insect management. A combination of systemic insecticide and quick kill chemicals can keep plots relatively insect free and some idea of the potential for insect management can be obtained. This method for insect control is probably sufficient because anything above this level of control requires such tremendous cost that it is really of no interest to the farmer and has no economic possibilities. Farmers in almost any area of the world are willing to try a new variety in a small test plot under their own management levels thus, an easy method of cultivar evaluation in an existing cropping system is to have the farmer grow a new variety. Disease management is more difficult to measure as disease does not always occur.

It has been our experience that farmers are willing to give us a small plot of land to try different cultural practices if they understand what we are doing and we do not want too much land. All farmers are willing to test new fertilizers in their existing cropping patterns. Farmers do not pose a problem to running a variety of simple single factor experiments in any village in Southeast Asia. Water management and an understanding of it will take more effort initially than the other factors, but it appears from some other work being done at IRRI that this is possible. The results of these single-factor experiments can then be compared with what the farmer has stated about the response of each of these factors. This is a good check for a variety of factors. There is also a possibility that when one of the inputs was used previously, it was not used properly, as the extension which goes with some new products is not clear. The factor under consideration may have potential in the existing cropping systems. It has also been found that when conducting the single-factor experiments a great deal more information can be obtained from the farmers than just getting their responses to the single-factor experiments. They comment on things tried previously which would not normally be obtained in surveys. They also discuss their needs in greater detail and compare what the new factor does in relation to what they feel their needs are and will be. Thus, the single-factor experiments have been found useful not only in getting more quantitative data but also as a very effective survey tool in understanding the farmers' current cropping systems and what they feel are the constraints. We are also able to gain data on changes the farmer would like to have in his cropping systems in the future in regard to the type of crops to be grown, the characteristics needed in those crops and the management techniques required for future development. The use of single-factor experiments have been found to be very effective in testing how well the researchers understand a particular cropping system. The single factor experiments are also used as a check on the reliability of the data obtained from the farmers. Certain farmers tend to give erroneous data for a variety of reasons. With the actual checks from the field it is usually easy to spot those farmers and they can be removed from the survey. It should be noted that in conducting these single-factor experiments it is most important that they be carried out properly. If the farmers find that the people conducting the research cannot grow a crop of corn or a crop of rice and cannot function in the barrio setting, the future of the survey and of the whole experiment plan is in serious jeopardy. The people who go to the barrio must know what they are doing and be able to get along with people.

Principles

Using the framework described above in three different studies of cropping systems and patterns, certain principles have developed.

The principles involved in surveying cropping systems are:

1. Get initial data on the environment of the study area as quickly as possible. This usually means a quick "dirty" survey of the area using existing data, rainfall pattern, total rainfall from the weather bureau, soil maps, road maps, statistical data on people, topographical maps wherever possible, a short discussion of the agricultural practices with the people of the community on the crops grown and the major systems that they are aware of, and finally, a discussion with the leaders in the village and surrounding area on the lifestyle and values of the people in the target area. This can be pooled into one large table to compare with the national average or some other standard. If any one of these environmental factors is very different, more detailed follow-up studies are required to get quantitative data on the characteristics of that environmental trait.

2. The next step is to define all of the resources available to the farmer and wherever possible, to quantify them. This involves a baseline survey of the area and a sufficient number of farmers to get an understanding of the resources the farmers are currently using and the resources that are available to them. This means surveying enough farmers so the differences can be measured.

3. The next step is to get an estimate of how the resources are being allocated to the various enterprises. For the enterprises, except cropping systems and perhaps livestock, a rough idea for each of the five categories is sufficient. For the cropping systems in which we are most interested, a detailed breakdown by crop and a

profile of use over time are needed. To get this data record keeping is involved.

In gathering this data the objectives are: a) to get a detailed study of the interaction of the resources with cropping systems; b) to study the interaction between the enterprises and cropping systems; and, c) a biological study of the interaction over a range of inputs to tie in with the farmers' responses.

To cover the last point effectively agronomic experiments of a single factor type using farm level management work well.

4. Quantify the products resulting from all the enterprises. This means a list of the quantities of each product that result from the enterprises. This also acts as a check on the data from resource utilization. It is unlikely that the farmer will be putting a lot of resources into an enterprise with very few products. If this is found further research is required.

5. List the main needs of the farmer based on what the farmer is currently using and then record these as his current needs.

6. Using questions, check what needs the farmer would like to satisfy the most.

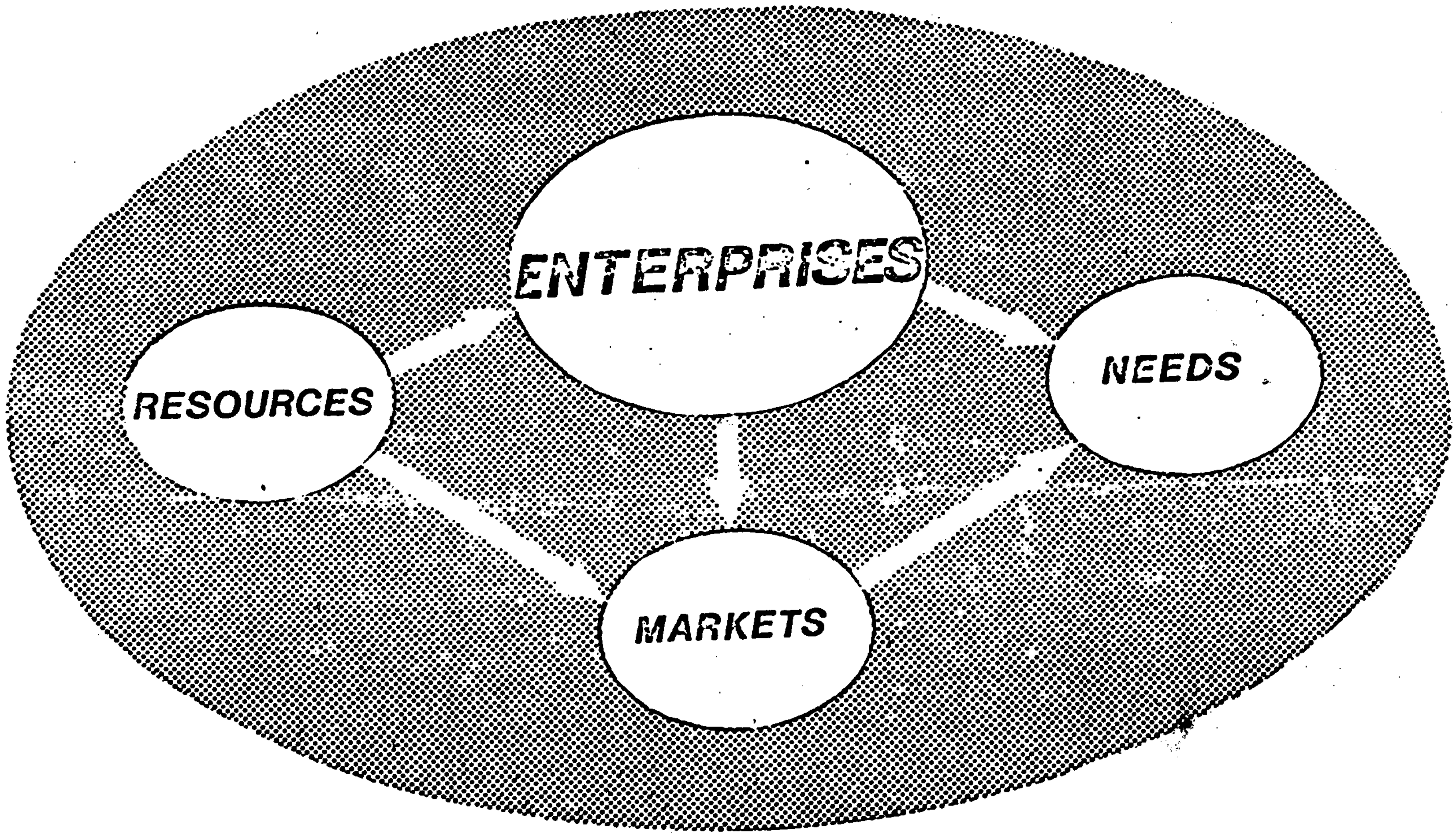
7. Delineate the constraints or area where technology is needed or where the technology available is superior and might be transferred to another similar agro-climatic type area.

The most important principle learned from this research to date is that we are looking at a total system and must always consider it as such. It becomes very interesting to look at specific components and certain very interesting relationships. There is a great desire to study them in depth, ignoring the rest of the system. This trap must be avoided if we are to truly understand the total cropping system. That is not to say that detailed studies are not needed, but they should all be kept in perspective and evaluated on the basis of their importance in the system.

CONCLUSION

1. To study cropping systems we must look at the farm and its total environment. We cannot look at the farm as an isolated unit and get an understanding of the cropping systems.
2. Any factor which does not interact with other factors on the farm does not need to be studied in cropping systems. We are only interested in those factors which interact.
3. Biological and social scientists working as an integrated unit will be the only ones who have a chance of understanding cropping systems and designing a technology which will fit into existing cropping systems in a planned manner.
4. The integrated team members who deal with the farmers must be able to communicate with, and more important, listen to farmers. That is, have empathy with the farmer.
5. We view the cropping system on the farm as one process of transforming resources to meet farmers' needs and look at it as an integral part of the total process.

6. A simpler methodology must be developed for use by small research institutions throughout Southeast Asia in developing their own cropping system team to assist their immediate community.


ENTERPRISES
RESOURCES
NEEDS
MARKETS

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THE CAQUEZA PROJECT

FOLDOUT

by

ICA-CIID RURAL DEVELOPMENT TEAM

A subjective and approximate presentation of information flow in agricultural production research, rural development activities and the small farmers decision making process.

THE CAQUEZA PROJECT

PREFACE

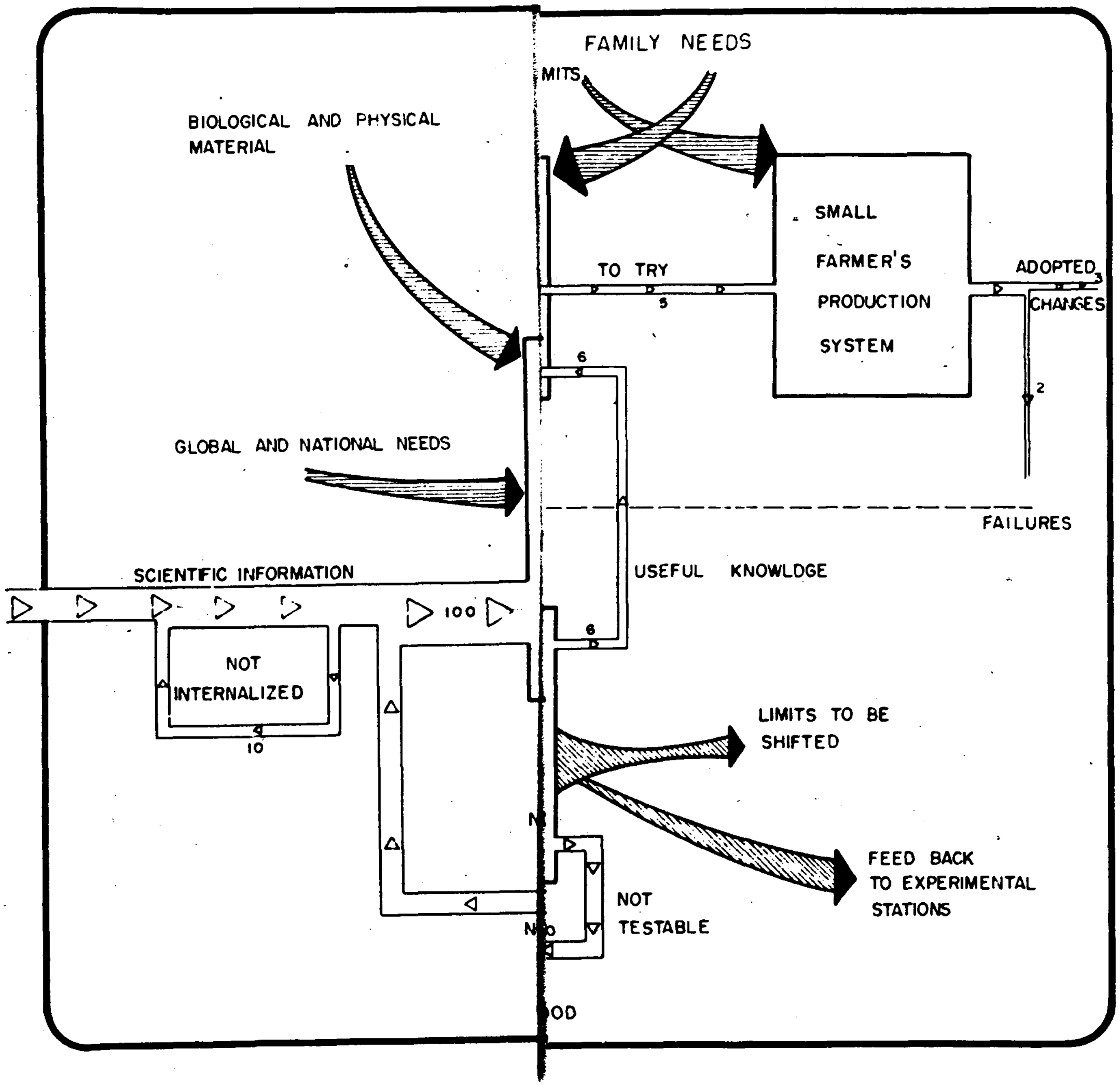
Agricultural research at both the national and international level is strongly oriented towards technological change. Much of this research seeks to develop components of agricultural production systems or complete production systems which will increase food availability from improved agricultural production.

The experience of the Cáqueza Project is that much of the technical effort invested into agricultural production research may not necessarily improve the well-being of the small farmer, unless the technical innovations are accompanied, at least in the first instance, by a comparable expenditure on activities to investigate the farmers' limitations to the incorporation of research results into their production systems.

The following four presentations, an interdisciplinary effort from IDRC and Colombian staff in the Cáqueza Project, reflect our increasing preoccupation with the issues involved in achieving higher levels of well-being by using the technology already known. By continuously studying the constraints which delay the acceptance of new production technology, the Cáqueza team is seeking to define which conditions must be met by the results of production research for the farmer to adopt new techniques. It is our contention that this approach requires an interdisciplinary team, and it is our experience that research that is purely production or technically oriented, disregarding the socio-economic and cultural aspects of the farmers' system, is likely to achieve only a very limited impact in improving the well-being of the rural community.

Bogotá, October, 1974

A PROJECT



FAMILY NEEDS
MITS
BIOLOGICAL AND PHYSICAL MATERIAL
SMALL FARMER'S PRODUCTION SYSTEM
TO TRY
5
ADOPTED
3
CHANGES
6
2
GLOBAL AND NATIONAL NEEDS
FAILURES
SCIENTIFIC INFORMATION
USEFUL KNOWLDGE
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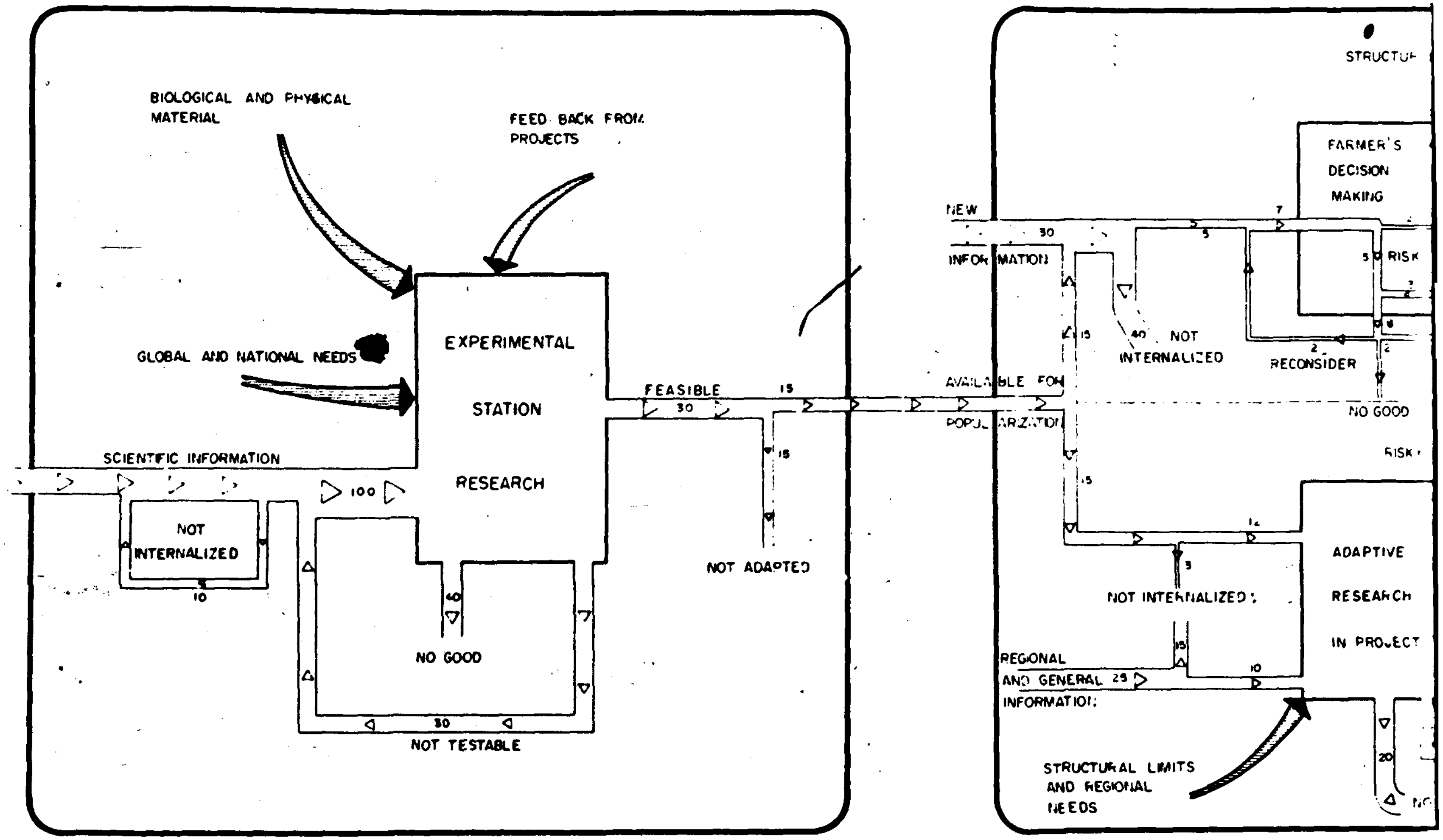
BIOLOGICAL AND PHYSICAL MATERIAL
FEED BACK FROM PROJECTS
GLOBAL AND NATIONAL NEEDS
EXPERIMENTAL STATION RESEARCH
SCIENTIFIC INFORMATION
100
NOT INTERNALIZED
10
40
NO GOOD
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NOT TESTABLE
FEASIBLE
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15
15
NOT ADAPTED
NEW INFORMATION
30
AVAILABLE FOR POPULARIZATION
FARMER'S DECISION MAKING
RISK
NOT INTERNALIZED
RECONSIDER
NO GOOD
ADAPTIVE RESEARCH IN PROJECT
NOT INTERNALIZED
REGIONAL AND GENERAL INFORMATION
25
STRUCTURAL LIMITS AND REGIONAL NEEDS
20

Draft
For Review Only

RURAL DEVELOPMENT INFORMATION REQUIREMENTS 1/

By

C.A. Zulberti 2/

1/ Paper prepared for the Agriculture, Food and Nutrition Science Field Staff Symposium of the International Development Research Centre (IDRC), November 18-21, 1974. The author is indebted to Barry Nestel, Hubert G. Zandstra, Kenneth G. Swanberg, Ronald J. Duncan and Ester Zulberti for their helpful discussions and useful comments while this paper was in preparation.

2/ Agricultural Economist, ICA-IDRC, Rural Development Project.

I. INTRODUCTION

The object of this paper is to try to define what information is required and from whom it is to be obtained, in order to generate successful action programs aimed at improving the well-being of the rural population.

In order to achieve this object, the paper will briefly discuss the origins of the Rural Development Projects (RDP) in Colombia. Then it will analyze various approaches followed in the past to design appropiate action programs, with particular emphasis on the information on which these were based and its sources.

Finally, conclusions based on the experience gained up to the present time in the Caqueza Project will be presented.

II. HISTORY OF RURAL DEVELOPMENT PROJECTS IN COLOMBIA

In 1967 the Colombian Agricultural Institute, ICA, took over the Ministry of Agriculture's 16 extension agencies and started its own extension activities. Soon after, the number of extension agencies was increased, first to 42 and then to 58.

At the same time, other institutions besides the ICA were carrying out technical assistance, for instance, INCORA (the Agrarian Reform Institute), the Caja Agraria (the Farmers Credit Bank), COFIAGRO (Financial Corporation to Promote Crops and Cattle Exports), the National Coffee Growers Federation, CECORA (the Cooperative Land Reform Institute), etc. In general, the aim of nearly all the extension activities carried out was to attain high agricultural productivity. Their work was rendered extremely difficult because of the number of very different ecological areas encountered in the country. Since ICA was in charge of the research activities required as a necessary basis for recommendations to farmers, it was logical for it to be given major extension responsibilities in order to ensure close ties between research and extension programs. This was a tremendous task in view of such conditions as the size of the land holdings and the educational level of the farmers. ICA consequently decided to divide its extension activities into two categories, applicable:
1) to the better-educated commercial producer with a relatively large holding, to whom a traditional extension system approach could be applied, and 2) to the small farmer (minifundista) with a very small holding and a relatively poor educational level, for whom a new approach had to be followed.

This new approach arose after an extensive study of similar projects in Asia and Latin America, with particular emphasis on the Puebla Project in Mexico.

A. THE PUEBLA PROJECT

The objectives of Puebla were: 1) to develop, field test and refine a strategy for rapidly increasing the yields of a basic food crop among small holders; 2) to train technicians from other regions in the elements and successful use of this strategy.

While these objectives were production oriented, they were closely associated with development. An early report on progress in the Puebla Project 3/ stated: "Unfortunately, the strategies currently being used to bring about development in this kind of area are largely modeled after extension programs in the commercial farming areas of the more developed countries".

The assumption underlying the Puebla Project was that the problems of the small farmer in a subsistence economy could be solved by increasing the yields of his basic food crop (corn).

The project employed the concept of limitations in its definition of action programs, in the sense that "The strategy is essentially a simultaneous and integrated plan of attack on the many problems limiting farmer use of adequate production technology". The action programs proposed concentrated on the provision of: 1) high-yielding maize

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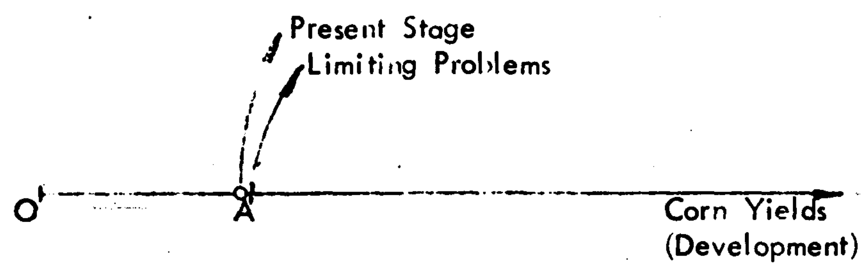
3/ Progress Report of a Program to Rapidly Increase Corn Yields on Small Holdings. The Puebla Project. 1967-1969 CIMMYT, 1969.

varieties, 2) information on optimal production practices, 3) effective communication of agronomic information to farmers and agricultural leaders, 4) adequate supplies of agronomic inputs at easily accessible points at the time when they are needed, 5) crop insurance, 6) favorable relationships between the cost of inputs and crop values, 7) adequate production credit at a reasonable rate of interest, and 8) accessible markets with a stable price for maize.

This conceptualization of Rural Development is represented in Figure 1.

Figure 1. A Graphic Representation of the Puebla Project



The farmers were producing a certain amount of corn, represented by point A; they were not able to produce more because of the limiting problems impeding their progress beyond that position.

Corn yields were considered to be highly correlated (r = 1.0) to development. Thus, the proper way to "generate" development was to introduce a "technological package" (high yield corn varieties, fertilizers, pesticides, new seeding practices, etc.) into the farmers' present production system and at the same time to attack the problems considered as impediments to the adoption of the package.

It was assumed that no information was required from the rural population in order to plan appropriate action programs. If information on the rural situation was needed, it was assumed to be already available and known to the professionals who designed and operated the project.

A number of evaluations of the Puebla Project have by now been carried out. In 1973, it was found that after six years of work on the project, only 11% of the farmers in the project area had adopted the full package of recommendations and only 40% were following the recommendations to use fertilizers. The increase in production for the whole area was 22% in 1973, taking 1968 as the base year and making the necessary allowances for weather conditions. This change in production represented an increase of 4% per year for the project area as a whole. While this result was undoubtedly important it fell far short of the original objective of doubling corn production in five years (i.e. a growth rate of 15% per year).

B. THE COLOMBIAN RURAL DEVELOPMENT PROJECTS

ICA started six RDP's in 1971 (there are currently 21 in progress). One of these projects, in Eastern Cundinamarca (Caqueza), receives support from IDRC. Although these projects were conceived as outgrowths of the Puebla Project, they have rather broader objectives.

In the case of the Caqueza Project the stated objectives were as follows:

a) To develop and test a strategy for the transfer of technical, economic and social information to small farmers, which would favour their active participation in matters such as the use of credit and purchased inputs, the sale of their products and the betterment of their social conditions;

b) To use this strategy to bring about higher crop and animal yields, improved economic returns and better family living in the project area;

c) To establish a system whereby the farmers in the project assume increasing responsibility for the execution and expansion of this strategy, using their own initiative;

d) To measure the changes in the community and in its incomes that will have resulted from the project.

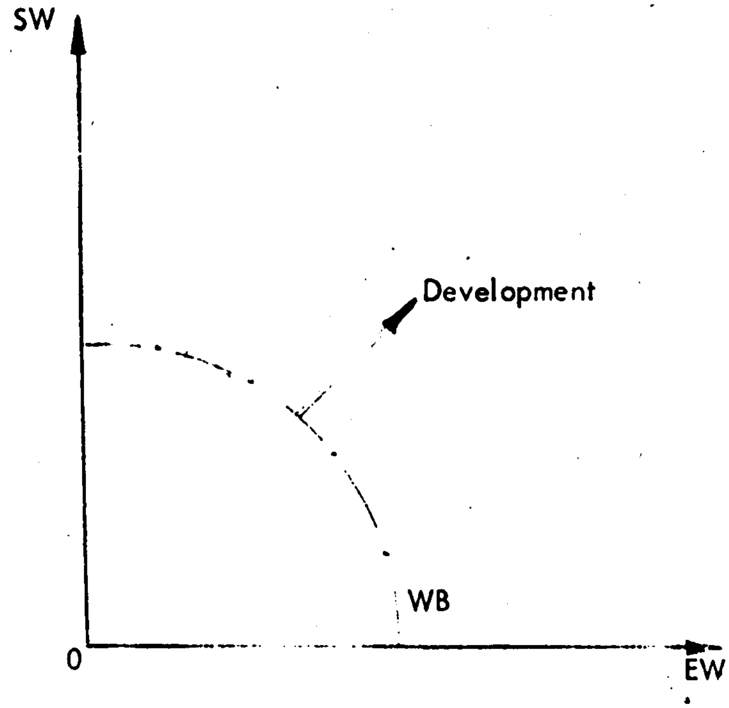
The basic assumption underlying these objectives was that Rural Development is multidimensional, having two main divisions: the social dimension and the economic dimension.

Figure 2 shows a simplified graphic representation of this conceptualization of Rural Development in the RDP's of Colombia.

The well-being of the people (WB) is a function of both social welfare (SW) and economic welfare (EW).

The objective of an RDP is to shift the well-being function to higher values through the generation and application of appropriate action programs. To achieve this goal, ICA decided to work initially in three main areas: Agricultural Production, Animal Production and Home Economics.

Figure 2. A Graphic Representation of the Colombian Rural Development Projects



III. APPROACHES FOLLOWED TO DESIGN ACTION PROGRAMS

The various approaches which were followed in Colombia in order to design appropriate action programs will now be discussed. Graphic representations will be used to help in their conceptualization. For this purpose a linear orthogonal two-variable world is assumed, where the properties of proportionality and additivity are valid. The well-being function is defined as follows:

WB = 1EW + 2SW

where

WB is the level of well-being

EW is the level of economic welfare

and

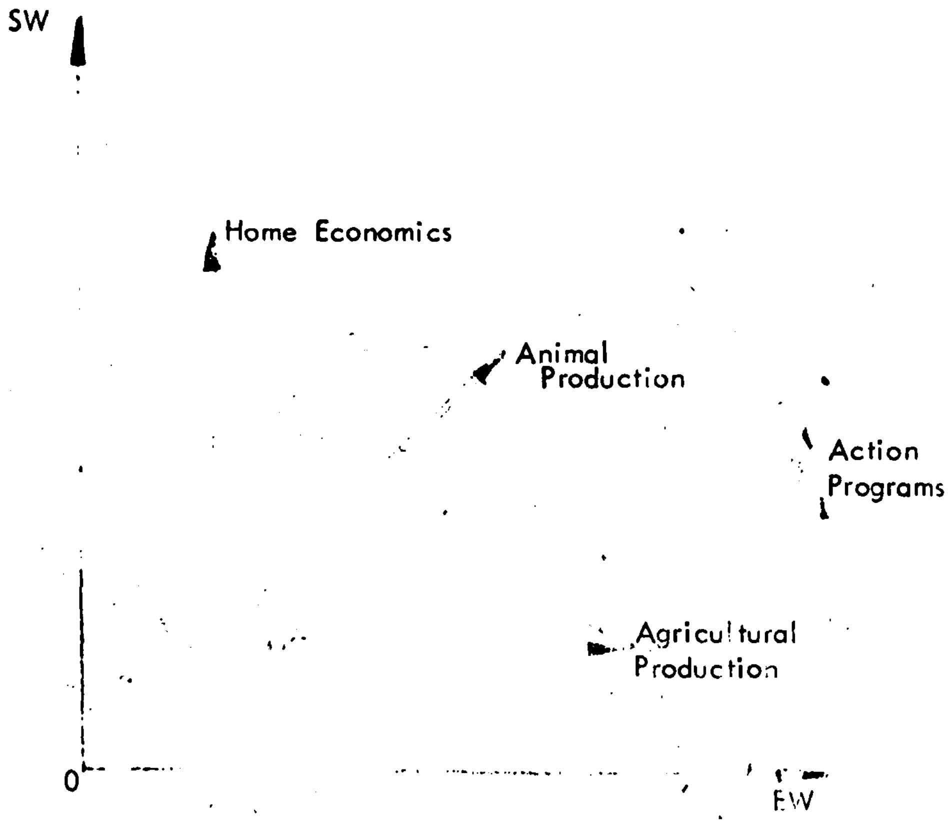
SW is the level of social welfare.

A. THE "GO OUT AND DO IT" APPROACH

The basic assumptions underlying this approach were that farmers followed a traditional system of production and consequently lived under very poor conditions. However, technical information obtained at experimental stations was available which would, if transmitted to them, improve the farmers' living conditions and help them to modernize. The task was thus to "go out and do it" by putting people in the field to carry out communication activities. The main activities planned were: meetings with farmers, field days, leaders, courses, divulgation pamphlets for distribution, etc.

This approach is represented graphically in Figure 3.

Figure 3. The "Go Out and Do It" Approach



At the beginning the action programs were designed at the national level. Soon after, professionals working at both the national and the project level realized that the planning model was likely to be ineffective unless it took regional characteristics into account. Therefore, the planning of field activities was delegated to the project level; nevertheless, the activities carried out were not, initially, substantially changed.

This lack of change can be attributed to the mental attitude of the project staff which was, at that time, very similar to that of the national planners (similar educational background, equal technological orientation, similar field experiences, etc.). In addition, they were using the same sources of information (experimental station research and general publications).

B. THE BASE-LINE STUDY APPROACH

Although the field staff at the project level had a "feeling" about the conditions of their region, this was not considered adequate for planning purposes. It was, thus, decided that some projects should start base-line studies using secondary data as well as questionaries.

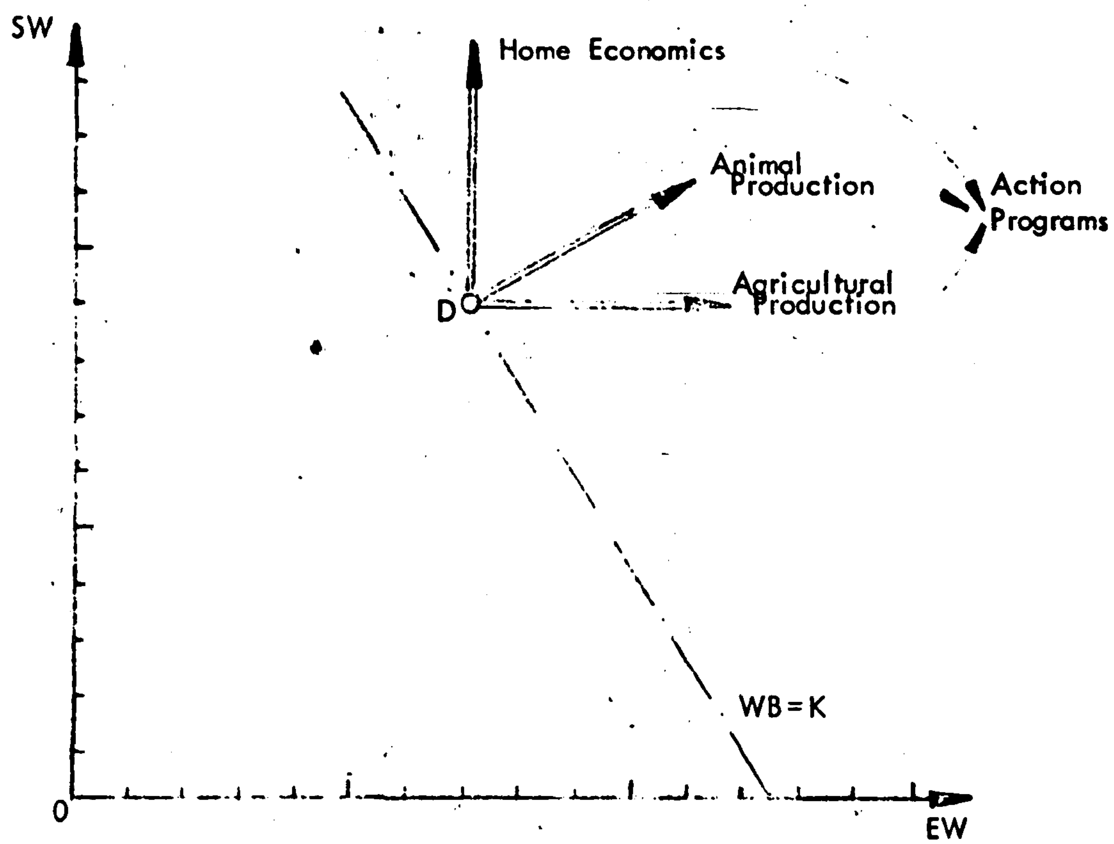
In the Caqueza Project the base-line study was carried out by the personnel of the Caqueza Project at a relatively low cost. At García Rovira (another Colombian RDP), the study is presently being conducted as part of a Ph.D. dissertation and enough information is available for two more M.S. theses. The basic data collected at García Rovira in 1972 (unpublished) were gathered at a cost of more than US$40,000, financed by the Ford Foundation. Although this approach yielded very useful data, its widespread use presents obvious problems with regard to time and cost, in terms of the long-run national objective of 100 + RDP's.

The underlying idea behind base-line studies was that, by defining the present regional state of affairs it would be possible to specify action programs in such a way that the well-being function could be more easily shifted from its present level to a more desirable one.

In practice this type of study has proved of limited value, since it described or measured the present situation but generally failed to say where the project should go in the future.

This approach could be represented graphically as in Figure 4.

Figure 4. The Base-Line Study Approach



The rural population is at point D, its well-being is expressed as K. 4/

4/ For the purposes of our graphic representation, it is assumed that the rural population is at point D (7,9). Specification of point D helps in assigning a value to the well-being function (K).

If WB = 1 EW + 2 SW, then $K = 1(7) + 2(9)$
$K = 25$

Many action programs designed modelled on the early base-line studies have been relative failures, for instance, home improvement, hygiene, latrinization; even the agricultural and animal production oriented programs may be considered as such.

The Caqueza team felt that these failures, which lay mainly in the production areas, were due to the broad, and in some cases inadequate, technological recommendations made by the experimental stations which were used to define the production packages. They therefore decided to look for a more realistic approach.

C. THE LIMITATIONS APPROACH (PROFESSIONALS)

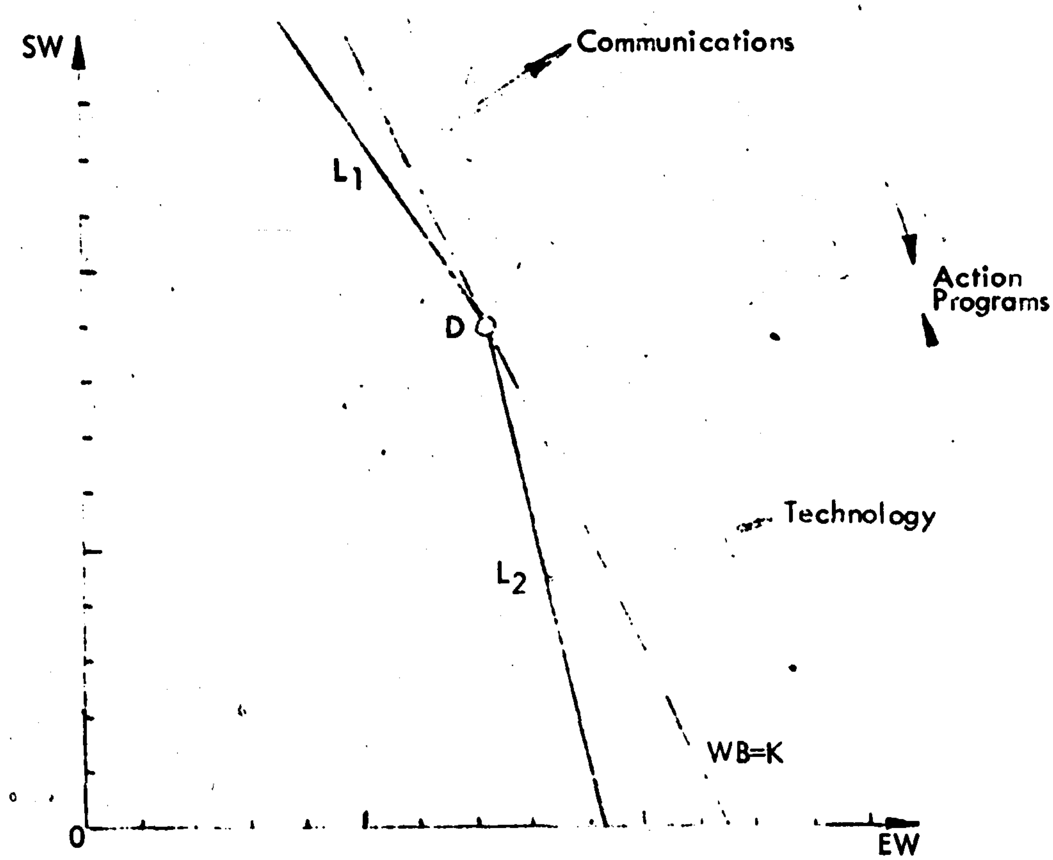
Professionals working on the Caqueza Project felt that the farmers were subject to constraints limiting their possibilities of adopting new technology. Hence, they introduced the concept of limitations used in the Puebla Project. They identified what they felt to be the two most important limitations:

1) "technology" adapted to the region, and
2) "communication" of that technological information to the rural population.

This approach differs from the base-line approach in that, whereas the goals of the action programs derived from the base-line studies are expressed as shifts of the well-being function to higher levels, the goals of the limitations approach are stated as removing the limitations that constrain the rural population to remain at their present level of well-being. This latter approach came about as a consequence of an increased awareness among professionals of the farmers' problems and values.

This approach is represented graphically in Figure 5.

Figure 5. Limitations Approach (Professionals)



The rural population was at state D, its well-being expressed as K. Two limiting factors, technology (L_1) and the lack of communication of that technology (L_2), were constraining them to remain in that situation 5/. Therefore, the action programs

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5/ For the purposes of the graphic representation, the limiting factors are as follows:
$L_1 = 4EW + 1\ SW$ $\quad$ $L_2 = 3EW + 2SW$
Since the value of point D is known (7,9) the values of the limitations may be given as:
$L_1 = 37$ and $L_2 = 39$

needed to be directed towards the removal of those limitations.

As a result of this approach, the project staff started to carry out applied research and developed "packages" of recommendations suited to local conditions for two main crops in the area: potatoes and corn.

The technological packages developed (and tested in farmers' plots) enabled both yields and income to be increased. They were widely communicated to farmers through field days, demonstration plots, etc. Nonetheless, the new recommendations were accepted only by a relatively small number of farmers.

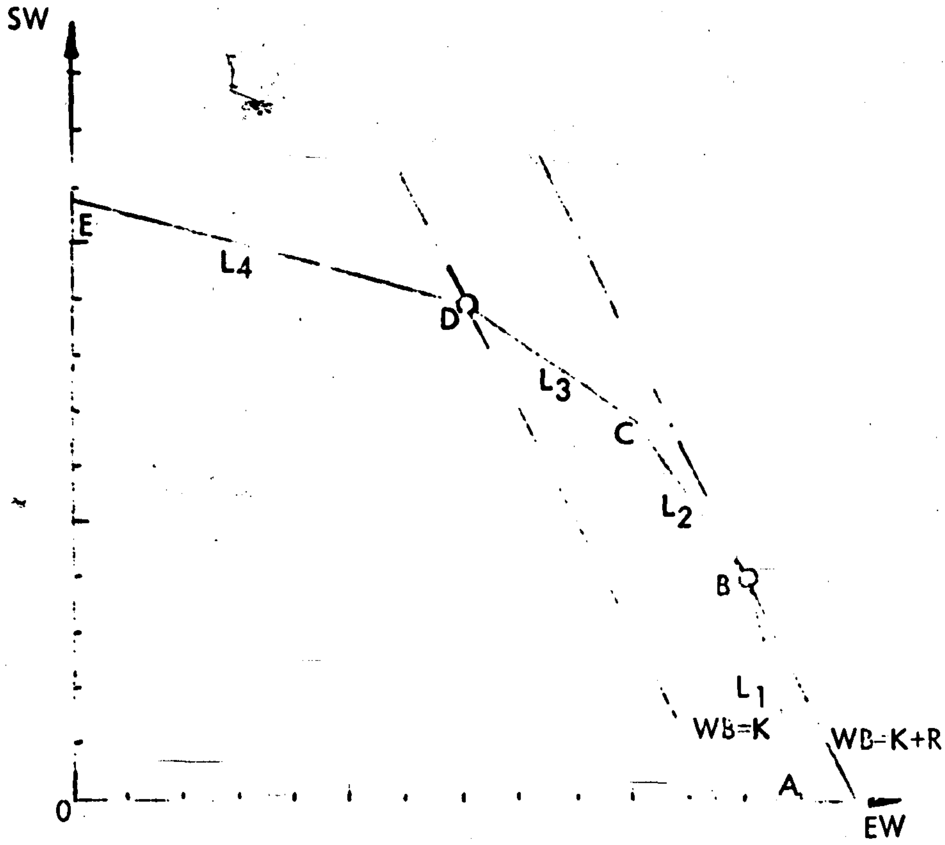
D. THE LIMITATIONS APPROACH (RURAL POPULATION)

The next approach adopted was to ask rural people to define what they themselves considered to be the limitations to their well-being. Interestingly enough, they expressed a set of limitations different to those postulated by the professionals. They repeatedly stressed infrastructural and institutional constraints such as credit, marketing, etc., rather than lack of technology.

There appeared to be two alternative explanations for this situation:

1) Farmers are inefficient decision makers. The rural population can achieve better well-being levels within their own set of limitations. Professionals have been mistaken in thinking that technology and communications were constraints acting on the present level of well-being of rural people, when in reality these people could be living at higher levels before those constraints become effective. This situation may be represented as in Figure 6.

Figure 6. Limitations Approach (Inefficient Rural Population)



The rural population has four basic limitations. Technology (L_1), communications (L_2), credit (L_3) and marketing (L_4) 6/.

The rural population is at point D, with a value for the well-being function equal to K 7/. If they were efficient, they would be at point B 8/ with a

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6/ The equations for limitations L_3 and L_4 are:
$L_3 = 2EW + 3SW$ and $L_4 = 1EW + 4SW$

7/ K = 23

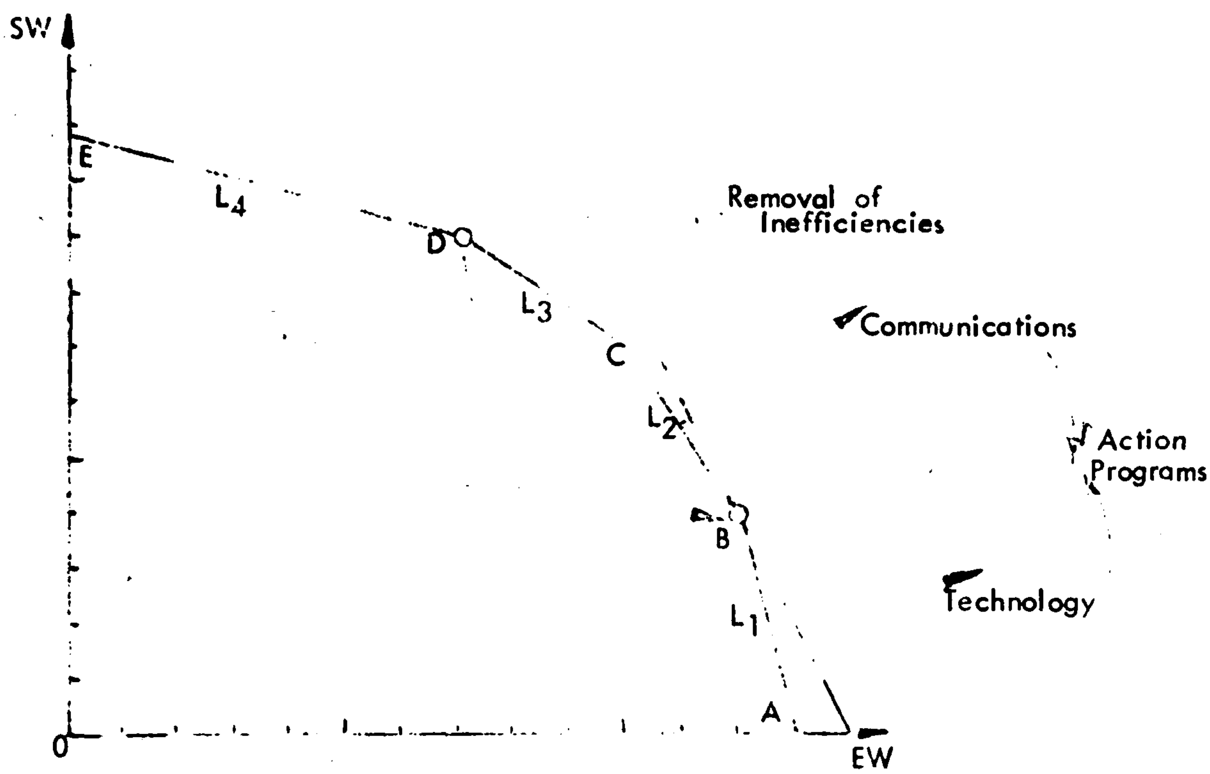
8/ B = (12,4)

value for the well-being function equal to K + R 9/.

This type of analysis is very much in line with the thinking of some development specialists who claim that rural populations are traditional, that they lack the desire for achievement, and even that they are composed of backward people who prefer to remain underdeveloped.

Given this explanation, the strategy to be followed could be represented as in Figure 7.

Figure 7. Strategy for Inefficient Rural Population



The first step to be taken is to move the farmers from their inefficient (D) to an efficient point (B); and then to remove the limitations constraining them to that new state, i.e. technology (L_1) and communications (L_2).

9/ If K + R = 28, then R = 5

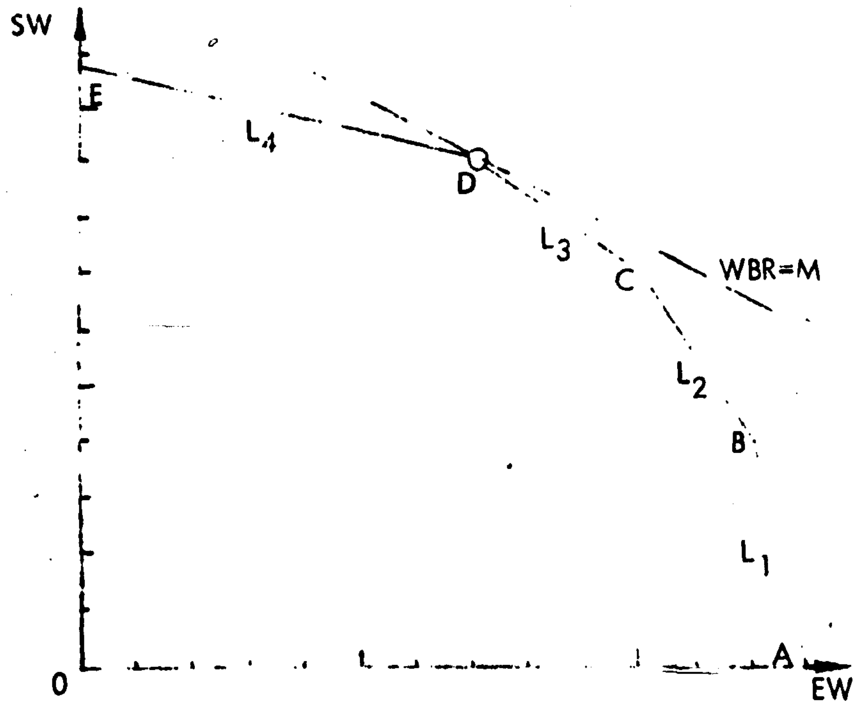
The question of how to move the rural population from point D to point B is almost impossible to answer unless we know the reasons for their being at point D. Duncan's work suggests that the above explanation as to why the farmers were stressing other limitations than those considered important by the professionals lies not in the fact that rural people are inefficient, but in the fact that their value structure is different to that of the professionals.

His work would therefore suggest that the second alternative presented below is of much greater validity:

2) Farmers are efficient decision makers but they have a different set of values (well-being function) 10/ to that of the proffesionals.

This approach is presented in Figure 8.

Figure 8. Limitation Approach (Efficient Rural Population)



10/ The rural population well-being function (WBR) is as follows: WBR = 1EW + 2SW

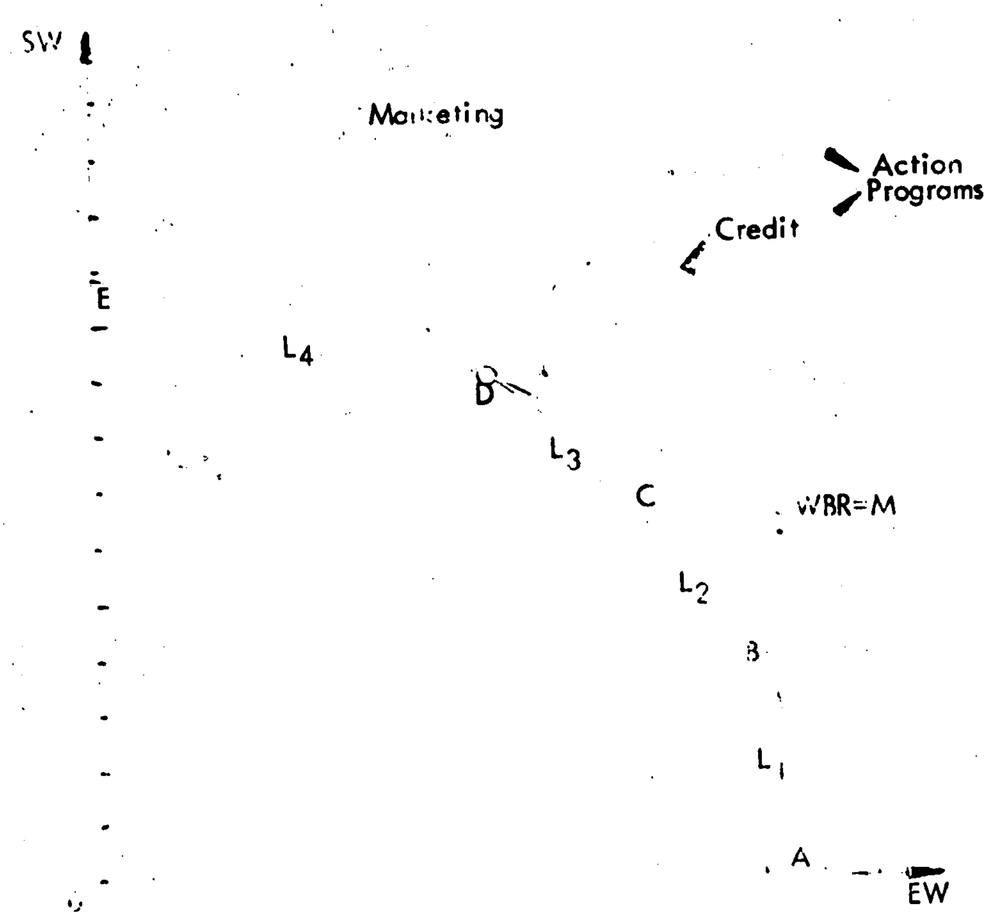
The limitations are still the same, and the rural population is still at point D. But according to this representation the farmers are efficient decision makers (and thus at the optimum point). Their well-being is WBR = M, their real limitations are credit (L_3) and marketing (L_4). This implies that rural people are not backward and do not lack the desire for achievement; however, they look at life from a perspective different to that of professionals.

The question now arises as to whether rural development projects should try to impose their professional sets of values on the rural population and move them from point D to point B, as suggested in the previous approach, or whether they should work from the standpoint of the rural people's concept of their own limitations in order to shift their well-being function (WBR) to a higher value.

The project staff believes that the second approach is the more desirable since it allows rural people to take their own decisions and make their own choices. As a concomitant of this approach, professionals working on the projects have to be responsive to the needs, desires and limitations of the rural population. This means that project activities should concentrate on removing the limitations confronting the rural people, as perceived by themselves (see Figure 9).

Action programs ought thus to be directed towards the removal of credit (L_3) and marketing (L_4) limitations. As a result of such action programs, the well-being of the rural population (WBR) should be shifted to higher values, until other limitations become effective. The presentations by Zandstra and Swanberg, respectively, will deal specifically with the removal of credit and marketing constraints.

Figure 9. Strategy for Efficient Rural Population



IV. CONCLUSIONS

Assuming that the humanistic approach to rural development (where the power to make decisions remains in the hands of rural people) is more desirable than "pistol type" development (where decisions and values are imposed) the first information requirement in initiating appropriate action programs is to know the limitations impeding change for the rural people. The best sources of information for this purpose are the rural people themselves.

A much closer interaction between professionals and rural people is felt to be a "sine qua non" for an RDP. Professionals must work together with the rural population in order to determine the real limitations and the causes of these limitations[11] before attempting to implement solutions.

Although this is a necessary action, it is not sufficient. Sometimes, even when a substantial effort to interact has been made and the supposedly real limitations and their causes have been determined, action programs generated on the basis of this information still fail. In this case, it is necessary to try to explain the reasons for their failure, an important part of the evaluation of action programs. Such an exercise helps to determine whether the real limitations and their causes were properly

11/ There is a clear differentiation between expressed limitations, real limitations and causes of limitations. A farmer may say that his limitation is credit (expressed limitation) but his real limitation could be the lack of cash to buy inputs (credit is one way of obtaining inputs but there are other possibilities). It does not help much to be able to point out at credit as a limitation, it is also necessary to look at the causes of the limitation (it could very well be that credit is not available at the proper time, at any time, it is too costly, it is to risky, it requires a lot of time to be spent in town, the farmer does not have the collateral or property rights are not in order, etc.).

defined or whether the situation changed in the course of the action programs.

The author hopes that this conceptual paper will set the frame of reference for the presentations to follow. His colleagures, who have been working in close contact with the rural population and professionals in Cáqueza for the past three years, will discuss a number of the factual examples that helped in the development of the ideas presented here.

Ronald J. Duncan will talk about how interaction with the rural population may be operationalized. Hubert Zandstra will explain why thinking in biological terms only or the proposition that "a good variety sells itself" did not apply to "corn recommendation packages" developed in the Cáqueza Project. He will also show how the project is dealing with this problem. Finally, Ken Swanberg will provide examples to show how the evaluation of past action programs is helping to determine the real limitations and their causes.

The ICA-IDRC team hopes that this form of presentation will provide an insight into the integration of the practical experiences of the group into a conceptual framework for Rural Development.

DRAFT
FOR REVIEW ONLY

TWO CORN PRODUCTION SYSTEMS IN THE CAQUEZA PROJECT 1/

by

H. G. Zandstra 2/

1/ Paper prepared for the Agriculture, Food and Nutrition Sciences Field Staff Symposium of the International Development Research Centre (IDRC), Ottawa, Nov. 18-21, 1974. Gratefully acknowledged is the helpful support of Roberto González, Barry Nestel, Carlos Zulberti, Ken Swanberg and Ron Duncan.

2/ Coordinator, ICA-CIID, Rural Development Project.

I INTRODUCTION

Production research for small farmers in Latin America is now generally recognized to require a different approach, design and interpretation from traditional crop production research methods as used in Europe and North America. The changes designed to better meet the small farmers situation have so far focused primarily on three additional requirements. Firstly, the need to realize research on new practices or materials within the region for which the application is intended. Secondly, the need to consider various levels of financial inputs, in order to structure recommendations to the farmers' ability to pay for them and his preparedness to accept the risks involved. Thirdly, the need to infuse new methodologies on materials into existing production methods, in this way avoiding the recommendation of entirely new production systems in an extremely risk sensitive society (ALADER, 1972 pp. 56,57; Turrent, 1973).

Although the need for these changes is now recognized, there remains a considerable lack of unanimity about the role of production research, its methodology and performance criteria for its results, in the process of rural development. Such results, which are generally expressed as production recommendations have, in the majority of cases, achieved a very limited acceptance by the small farmer. This lack of adoption has been widely discussed and used as an argument both to justify the employment of and to criticize the performance of communication specialists assigned to "extend' research results to the farmer.

In this study, some of the results of the production research in the Cáqueza Project and some of the experiences acquired from studying farmers' adoption behaviour related to production recommendations, will be employed to further define the role of production research in rural development. In addition, methods for the interpretation of research results will be discussed that may lead to action programs better adjusted to the operational restraints existing in the small farmers community.

II TWO CORN PRODUCTION SYSTEMS IN THE CAQUEZA PROJECT

A. The Farmers Methods

Farmers in the project region generally make a plowing contract with a member of the community who owns oxen and a wooden plow. Corn is then seeded in hills, spaced 1 m. by 1.20 m. Seeding rates are three to four plants per hill and the resulting stand is not thinned. The field is weeded twice and hilled up once, at the time of the second weeding. No fertilizer is applied. The family harvests corn with the cobs covered and stores the cobs with half the covering leaf still on the cob (González and Zandstra, 1973).

A survey of 185 farmers' fields (Narvaez, 1974) provides a more precise analyses of this production system (Table 1) and shows the low production costs, low yields and the precariously low returns provided to the farmer using 1972 (10 ct/kg) and 1974 (16 ct/kg) corn prices.

B. The Projects Recommendations

Because of the obvious potentials for production increases indicated in Table 1 and the dominance of the corn crop in the region, the Cáqueza Project has devoted considerable research effort towards the definition of an improved corn production method in the project area. Initial research concentrated on the selection of adapted hybrids and varieties from the assortment of ICA-produced certified materials that were already available (González and Zandstra op. cit.). Major emphasis was, however, given to experiments on farmers' fields formulated to define adapted recommendations for planting densities, fertilizer application and pest control (Cobos and Zandstra, 1973).

Two- or three-replicate trials were carried out over a period of three years at 27 different sites, in order to arrive at suitable recommendations. Yield analyses from these trials, combined with yield figures from 23 commercial farmers fields in which recommended fertilizer levels were applied, permitted an estimation to be made of the benefits to be derived from following the projects recommendations (Table 2). To derive the yield estimate presented in Table 2, experimental yields were deflated by an average of 20% (for the highest yields the deflution factor was approximately 40% in order to adjust for bias in experimental control and site selection, Zandstra and Villamizar, 1974).

C. The Project's Experience with Farmer's Adoption of its Recommendations

Since the early project work in 1971 suggested that it was possible to increase production and net income by over 200%, the project began to make preliminary recommendations in the extension program for 1972. In 1972 and 1973, it also studied the response to farmers to a six-factor package of recommendations. In 1972, farmers who received credit and were urged to follow the recommendations showed considerable resistance to the application of some of the components of the recommendation. Only 22% of the recommended fertilizer was applied, even though fertilization was a well recognized part of the trials on farmer fields (Escobar, 1972). Most farmers (86%) did, however, adopt a higher planting density, although during the experimental phase, this measure was unpopular with many farmers.

The project team's reaction to the low adoption of the fertilizer recommendation was two-fold. Firstly, they recognized the desireability of simplifying the fertilizer recommendation from a triple application to one in which all fertilizer was applied early in the season (when the farmer still had cash from the credit program), if possible in a single application. This led to a new research program with ten on-farm experiments carried out over a period of two years. This program will terminate next month and is designed to compare the performance of the simplified fertilizer application methods to that of the split application, taking into account adoption experiences, income and risks. The second reaction to low adoption of their recommendations was to criticize the extension methodology used (a traditional reaction by technicians to a lack of adoption of their recommendations).

In 1973 considerably more pressure was applied and more supervision was given by the project to recipients of corn production credits. The fertilizer recommendation was reduced from a three-fold application to a two-time application method. Preliminary results of the 1973 adoption study (which, unlike the 1972 study, also includes yield measurements) indicate that there was a substantial increase in adoption rates and a marked improvement in corn yields. The staff did, however, sense a lack of enthusiasm by farmers for the corn production credits in comparison ~~to~~ credits for horticultural crops or potatoes. This lack of enthusiasm existed even though the price of corn in the field had increased from 10ct/kg in 1972 to approximately 13ct/kg in 1973, but may relate to the fact that average per ha net incomes from vegetables and potatoes are much higher than those from corn.

III AN ANALYSIS OF THE CONSTRAINTS ON ADOPTION

Through regular meetings with farmers and a research project designed to establish the "real cost" of credit in the region (M.S. thesis of V. Villamil directed by K. G. Swanberg, in preparation), the project team began to suspect the existance of some constraints, of which they were not fully aware, that were limiting the adoption of what appeared to them to be sound recommendations. This led to a more complete comparison of the two production systems, with particular emphasis being given to comparative risks, returns to inputs and cash and labour requirements. The production method recommended by the project showed advantages over the existing production method, except for cash and labour requirements, returns to cash invested and both measures of risk (Table 3). Each of these disadvantages will be discussed separately:

Cash requirements were increased by 575% in the recommended method. This changed the production system from one that was land and labour intensive (75% of total investment for the actual method) to one that is cash intensive (62% of total investment for the recommended method).

To appreciate what this change may mean to the Cáqueza farmer, one needs to compare these figures to the average income for the region, the approximate cash turnover and the available cash on a per ha basis. The project benchmark study (Escobar, 1973) indicated a per ha income of $235,[3/] of which approximately $150 was received in cash and the rest as farm produce for consumption on the farm. The average income from agricultural production was $190 /ha ($85 consumed and $105 sold) and

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3/ Adjusted for inflation at 25% per year and differences in peso exchange rates, assuming an average farm size of 3.2 ha and a family size of 7.5 members.

$45 /ha was received off-farm sources of income. A separate study of food consumption data of 259 families in 1974 allowed these figures to be cross checked against actual consumption data. On a per ha basis using the same assumptions, per family food costs were $222. Although this estimate of cash available after food costs ($13 /ha) can be substantially varied by slight changes in inflation rates, it is most indicative of the limited cash available to the farmer for investment in crop production. Where he originally needed to invest $21 in cash, to follow the project's recommendation he will need $142 or nearly six times as much. His low cash availability suggests that, to do so, he will need to seek credit from the agrarian bank or from his community. He will therefore incur an interest charge of $21 (Table 2) which is nearly equal to the total cash requirement of his original production method.

Labour requirements were 18 man days /ha higher with additional labour demands evenly distributed throughout the season. Depending on the availability of labour (under study), this factor may reduce adoption rates. However, returns to labour under the recommended method increased substantially and may therefore be competitive to other employment possibilities.

Returns to cash dropped in the change from actual to recommended practices. This production input was receiving the highest returns per dollar in the actual production system, which could be considered an expression of the value the farmer attaches to cash input. The combination of reduced returns to cash with its limited availability may well be sufficient reason to qualify the recommended method as an inadmissable strategy in the decision-making space of the farmer. The reduction in the productivity of cash inputs may also explain the farmers' preference for credits for horticultural crops.

The farmer's risk was calculated as the expected value of the loss.[4/] Two different loss functions were calculated using (a) the total cost of production, including land, labour and cash, and (b) using cash outlays alone. The second alternative was considered important as the farmer appeared to be more sensitive to a loss of cash than to reduced productivities of land and labour. Indeed the work of Duncan and Swanberg suggest that farmers did not regard land as an input and that many disregard labour also. In their low cash economy, cash was the primary, if not the sole, item in any consideration of inputs.

Calculated risks on total investment more than doubled and risks associated with cash inputs increased 15 times (Table 3). As the farmer needs to borrow money for the recommended production method, this means that he acquires a risk liability to his community of at least $53, a sum that represents 23% of his per ha annual income. This risk may be excessive for the farmer, particularly if weighed against the low returns on cash inputs that he obtains from the recommended system. If the farmer does not change his actual production system, his risk equivalent is only $3.25 (Table 3, last line), which would not be vis-a-vis the community, as he is probably able to raise the $21 cash requirement without borrowing.

The above analysis suggests that resistance to acceptance of the recommended production methods lies in the high initial cash requirement, the low returns to cash invested and the high risks related to the change. The possibility exists that the additional labour required for the change and the necessity to market a larger crop will

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4/ The expected value of the loss was calculated employing a loss function that took values between zero and the cost considered (total or cash). No negative loss values (gains) were considered so that the risks are related to the probability mass associated with losses larger than zero and the size of these losses (Appendix 1).

also constitute limiting factors. These matters are currently under study (See K. G. Swanberg's presentation).

Acceptable recommendations must apparently satisfy a set of requirements that are defined by the producers' community. The lack of knowledge of researchers and planners of action programs about these conditions and their relation to the rural community, has probably been the overriding reason for the failure of new production technologies in the small farmers' community.

A telling indication of how little thought these matters have been given lies in the fact that no clear understanding exists of which conditions a production recommendation must satisfy to really constitute a better alternative for the producer. Most researchers will employ production figures or net gains as their criteria for comparison.

Through continued research closely associated with rural development action programs, the project staff hopes to narrow down more and more specific criteria for the admissability of alternative production strategies. In addition, a clearer understanding is sought of optimization criteria that include limits on returns to inputs (or their availability) and on risk, as dictated by the criteria for admissability.

At this time, the project staff is considering the following tentative conditions for admissability of alternative production strategies:[5]

1) A necessary condition is that average returns to total inputs are higher for the alternative than for the actual method;

5/ These conditions employ average returns, as marginal returns require a knowledge of the production function and an analytical capacity rarely available in field situations.

2) A necessary condition is that the risks associated with the alternative methods not be substantially higher than those associated with the actual methods;

3) A necessary condition is that returns on limited input factors (cash, land and maybe labour in the Cáqueza case) be increased by the alternative production strategy; and

4) A sufficient condition for production alternative acceptable in economic terms, appears to be that the average returns to each production factor are higher than for the actual production method, and that risks are lower.

As stated, these conditions are far from complete, e.g., the project is still attempting to define what the tolerance relation is between increased risks and increased net returns. There also exist non-economic constraints on adoption that should be considered. Moreover, this document confines the discussion to the introduction of an alternative production method for the same crop. The conclusions of this study need to be made applicable to the introduction of alternative crops and, more generally, alternative economic activities.

IV FORMULATION OF THE PROJECTS CORN PRODUCTION PLAN

To reduce farmers' resistance to adoption of the recommended production practices, one could consider reducing cash inputs for fertilizer. This would result in lower cash requirements and lower risks. However, the project does not consider this an acceptable alternative because benefits of the recommendation are closely linked to fertilizer inputs. The formulation of recommendations for different levels of richness would, therefore, lead to low incomes for poor farmers and higher incomes for richer farmers, which hardly leads to improvements in income distribution.

For this reason, the project team designed an experimental credit/risk-sharing scheme that sought to reduce the farmers' cash requirements for production to near his actual cash input level. This scheme was structured so that the participating farmers shared the risks associated with the adoption of the recommended investments in fertilizers and insecticides (Zandstra and Villamizar, 1974).

The plan operates as follows: Interested farmers specify the area to be seeded and provide information on the soil type, topography and history of the field. They pay an entrance fee of $10 /ha (Table 4). The project staff visits the farm and in consultation with the farmer formulates recommendations with respect to variety to be seeded and fertilizers and insecticides to be applied. The farmer is given a note authorizing the project cooperative to supply him with the seed, fertilizer and insecticide required at seeding time and at the time of top dressing. The farmer signs a contract, which specifies that he will share in equal parts with the plan all production exceeding 800 Kg. grain/ha and that he will be liable to a fine of $10 /ha in addition to the costs of inputs he received from the plan, if he breaks the contract.

Comparison of the production plan with the actual and recommended practices (Table 5) shows that the plan increases cash outlay by $10 because of the entry fee, but the cash costs for the farmer participating in the plan are far less than those of the farmer using the recommended package. As far as risks are concerned, the plan shows low probabilities for low yields, a risk related to total investment similar to that of farmers' actual practice, and a risk related to cash investment that is substantially below that which the farmer accepts for his actual corn production method (Table 5, last 3 lines).

The production plan was designed to reduce cash requirements and risks and to avoid that returns to cash were below those obtained by the actual system. In this case, returns to cash were increased from $3.75 to $6.03 per dollar invested. These high returns may be required to make sure that the plan can compete against high value product crops such as tomatoes and onions.

Under the plan, the farmer's per ha net gain is reduced from $205 to $168 because the plan generates a net return to itself of $48 [b/]. This income is required to insure continuation of the plan, to cover its operating costs (transport, handling, losses, over-application of fertilizer, etc.) and to serve as a buffer against unexpectedly low yields. It is expected that the costs of supervising the harvest will be high and ways to reduce this will be a key item in refining the plan.

In 1974, 27 farmers participated in the plan. To date, farmers seem to be pleased with the way it operates: one farmer was heard to say to a participant in the plan "You have won the lottery in corn this year". Although yields appeared to be

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b/ Total net gain from the plan ($168 + 48 = $216) exceeds net gain from the projects recommendation ($205) by the difference between the cost of credit ($21) and the entry fee ($10) at or above the expected average, the corn had not been harvested at the time of writing (October). Furthermore, the plan is expected to present problems in terms of transport of produce, the farmers' and the extensionists' accuracy in estimating the yield and their preparedness to agree to an estimated yield figure, etc. In this sense, we regard the plan as a link designed to explore a new approach to credit, in the complex chain of activities that constitute rural development.

V CONSIDERATIONS FOR AGRICULTURAL PRODUCTION RESEARCH

The experiences discussed are in reality no more than a documented example of what often occurs when national and international research programs endeavor to introduce new production technologies on small farms. A prime reason for this may be the isolation of these "centres of excellence" from the reality of the small farmers' society to which they are supposed to direct at least part of their activities, since in general there appears to be a deep void between those responsible for biological research and those responsible for delivery systems to small farmers. Because of this a dismal picture of non-participation and non-identification is often seen all the way up the ladder. Although rural development personnel make valient attempts to sell new technology, this study indicates that it is not always saleable and probably will not be until methods have been developed to insure a realistic participation of the farmers' community in the problem definition and research of the projects (See also Ronald Duncan's presentation).

The small farmers are even less understood by central experimental station research personnel, to the extent that the majority of these researchers are hard pressed to understand and assign importance to what rural development staff tell them about the small farmer with respect to the design of new production technology. Except for a few personnel specialized in small farmers' agriculture and in agricultural development, sociology or economics, staff at most major centres for agricultural research in developing countries continue to think in biological terms only about what is in reality a problem that heavily overflows into economic, social and culturally oriented areas of knowledge.

This study clearly indicates that the proposition: "A good variety sells itself" may only be valid under a specific set of circumstances, of which the probability of occurrence in a small farmers' community is extremely small. For this reason, production research designed to benefit small farmers should incorporate into its planning and design stages the socio-economic and cultural specifications of the recipients of their results. To do this, researchers need to acquire a better understanding of the relation between the socio-economic and cultural characteristics of the farmers' community and the optimization criteria to apply in the formulation of recommended production practices. The most effective method to arrive at this is to structure realistic participation in the decision-making processes, of the farmer at the change agent level, of the change agent at the research station level and of the national research organization at the level of the "centres of excellence".

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CALCULATION OF EXPECTED LOSS

Let f_y be the probability density function of corn yields and assume:

$$f_y \sim N(\mu, \sigma^2)$$

Let f_L be a corn function in terms of costs, yields and prices so that

$$f_L = \bar{L} \text{ for yields} < x \qquad f_L = 0 \text{ for yield} \geq x$$

where x is the break even point.

Then the expected value of the loss will be:

$$E(L) = \int_{-\infty}^{\infty} f_L \cdot f_y \, dy$$

In this sense, the loss function specified is not an actuarial loss function, as it does not take on negative values (See Halter and Dean, 1971).

As in this document the loss function for the two production systems can be specified as:

$$L = C - yp \quad \text{for } y < C/p$$
$$L = 0 \quad \text{for } y \geq C/p$$

where y = yield; p = price of corn and C is costs (total or cash).

Then the expected value of the loss is

$$E(L) = E(C-yp) \quad \text{for } y < C/p$$

$$E(L) = -p \cdot E(y) + C \text{ for } y < C/p \quad 1/$$

$$E(L) = -p \cdot E(y \mid y < C/p) + C$$

So that the expected loss can be calculated from the cost of production, the price of corn and the expected value of the truncated (normal) distribution of the corn yields.

1/ As the price of corn and costs of production are independent of yield for each of the production systems compared.

Table 1: The actual corn production method in Cáqueza*

Costs /ha	1972	1974
Cash: 1) Land preparation	$ 13	$ 16
2) Seed and others	$ 5	$ 5
Land (Cost of rental)	$ 30	$ 36
Labour (26 days)	$ 23	$ 28
Total	$ 71	$ 85
Yield, kg/ha	907 (S.d. = 660)	907 (S.d. = 660)
Returns /ha		
Value Product	$ 91	$144
Net gain	$ 20	$ 59

* $ = Cdn$

Table 2: The recommended production method in Cáqueza*

Costs /ha	1972	1974
Cash: 1) Land preparation	$ 13	$ 16
2) Fertilizer and seed	$ 49	$ 97
3) Insecticides	$ 6	$ 9
4) Interests (24%/yr.)	$ 6	$ 21
Land	$ 30	$ 36
Labour	$ 41	$ 50
Total	$145	$229
Yield, kg/ha	2740 (S.d. = 1170)	2740 (S.d. = 1170)
Returns /ha		
Value product	$274	$434
Net gain	$129	$205

* $ = Cdn$

Table 3: Comparison of actual and recommended corn production methods in the Cáqueza Region, assuming the 1974 corn price of 16 ct/kg.

Cdn$ /ha	Actual	Recommended	% change
Yields /ha	907 Kg.	2.740 Kg.	202
Total costs	$ 85	$ 229	170
Net gain	$ 58	$ 205	253
Cash costs	$ 21	$ 142	575
Return to land /$	$2.61	$6.69	155
Return to labour /$	$3.07	$5.10	73
Return to Cash /$	$3.75	$2.44	58
P [gain < 0]	0.28	0.13	- 53
P [gain < cash costs]	0.12	0.06	- 50
Risk on total input *	$ 37	$ 78	111
Risk on cash input *	$3.25	$ 53	1,530

* See Appendix 1 for the method of calculation used.

Table 4 Description of the Corn Production Plan Developed in the Cáqueza Project (1974 Prices)

	Cdn$ /ha
Entry Fee	$ 10
Farmers Investment	$102 (Land + Labour)
Plan Investment	$106 (Inputs)
Minimum Yield for Farmers	800 Kg./Ha
Expected Farmers Yield	1770 Kg./Ha (800 + 970)))-2740 (Table 2)
Expected Yield for Plan	970 Kg./Ha)
Net-Return to Farmer	$168 (Cash Equivalent)
Net-Return to Plan	$ 48 (Cash Equivalent)

Toble 5 Cash requirements, returns to inputs ond risks to the former of the Corn production plan, ond the octual ond recommended production methods.

	Actual	Plon	Recommended
Farmers Cash Required /ha**	$ 21.00	$ 31.00	$ 142.00
Net Gain /ho	$ 58.00	$156.00	$ 205.00
Return to Totol Input/$	$ 1.68	$ 3.42	$ 1.90
Return to Labour /$	$ 3.07	$ 4.12	$ 5.10
Return to Land /$	$ 2.61	$ 5.33	$ 6.69
Return to Cash /$	$ 3.75	$ 6.03	$ 2.44
P (Yield 800)	0.44	0.05	0.05
Risk on totol input /ha *	$ 37.00	$ 39.00	$ 78.00
Risk on cash input /ha *	$ 3.25	$ 0.50	$ 53.00

* For calculation method of expected losses see Appendix 1.

** $ -- Cdn$

DRAFT
FOR REVIEW ONLY

SMALL FARMER COMMUNICATION[1/]

by:

Ronald J. Duncan[2/]

1/ Paper prepared for the Agriculture, Food and Nutrition Science Field Staff Symposium of the International Research Centre (IDRC). Nov. 18-21, 1974. The author is indebted to Barry Nestel, Hubert G. Zandstra, Kenneth G. Swanberg, Carlos Zulberti, and Gloria S. Duncan, for discussions, criticisms, and the effort to understand anthropological input.

2/ Anthropologist, ICA - CUSO - IDRC, Rural Development Project.

INTRODUCTION

The anthropological contribution to the rural development team has been to attempt to conceptually match programming and communication "materials" with the cognitive organization of the small farmer.

The communication system that is being developed and tested in Caqueza is designed with particular attention to the special problems of marginal groups of small farmers, who are customarily not exposed to much outside information.1/ They have high rates of verbal illiteracy 2/, and their visual literacy is markedly different from that of urban people accustomed to mass media 3/.

I. MUTUAL-AWARENESS COMMUNICATION

Agricultural development plans such as Puebla have traditionally emphasized experimental farm, "ideal" solutions for the small farmer. But, the years have shown in both Puebla and other similar cases, that scientifically "sound" information can be nullified by non-acceptance because it is not "sound" in terms of local social knowledge.

1/ "Communication" is a "communal" activity, although many people unconsciously conceptualize it as a unilateral transfer of information from those who have it to those who do not.

2/ 45% of the men and 52% of the women are officially listed as illiterate. The unmeasured functional illiteracy rates would be much greater.

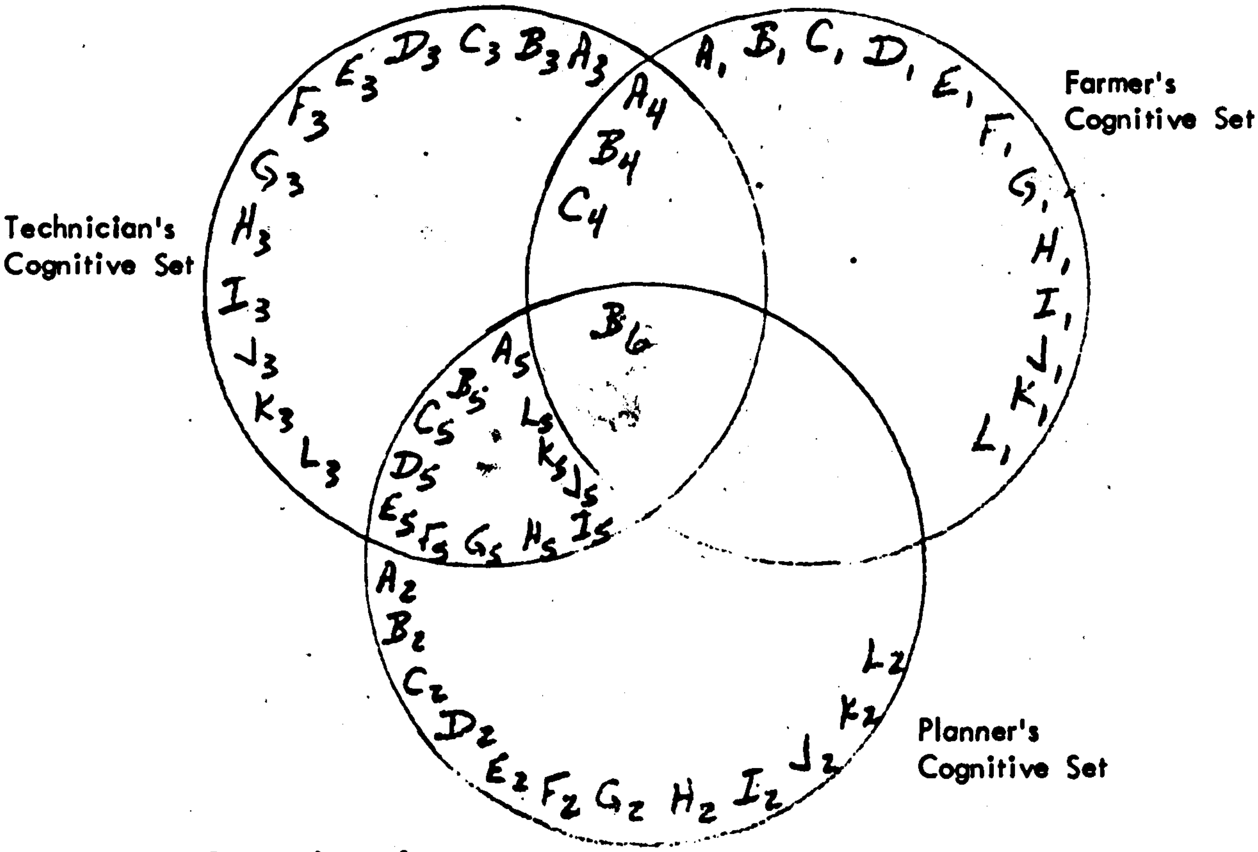
3/ Research in progress.

With small farmers it is necessary to use social and cultural information as well as agronomic and economic information because adoption and use by farmers are essential to ultimately validate the significance of scientific innovations in plant or soil information. In addition to the new production and economic alternatives, rural development must include new cognitive alternatives for the farmer (See Zulberti's paper).

Mutual-Awareness communication is a system to insure that the social knowledge of farmers and the scientific knowledge of planners can be synthesized. This system involves 3 separate but related steps. Step one consists of mutually exclusive definitions of the state of well-being, priorities for change, and mechanisms for that change. Step two is reverting that information to the farmers as a check and a further refinement of the definitions. Step three is program planning bases on a synthesis of social acceptability and scientific validity of recommendations. (See Figures No. 1 and No. 2)

The experience with corn in Caqueza as described by Zandstra is an example of the way in which a communication system designed to create mutual awareness can operated. The design and definition of this communication system has been made in response to the vary specific needs of an operating rural development project. The concept of mutual awareness communication has been built on several years of experience in Caqueza.

Figure No. 1 - Non-Coincidence of Cognitive Sets

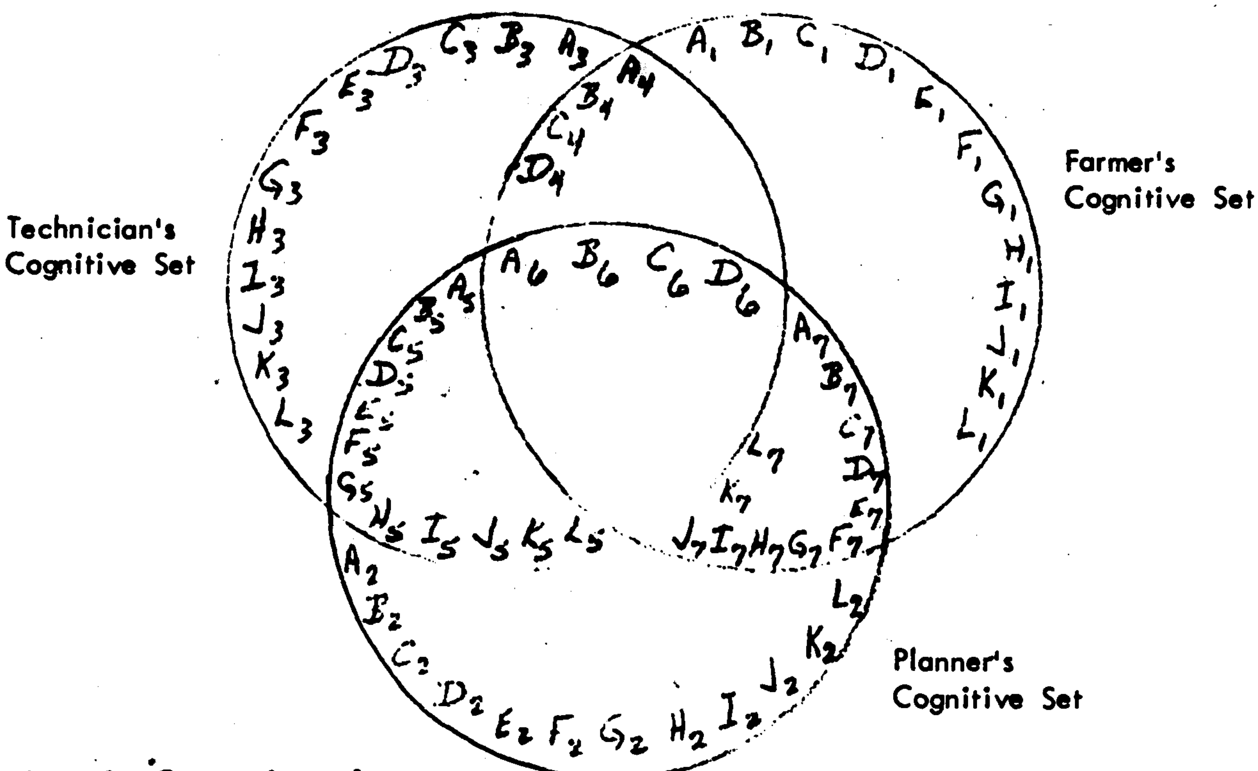


Code for Conceptions of

A = Crops
B = Land
C = Expenditures
D = Natural Processes (rain, sun, wind, etc.)
E = Supernatural Forces
F = Wife and Children
G = Extended Family
H = Compadres
I = Neighbors
J = Political Alignments
K = Government Representatives
L = Scientific Knowledge

Each has his own conceptions of the variables listed. There is considerable coincidence between Planner and Technicians, little between technician and farmer, and none between Planner and farmer, and hence none between the 3.

Figure No. 2 Incorporation of Farmer's Social Knowledge in the Planning Process



Code for Conceptions of:

A = Crops
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Through research and proper modes of communication specific variables of farmer's social knowledge can be incorporated by the Planners and Technicians.

II. THE INITIAL PROGRAMMING PROCESS

In this section the initial programming method employed in Caqueza will be described, to serve as a point of reference for the improved methodologies described in the next section.

A. The Determination of Agronomic and Economic Needs for Production

As Zandstra's paper shows, the traditional production system shows low production costs, low yields, low risk, and low profits. His paper gives a detailed presentation of this information.

Again as Zandstra indicates, over a period of three years various trials were replicated in experimental plots on commercial farms to establish a set of recommendations which would maximize production possibilities on the mini-farm.

B. Communication of Recommendations to Farmers

The project began to introduce its recommendations in its extension activities in 1972. Traditional extension approaches were utilized. In numerous small group meetings the ICA technicians verbally presented the information to the farmers who attended. In general these meetings were structured and controlled by the ICA representative. The farmer was allowed limited opportunity for talking. Critical farmer response was not encouraged.

Three other approaches were also used. One, field day demonstrations on experimental plots were used, where possible, so that farmers could visit and see the results of the project recommendations. Two, the recommendations were communicated to a limited number of farmers by personal contact. Three, a newsletter was printed for the Project and carried some of the recommendation information.

Although some farmer responses were collected as a part of this process, it was informal and non-systematic, and there was no systematic analysis or incorporation of that feedback information into analysis or programming activities.

C. Adoption of Recommendations

The farmers response was mixed. Zandstra notes that only 22% of the recommended fertilizer was applied, even though fertilization was a welcamed part of the experimental trials on farmer's fields. However, 86% of the farmers did change planting distances, a measure that had been unpopular during the experimental phase. They adopted the recommendations that did not entail investment and rejected the others. Adoption rates were comparable to those in the Puebla Project, as described by Zulberti.

D. Evaluation of Adoption Rates

The reaction of the people of the Project to the lack of adoption was two - pronged. On one hand, the fertilizer recommendations were revised. On the other, the extension methods utilized were re-examined in the light of the anthropological information that was being developed.

III. REVISED PROGRAMMING PROCESS

An understanding by project personnel of the farmer's definition of his well-being is a prime requirement for program action planning, as was discussed by Carlos Zulberti.

A. Mutual Definition of the State of Well-Being

Traditional agricultural and sociological-anthropological research methodologies were utilized to describe the actual state of well-being. The agronomic and economic research, as described by Zandstra and Swanberg, began to identify basic production information. Interviews and participant observation by the sociologist and anthropologist established some farmer definitions of well-being needs. ICA technicians, who are in continual contact with farmers, also received such information. After initial guidelines were established about the farmer's conceptualization of their own state of well-being the information gathered was used to structure a series of formal, controlled interviews to further specify our information. Among farmers, social knowledge about corn is male knowledge. Women do not directly make dicisions about crops. Research has shown that men are more conservative about risk and change behaviours. (Drufoca "The Economic Role of the Woman". Study in process). Men are more willing to accept the sure minimum, than try for the possible maximum. They said "We plant corn and leave it, and we know that at harvest the attics of our houses will be full, and we will have enough food for the year. It does not need fertilizer or attention. Sometimes weavels are bad". That translates into the following variables about corn cultivation: (See Figure No. 3).

V 1) Corn is the Food Supply. Farmers object to selling corn because they think that they might run short and have to buy corn later, It is best to store it.

V 2) Corn is cheap. Since it is for consumption and not for sale, insecticides and fertilizers are not used because that would increase the price of the family's food.

V 3) Corn is easy. No special cultivating has to be done. Other cash crops may fill labor demands to the maximum in peak work periods, which could leave little labor capacity to expand cultivation of corn.

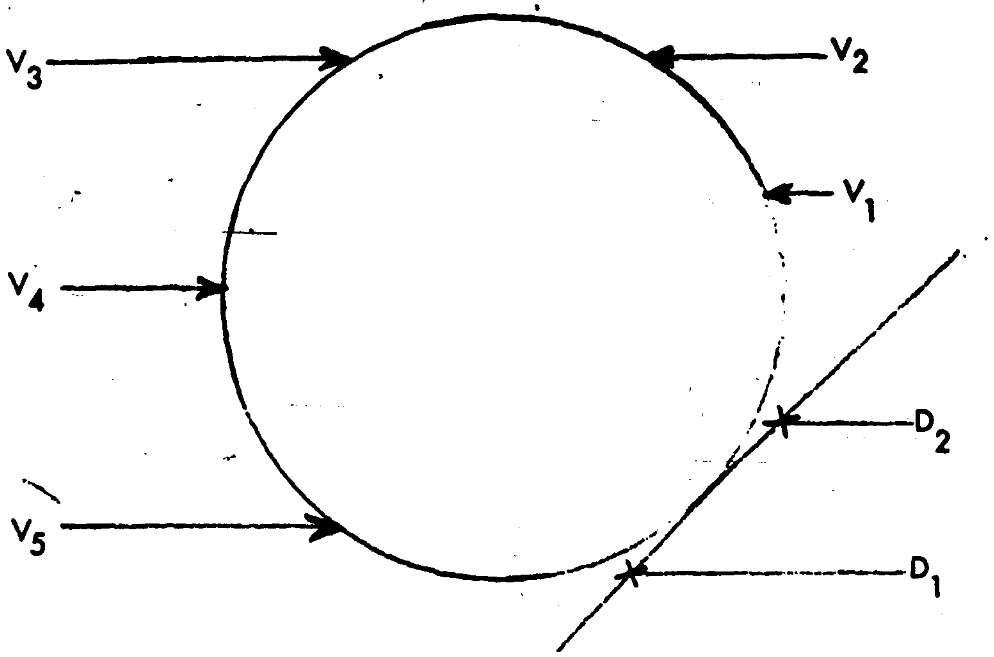
V 4) Corn is sure. Traditional cultivation is dependable and known. There is minimum risk, also minimum expectation.

V 5) Corn has low productivity. Not using fertilizers or insecticides means low productivity. That level of productivity is known and acceptable. Experimenting with production might lead to crop failure. A sure, minimum production is more acceptable than possible failure and no food.

This social knowledge was then combined with the previously collected agronomic and economic information.

Figure No. 3 **Limits on Action Possibilities**

Example: Corn Recommendations



Past Experience And Accumulated Social Knowledge

V_1 = Corn is Food supply

V_2 = Corn is cheap

V_3 = Corn is easy

V_4 = Corn is sure

V_5 = Corn has low productivity

D_1 = Decision on cropping pattern

D_2 = Successive decision on cropping pattern

D_1 and D_2 are approximately the same, with only slight variation between the two.

B. Pre-Test of Scientific and Social Knowledge

1) Feedback Form

In this stage the farmer's conceptualization of his well-being is put into a communicable form and his own information is presented back to him. The purpose is to feed the information back in a social context which will stimulate "social analysis and interpretation" in the farmer group. Since the Caqueza region is fragmented into small social groups in dispersed farming settlements, this method seeks to bridge that fragmention and show that there are common well being problems from one group to another. The realization of common problems can facilitate identification and acceptance of common solutions.

Information was fed back to the farmers in three ways. One, visual communication materials were produced, such as the film, "Paredes de Piedra". Two, anthropological studies were designed to test parts of the original analysis of farmer's social knowledge: including a evaluation of the information in the film and analysis of the farmer's concept of well-being. The results of these studies are currently being analyzed.

Three, ICA technicians used their daily contacts to test farmer's verbal reactions to the revised recommendations.

2) Content

In any communication exchange, overt and covert messages are passed back and forth. In the pre-test, the overt message contained the substance of the scientific and social knowledge. The farmer's social knowledge about corn production was included in the first film that we produced in the area. In the segment that talks about corn production we see how that was done. The farmer's definition of their own well-being is usually in negative terms; they talk about limitations and things they do not have. The overt scientific knowledge that was socially tested was the recommendations.

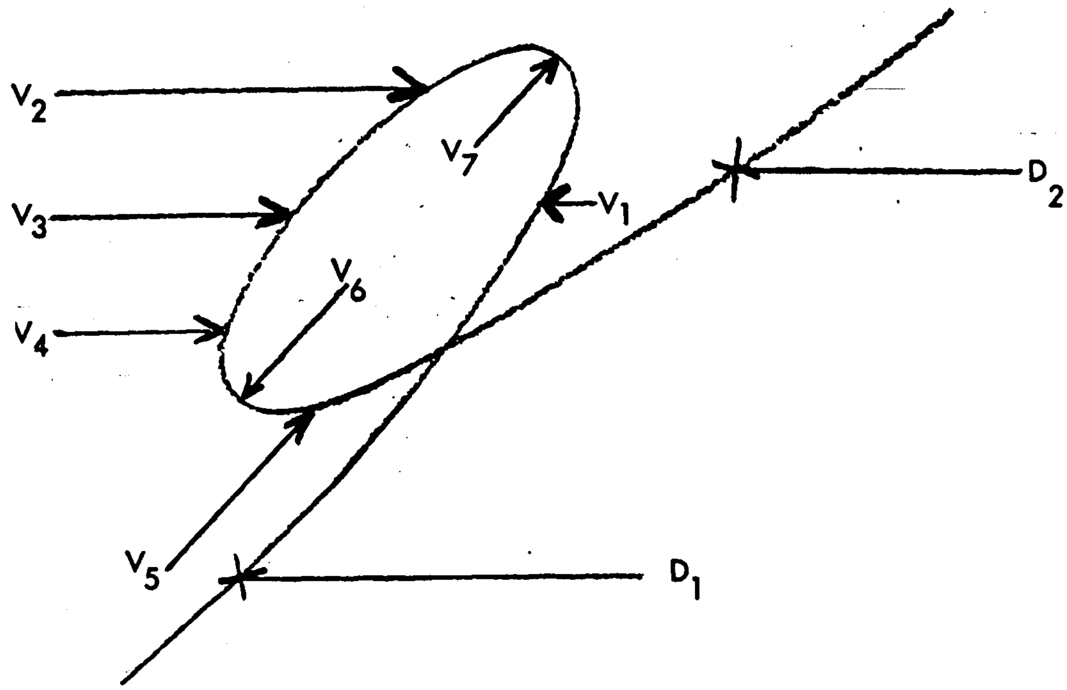
This pre-testing of information carries covert messages, which are very important in terms of the goals of rural development. These covert messages are basically intended to facilitate cognitive re-organization necessary to change from a sub-ordinate position to a position of participation in development. One covert message is their own image of themselves as important members of the national economic. For example, they responded to the film with these words, "The farm is pretty in the film, and when we were working we were not as dirty and awful as I though we were". This way they are proud of being farmers. They were also excited that their friends, neighbors, and region could be seen in a movie. Being able to participate in mass media, suggested to them that they were important enough to be shown. The result was that the image of the farmer in the film is closer to an acceptable image of themselves; this counteracts the usual mass media image of the farmer as a country bumpkin. If farmers involve themselves personally in the rural development effort, they first have to be proud of being farmers. If they are ashamed of being farmers (as is traditional in Colombia), it is difficult for them to want to be better farmers.

The second covert message in this pre-testing process is the importance of manipulating and criticizing information input. In the traditional extension system of ICA the farmers receive the minimum technical information needed and have little systematic opportunity for critical evaluation. Pre-testing supplies the farmer with more information than he previously had. He is encouraged to critically evaluate the information and to specify the variables involved in his own problem definition, (See Figure No. 4).

3) Forums

The forums in which information can be pre-tested with small farmers are numerous. In Caqueza pre-testing has been primarily done in anthropological research situations. My research initially defined problems, according to local social knowledge. In a number of student research projects my information has been re-tested.

Figure No. 4 Effect of Covert Messages on Action Possibilities



Past Experience and Accumulated Social Knowledge

V_5 = Farmers are important

V_6 = Manipulating information

Variables 5 and 6 can affect the decision process but are not sufficient to affect major changes.

The process of pre-testing should be carried out in a wide variety of forums to insure efficiency of the feed-back process that we seek to stimulate. In the rural development projects, pre-testing should take place in the following settings:

Rural, Small Group Meetings

The ICA extension program is based on the principle of a small group of farmers meeting in their own settlement. Utilizing that situation, ICA technicians should be trained to maximize the participation and feedback possibilities from the farmers. In these same meetings visual communication materials can be introduced and used. This process has already begun in Coqueza.

Visual Programs in Town

On the weekly market day and on holidays farmers gather in town. These days have been utilized to program film screenings and other kinds of public presentation. In this way film or slides about rural development can be shown to as many as 500 people in one day in contrast to the normal small groups of 20.

4) Significance of the Pre-Testing of Information

The overt messages can be re-analyzed to correct them or further elaborate them before they are formally included in the programming decisions. The covert messoges basically tell the farmer that rural development is worth the effort. After decades of mistrust of government programs and mistrust of people who come from the city, special effort has to be made to get beyond the mistrust to see that positive changes may be possible. And, significant for ICA, is the fact that farmers social knowledge is becoming a part of the body of information with which ICA works in its own planning, research, and evaluation (See Figure No. 2).

C. Programming

With this approach to rural development, planning is done by a professional who uses social and technical knowledge to plan the project's recommendations. In this way there is a greater possibility that the scientific knowledge developed in myriad experiments can be incorporated and utilized in the everyday farming situation by the farmer. Zandstra will define some of the agronomic and economic data that has been used in programming in relation to corn production. The social knowledge that is incorporated in programming included the lacal conception of corn production, cost of farm supplies, aridity, low profit margins, plan disease, yauth and inexperience of rural development personnel, etc.

In some cases problems so identified have no inmediate solution and simply have to be occepted by the development professional as limits on the development process. If it is a treatable problem, it has to be broken down into its component variables, so that the particular problem variable or variables can be specified.

For example, Caqueza farmers are little interested in applying fertilizer to their corn crops because of the high cost of fertilizer, the fear of risking their own year's food supply if something goes wrong, and the anticipation of low prices and low profits. So, their, reaction has been to reject fertilizer for corn. They said that the only solution was that the supply companies not continue to raise the prices and establish some kind of control on the intermediary system, so that farmers and not intermediaries would get more profits.

However, given their low-information position, they did not have control of needed information to generate specific programs to solve their economic squeeze that prevented them from adopting corn recommendations. They could identify the problem, but they could not solve it.

When the farmers rejected fertilizer applications to corn, a simple componential analysis was used to determined which variable or variables presented the real problems to the farmer. Was it that he did not have cash at the time that he needed fertilizer? If so, credit might solve the problem. Was it that the anticipated profit margin was interpreted as being too narrow to support sustantial investment in fertilizer? If so, low cost innovations could be suggested until the profit could be widened to an acceptable margin. In this manner the component variables of the fertilizer rejection were isolated one by one and their solutions identified. One by one the variables were pre-tested against local social knowledge to determine which would be effective solutions. In this way the program of intervention was planned.

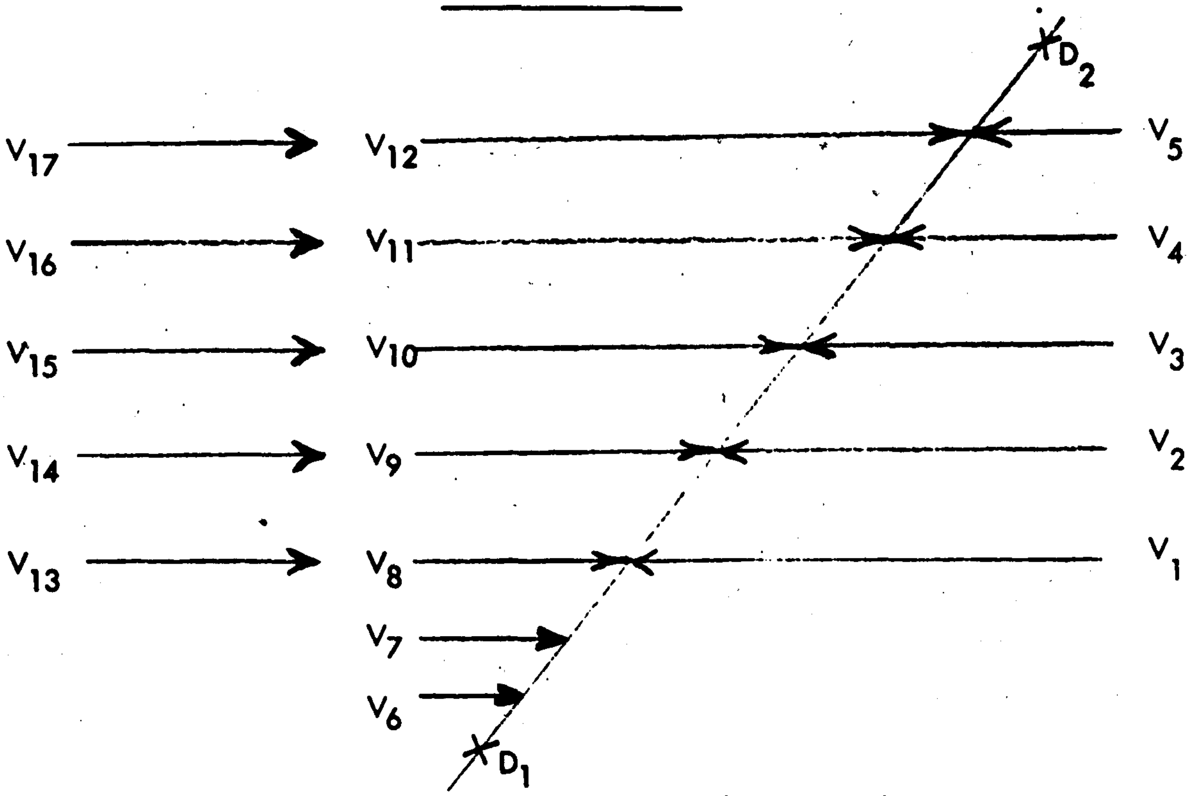
The solution that was developed utilized the local version of "share-cropping", called Compañía, between the local agricultural cooperative and the individual farmer. The farmer gets fertilizer on credit from the Coop. and signs an agreement to market through the Coop. Thus, the Coop. can control fertilizer cost and market price to insure the farmer the widest possible margin of profit. In this way the farmer was freed of some of the limitations on his decision process. Thus, it increased his possibility of being able to adopt recommendations for corn production. (See Figure No. 5).

D. Communication of Technical Information

1) Traditional Rural Development Communication

The traditional orientation in rural development projects has been to develop desired production conditions and to communicate them to the farmer, with the assumption that he will accept the innovation. This assumption is based on the idea that the farmer has the same cognitive set as the research oriented scientist, and that he will realize the advantage of the innovation. All too often the farmer has not accepted the recommendations, or he was interested in accepting only part of the innovative package.

Figure No. 5 New Action Possibilities with Socially-Relevant Technical Recommendations



Past Experience and Accumulated Social Knowledge

Variables:

V_1 = Corn is food supply
V_2 = Corn is cheap
V_3 = Corn is easy
V_4 = Corn is sure
V_5 = Corn has low productivity
V_6 = Farmers are important
V_7 = Information Manipulation
V_8 = Corn is cash crop
V_9 = Corn can be profitable
V_{10} = Corn can be worth labor investment
V_{11} = New Recommendations are reasonably sure
V_{12} = Corn can have ligh productivity
V_{13} = The Cooperative will market it
V_{14} = The Cooperative will give credit on fertilizer
V_{15} = Other can manage increased labor demands
V_{16} = Experiments have been successful

Decisions:

D_1 = Traditional Decision on Cropping patterns

D_2 = New Decision on Cropping patterns

V_{17} = High Production on experimental plots.

Why? Because his cognitive set is different from that of the research scientist. His educational experience, his farming experience, and his vision of the world are radically different. What is "logical" in scientific terms is not necessarily "logical" in terms of the low-information, subsistence farmer on a mini-farm.

For these reasons pre-testing is essential to transform the technical, scientific information from rural development professionals into terms that are acceptable and useable by the small farmer. Pre-testing insures that program plans are not only valid in terms of scientific knowledge but are also valid in terms of the social knowledge of the receiving group.

2) Content

In contrast to the relatively open, problem defining process in the pre-testing stage, technical communication has a direct message about the content and significance of technical recommendations, similar to traditional extension techniques. However, the style of presentation of this specific information must permit farmer reaction and interchange. The overt message may be direct and specific, but the farmer needs the opportunity to respond.

3) Form

Direct personal contact and visual communication are the necessary forms of communication with the Caqueza population with its high illiteracy rates. For this reason, ICA has developed its communication around intensive use of technicians in the rural communities, and we have been actively involved in the development of a complementary visual communication system, which now consists of 3 films that can be used in pre-testing and 3 films of technical information.

4) Forum

The forum of interaction is basically the same as in pre-testing: small rural group meetings, transitory market day gatherings, and holiday celebrations. One additional forum is utilized for unilateral technical communication, the ICA special meetings. On special field days farmers are invited to visit an experimental plat located on a farm in their zone. On other occasions trips are made ta an experimental farm or even to a rural development project in a different agricultural zone. In these meetings the technical information and recommendations are presented to the farmer with concrete evidence in front af him in the form af the experimental plot.

5) Significance af Technical Communication

The absolute level of information is increased for the farmer. In the comparisons of one zone with another, he can understand more precisely the specific influence of certain variables. His information cantent and analytical capacity increase. So, beyond the improvement in production and marketing possibilities, his cognitive skills and possibilities are improved.

IV. INTERNAL COMMUNITY COMMUNICATION

The existing communicational infra-structure of the community is the most potent means of communication within the local community. The employment of existing communication by the project could substantially increase the efficiency of the pre-testing and programming stages described. So, it cannot be ignored. But, such channels of communications are so diffuse, and omnipresent in the small farmer community that it is impossible to directly utilize them in a formal communication system. For this reason this is not a major intervening activity on the part of the rural development project. However, it is possible to plug into the existing system at certain points.

A. Project Support for Community Communication

The community communicational infrastructure can be supported by encouraging contact between the normally isolated rural communities. ICA technicians each have the responsibility of visiting various such communities. In so doing they carry information from one community to the other. Their presence gives the local people a new channel to send and receive messages.

B. Farmer Produced Communication Materials

ICA has been active in organized public programs on certain holidays in which farmers have the opportunity to present couplets, songs, skits, or dances, usually of their own invention. The project Newletter has also been used to communicate some of these materials.

In other social change programs video and film materials have been produced by the local community as a channel of internal communication. Small farmers of Colombia do not normally have much mass media exposure. In addition to their lack of familiarity with visual communication media, many technical problems exist for the realization of such communication plans in Caqueza. Nevertheless, we are encouraging experimentation with such materials as a means of expanding rural development communication beyond one region.

C. Farmer Control of Their Meetings

Community control of small farmer meetings has been used as a means to re-inforce internal communication. Someone from the local community directs the meetings. As community people control the meetings, they control the subject matter to be discussed, and they interchange more ideas and criticism. The draw back of community control of meetings has been that if one political faction gains control of the chairmanship of meetings, then no one comes from opposing factions.

The traditional extension approach is that the extension agents talk and direct the meeting, resulting in minimal interaction on the part of the farmers. That lack of interaction seems to have led to a passive resistance to the information communicated.

D. Significance of Support for Internal Communication

1) Increased Horizontal Communication

Basically, this means that the increase in the level of information gives the people more to talk about. Providing rural development information input to the local community increases the potential audience. Some of the information is included in normal conversation and gossiping networks. So, utilizing local communication channels means that more people will receive the information. Those who are ICA related farmers will tell some of the non-ICA related farmers some information.

2) Screening Outside Information

Plugging into the internal communication processes also means that information from outside sources will be screened according to the needs and capacity and tolerance thresholds of the small farmers. Problems of culturally irrelevant information, culturally uninterpretable information, information overload, or offensive information can be screened out and eliminated. Thus, information is presented within communicational thresholds of the small farmers.

3) Community Specific Treatment of Information

Local people can generate kinds of information or interpretations not recognized as important by outside professionals or technicians. Rural development data can become mixed with gossip, community information, or covert parallel communications and will more readily become a part of the existing informational structure.

V. CONCLUSIONS

A. Shape of Information

With the various checks on the communication system by both professionals and farmers it is possible to transform the information into the necessary acceptable form. The silent withdrawal and non-understanding of scientific information on the part of the farmers is no longer the only means to react to unacceptable information. In this system technical information can be more readily utilized. In the traditional vertical communication system the dominant professionals unilaterally communicate to subordinant farmers. In part the farmer rejection of that dominant social relationship also led to their rejection of the information.

It is not easy for farmers to accept that a young, inexperienced rural development technician from the city tells them that he knows something about farming that they do not know. But, if the technician comes to hear their definition of their own problems, and then later returns with a proposal to solve those problems, they may be more amenable to listening to his information.

B. Mutuality

The concept of rural development as one of a communication process designed to increase mutual awareness, makes program planning depended on the farmers input.

In this way program planning is closely tied to the farmer's perception of his problems, so that the development recommendations are more understandable to the farmer, and he can more readily accept them and use them. In traditional agricultural extension approaches the farmer was given technical information that did not directly relate to his production situation. He was expected to do the necessary work to transform that information into forms that he could use.

We are suggesting that the planner, using social and anthropological information, should assume a larger part of the responsibility for transforming information into forms and terms more readily useable by the farmer (See Cover).

C. Definition of Development

Rural development is an effort to expand the effective knowledge base of the farmer, change his cognitive set, and realize a chance in factors limiting the farmer's production and marketing possibilities.

Small farmer agricultural development depends on expansion of the farmer's information base and cognitive set so that he can efficiently utilize the possibilities open to him.

D. Evaluation

As development recommendations are communicated to the farmer in the rural, small group meeting, or in the field demonstration day, etc., the sought effect is that the farmer's information is expanded from point A to point B and that the cognitive possibilities for action are augmented, as described by Zulberti. The success of a rural development project therefore can be measured in 2 ways. One, is the percentage of increase in action possibilities open to the farmer, such as an increase in the availability of "useable" credit and not a total increase in credit. Two, is the alteration of the farmer's cognitive organization to permit him to identify his production and marketing problems with more precision and to identify specific solutions.

This utilizes Leon Festinger's theory of cognitive dissonance, in which each new presentation of information results in an adjustment in the organization of existing information. These gradual adjustment of information organization are constantly in process. Specific actions, as generated by the person, are determined by content and organization of the person's information.

E. The Goal of Development

According to this definition of rural development, the ultimate goal is not defined only in terms of production levels or profit margins. The goal is a state of being in which the farmer is continuously generating effective solutions to the continuously arising problems confronting him (See Zulberti's paper). Development is the capacity of the farmer to solve his problems to the maximum within the limits of the system in which he lives.

DRAFT
FOR REVIEW ONLY

EVALUATION IN RURAL DEVELOPMENT [1]

By

K. G. Swanberg [2]

1/ Paper prepared for the Agriculture, Food and Nutrition Science Field Staff Symposium of the International Development Research Centre (IDRC), Ottawa November 18-21, 1974. The author is indebted to Barry Nestel, Hubert Zandstra, Carlos Zulberti and Ronald Duncan for their helpful criticisms and useful comments.

2/ Agricultural Economist, ICA-IDRC, Rural Development Project.

I. THE OBJECTIVES OF EVALUATION

The major thrust of this paper will be to show how an evaluation program in rural development may be structured to allow for analytical evaluation. Analytical evaluation becomes necessary to explain which factors cause less than full goal achievement in action programs. Only after this knowledge has been acquired do evaluation programs take on real significance and usefulness.

Since my discussion of the role of evaluation will follow a somewhat non-traditional course in this paper, it may be useful initially to consider the most limiting aspect of evaluation, namely, defining its purpose, since the type of evaluation methodology chosen is likely to depend upon the objective of the evaluation. Examples of three different purposes for which the evaluation of the Caqueza project may be used will illustrate this point.

1) The Colombian Government has charged the Colombian Agricultural Institute (ICA) with the responsibility for agricultural extension. Let us suppose that its reason for doing so is to prevent rural unrest by showing that the Government is serving the needs of the peasant farmer. An evaluation system designed to measure the success or failure of this program would attempt to identify an increase or reduction in peasant farmer unrest and displeasure with the existing Government structure. The analysis would involve eliciting farmer attitudinal changes, and observing the degree of change in the number and intensity of farmer opposition activities. Income generation, social well-being, and wealth levels would not be included in any evaluation scheme designed to satisfy this purpose.

2) The Colombian Government is also attempting partially to finance its rural development program with the assistance of a substantial loan from the World Bank Group. The types of analysis being carried out to justify this loan financially are strictly economic in nature. The factors being studied include base-line production information, and the projected costs for the construction of infrastructures (such as roads, markets, rural electricity, processing plants, etc.) and the benefits which they will generate over the next several years. It is this type of financial evaluation which is the most widely used by donor and aid-giving institutions to demonstrate project viability.

3) There is yet another form of evaluation, however, namely, that in which the IDRC is involved in its present relationship with ICA. This is to evaluate whether the rural development project contributes to increased rural well-being, and to determine the extent to which the rural development projects contribute to national well-being. In this case, the criterion for evaluation is "well-being" and not "economic development" per se. This implies that such variables as group participation, regional or national decision-making capacity, health and nutrition, leisure time, etc., must be formulated in quantitative terms. It is also necessary to generate standard types of data on income levels, farm size, population, etc. Initial values of these variables may thus be combined to form a general quantitative "well-being" index.

Although this is the type of evaluation information which is required in order to ascertain whether or not the goal of increased well-being has been achieved, it is not certain that an aggregated quantitative index will be easily obtained nor that it will be viable as an evaluation tool once the data are processed. It may be that each variable will have to be considered separately, and some form of arbitrary weighting will have to be designed to counterbalance the increase in one variable with the decrease in another. This approach is in contrast to the traditional technique of using "net family" or "per capita income" as proxy variables for all of the other well-being variables.

These examples illustrate three distinctly different evaluation objectives which are currently being applied in the Caqueza rural development project, each of which requires a quite different evaluation methodology. The first measures farmers' values, attitudes and political awareness, the second is almost exclusively financial, and the third involves developing measurement techniques for well-being variables which often have attributes of a social rather than an economic nature.

II. TRADITIONAL EVALUATION TECHNIQUES

Donor agencies traditionally employ standard financial analyses to evaluate the viability and success of the development programs in which they invest. Several alternative techniques are available, which have been adequately discussed in the evaluation literature, especially those documents emanating from the World Bank Group.

The more simplistic financial evaluation techniques are the payback period and the simple rate of return. However, there are serious drawbacks to these two techniques, mainly because the time value of money is not taken into consideration. The techniques which do employ this concept are the ratio of present value benefits to costs, the present value of benefits less costs, and the calculation of the internal rate of return.

In spite of the fact that the techniques which employ the time value of money concept are regarded by the donor agencies as providing adequate ranking systems for investment fund allocations, their conclusions may be misleading and meaningless for development purposes. The reason for this stems from the measurement problems encountered in benefit-cost evaluation systems. The major problem involves the choice of the interest rate to be used in the calculations, a choice which depends chiefly on the cost of capital, according to the source of the funds being used. The second major problem lies in determining project duration and, more specifically, the duration of project benefits. The third problem is that of designing quantitative proxy variables for both social benefits and social costs. Lastly, comparison of projects of different magnitudes may give different ranking for each technique applied. Suffice it to say that if financial analyses are to be employed in rural development project evaluation, extreme care must be taken in selecting the technique to be used, and in considering the measurement problems to be encountered.

Perhaps the most critical question that may be raised against those evaluating rural development orojects by methodologies based on financial investment criteria is "Does the level of funds allocated or the rate of return on them really constitute an adequate measure of 'development'?"

III. EVALUATION IN THE CAQUEZA PROJECT

There are several points to be made about the evaluation program in the Caqueza project. As I said earlier in this paper, the primary objective of evaluation activities is to measure goal achievement in the pursuit of improved rural well-being. In order to perform this task effectively, evaluation concepts must be taken into consideration during the diagnostic period, during action program planning, and throughout the period of on-going project operations. These activities must be performed in addition to post-project impact evaluation. The Caqueza project staff also feels that it is necessary to charge the evaluation program with the responsibility of designing evaluation research of an analytical nature, which may detect the causes rendering goal achievement less than satisfactory, when such instances are identified. This type of activity is not generally considered to be appropriate for the evaluation team in most rural development projects; instead, it is assigned to the research team. However, in our experience the research team is composed of the more scientific research personnel, such as agronomists, animal scientists, plant breeders, etc., and no orientation toward research into socio-economic conditions, which constrain the adoption process, is forthcoming. Hence, these tasks fall into the purview of the evaluators, who are, in most instances, at least familiar with the fields of economics, sociology, communications and anthropology. Analytical evaluation, then, becomes part of the evaluation structure, and is designed to investigate the institutional constraints imposed on the peasant farm community, which inhibit the farm families from obtaining the full potential benefit of the new technology, both scientific and economic, which is being introduced into the region.

A. Diagnostic Studies

Prior to initiating any action program, it is usually necessary to carry out some form of diagnostic study. Such a study attempts to provide a base-line or initial status level of the regional characteristics which the action program is designed to change. Experience in the Caqueza project, however, has shown that such base-line studies prior to project action are often inadequate, mainly because the depth of analysis is far less than that required by post-project impact evaluation actitivities. If, as was found by subsequent analytical evaluation in the project, farm incomes are incorrectly estimated in the initial stages of project development, the degree of goal achievement, as determined by post-project activity estimates, will be incorrectly calculated.

The initial Caqueza diagnostic study can be used as an example (Escobar, 1973). The original data for farm size and production patterns, based on the socio-economic survey of more than 600 families in early 1972, provided a rough estimate for income p.c. of about $50 (Cdn.) derived from monoculture corn production, some double cropping of horticulture crops, and off-farm labor income. Six months later, improved estimates of agricultural production, which took into consideration the actual pattern of multiple croppings encountered in the area, and which were derived from cost accountings of the major crops and their associates, yielded per capita income figures of about $86 (Cdn.) in July 1972. Subsequent analytical evaluation, which more accurately reflects production income and food expenditures, suggests per capita income levels of approximately 20% higher (Ramirez, Villaruel, Swanberg, 1974; Shipley and Swanberg, 1974; Florez and Swanberg, 1974). Obviously, an evaluation program based on the original estimate of $50 as the base level would unduly inflate the degree of project achievements.

The principal reason why the original estimates were so erroneous was because the peasant farmer, prior to the development of benefits from project activities, was overly suspicious of the motivations of the ICA personnel soliciting income information. Traditionally, the farmers of this region suspect that government employees are trying to elicit information for tax purposes. This type of information was thus not available directly, but had to be calculated from information on farm size, family size, agricultural production and costs, and off-farm labor returns. And it was found in this type of situation that each subsequent analytical evaluation provided more complete information on agricultural production, costs, and returns, and more exact data on the patterns of multiple cropping utilized by the farmers in the area.

Two major conclusions have been drawn from the experiences gained in developing the Caqueza diagnostic study. First of all, the determination of base-line levels of socio-economic characteristics must be derived not from vague estimates, but from hard data, which are obtained over the first few years of a project and not during the few months of superficial pre-project surveying. The information garnered during the pre-project period serves well for selecting project areas and, indeed, gives guidance as to the type of activities to be initiated, but does not lend itself to establishing base-line levels of socio-economic characteristics. The second conclusion is that the trends of change over time must accompany base-line data levels. A knowledge of the trends of change in farm size, family size, income, health levels, migration rates and employment levels is necessary to substantiate the degree of project impact in goal achievement attributed to project activities.

B. Impact Evaluation

Impact evaluation is carried out only when an action program has been in operation for a significant period of time, in order to allow for the expectation that at least partial goal achievement has been obtained. The type of evaluation employed is dependent upon the objective of the specific evaluation and the type of goals set for the action program. Although it must be realized that net per capita income is not an all-encompassing proxy variable for those items included in the well-being index, an illustration of impact evaluation using this variable as an example will serve to demonstrate one of the techniques currently accepted in this field.

Farm income in 1972 was estimated at $645 (Cdn.). The technological potential developed up to the present could produce a farm income, assuming no change in farm size, of $400 in corn, $400 in horticultural crops, */ $50 in animal production and $113 in off-farm labor, totalling $963. Recent projections based on a number of analytical studies currently being processed, lead one to hypothesize that corn technology adoption could be 30% of the recommended package, and horticulture and animal husbandry technology adoption could be 50% of the recommendation over the three years of project operation. This would yield an income increase of 20% with farm incomes of $772, assuming that prices remained constant. An evaluation of the achievement of the goal of substantial income increase in this situation would conclude that the project has been successful. Nevertheless, several questions emerge. Why was the adoption rate low for corn and high for horticulture? What happened to the unemployment rate meanwhile? Why is horticulture income higher than corn income in a pre-

*/ This figure is an estimate of the possible yield for horticultural production, assuming no substantial substitution of acreage or cropping patterns.

dominantly corn-producing area? These questions are not answered by impact-type evaluation methods. Yet it is precisely the answers to these questions which will shape and guide policy decisions for programming future project activities. It is to answer them that analytical evaluation has been designed.

C. Analytical Evaluation

The first impact study carried out in the Caqueza project was designed to study the nature of the adoption rate in a supervised credit program for corn. The conclusions showed that the farmers who agreed to accept the loan on condition that they adopt the new technology, adopted 86% of the seeding density component of the recommendation, but only 22% of the fertilizer recommendation (Escobar, 1972). A similar study was carried out in the potato zone, and the results showed that the technological package was adopted almost in its entirety (Escobar and Swanberg, 1974). In this case, however, the recommendation did not call for increased input costs. Prevailing fertilizer, seed, and pesticide costs were at that time at the same level. Only their quality and the timing of application had to be changed to fulfill the requirements of the recommendation. These studies did not, however, attempt to identify the reasons for the different adoption rates for the two crops. Nevertheless, the studies did draw attention to the fact that those portions of the recommendations which required substantial input cost increases were rejected, whereas those portions which did not were readily accepted. The project evaluation section therefore concluded that additional studies were required. Several analytical evaluation studies have now been elaborated and are currently being processed. They have led to a number of interesting conclusions, a short review of which will be presented below, as will the results of a nutrition study.

1) The Real Cost of Credit

Over the past year, several sources of credit have been available in the project area (Villamil and Swanberg, 1974). Bank credit was offered, at the most nominal stipulated interest rate, 13% annually, and was utilized by approximately 30% of the farmers interviewed. However, if the costs of loan administration, time spent in aquiring the loan, the cost of hospitality and bribes offered to bank representatives and co-debtors are included in this figure, the annual interest rate rose to 24%. Friends and relatives were the source of 59% of the credits, with an annual interest rate of about 46%. Commercial sources of credit, largely determined by excess pricing, gave rise to interest rates of approximately 52%. The weighted average interest rate for the study was 42%.

The study also showed that the interest rate was negatively correlated to wealth and income levels. It appears that farmers with low capital stock pay substantially higher capital costs than those with high wealth levels. Wealth levels of $6.000 (Cdn) were found to incur capital costs of 48% and those of $14.000 (Cdn) appear to pay 30%.*/ The conclusions of this study, if applied to project programs, would increase production costs, which would lead to a reduction of recommended levels of inputs in the maximization process.

2) Income Alternatives

Analysis of traditional corn and potato production practices revealed several

*/ Wealth levels are the total value of the farmers' fixed and liquid assets.

interesting characteristics of the economic activity in the project area (Narvaez, 1973). It was found that these crops are rarely grown alone but are usually part of the associated cropping complex referred to earlier. In both the corn and potato complexes, legumes play an important role. Cash income generated from corn is minimal whereas over 80% of the potatoes, legumes and other vegetables are sold for cash.

1972 market prices showed that potato production easily out-produced corn as an income-generating activity, in the form of cash or income-in-kind. In the following year, however, the relative prices for these two crops were reversed. Hence, this year's adoption study of the supervised credit program showed a substantially higher adoption rate for corn technology compared to the previous year.

In addition to the analysis of corn and potato production, eight horticultural crops were analyzed. The associated cropping patterns at present employed by the local farmers were obtained through a study on the frequency of land use. From this information calculations were made as to the returns to factors for individual crops and associated cropping patterns. Returns to factors and net income were found to be low for corn, cabbage, potatoes, and legumes, but substantially higher for the other vegetables.

Taking all this information into consideration, the following postulates began to emerge. Adoption of new practices depends upon several factors, which include:

a) The expected net income of the crops, and the variance of the physical production schedule.

b) The level of cash costs required for production, and the probability of loss which would prohibit recovering these costs.

c) The relationship between the supply of and demand for farm labor now under the farmers' cantral, and the increase required for the new practices.

d) The farmers' perception of market possibilities for cash crops.

In order partially to demonstrate the complexity of the decision-making process which the farmer faces, the following set of calculations are presented (see Table I). It should be noted that market price variatians, values of the expected loss functions and the problem of labor supply and demand are not included in this table, but that these conditions must be considered by the farmer.

Nevertheless, as stated above, the farmer cultivates these crops in various associated patterns. The mast cammon of these patterns are listed in Table 2, tagether with some calculatians of retuns ta factors.

TABLE 1. FACTOR COSTS AND RETURNS TO FACTORS, PER HECTARE

INDIVIDUAL CROPS - CAQUEZA, 1973

	Corn	Potato	Beans	Cabbage	Beets	Green beans	Tomatoes (chonto) 1/	Onion	Leaf lettuce
Inputs									
Cash ($Cdn.)	$ 19	$ 99	$ 102	$ 80	$ 104	$ 161	$ 244	$ 318	$ 56
Cash + Salaried labor ($Cdn.)	$ 38	$189	$ 146	$129	$ 225	$ 392	$ 419	$ 456	$ 169
Labor (man-days)	26	114	61	89	183	182	221	188	202
Returns									
Capital 2/ (%)	53%	20 %	70%	58%	250 %	241%	228 %	246%	289%
Labor 3/ ($ per man-day)	$ 2.58	$ 2.87	$ 2.39	$ 1.39	$ 3.74	$ 6.46	$ 5.13	$ 6.70	$ 2.97
Net Income	$ 85	$ 38	$ 102	$ 75	$ 564	$ 945	$ 959	$1120	$ 488
Price/Kg. 4/	$ .09	$ .03	$ .54	$ .04	$ .08	$ .15	$ .24	$ .17	$ .16

1/ A Colombian variety similar to Cherry Tomatoes.

2/ Capital includes cash outlay plus salaried labor.

3/ The local wage rate for hired labor is $1.04 per day.

4/ Prices were taken at the harvest season, 1973.

TABLE 2. RETURNS TO FACTORS, ASSOCIATED CROPPING

CAQUEZA, 1973

Type of Associated Production System	Net Income ($Cdn/ha.)	Returns to Capital (%)	Returns to Capital Per Month (%)	Returns */ to Labor ($Cdn.)	Returns to Cash and Family Labor Per Month($Cdn/ha)	Observed Frequency of the Association (%)
Simultaneous Production						
Corn - Bean a/	$ 64	70%	9%	$ 1.07	$ 8	21%
Corn-Bean a/-Broad Bean	$ 81	103%	13%	$ 1.33	$ 10	9%
Potato-Pea	$ 409	84%	14%	$ 2.69	$ 68	4%
Potato-Bean b/	$ 177	42%	8%	$ 1.01	$ 35	6%
Tomato-Green Bean	$2,184	413%	103%	$ 6.60	$ 546	< 1%
Simultaneous Production followed by Second Crop						
Corn-Bean a/; Tomato	$ 567	111%	9%	$ 2.82	$ 44	< 1%
Corn-Bean a/; Potato-Onion	$2,316	335%	26%	$ 8.64	$ 178	< 1%
Potato-Pea; Onion	$1,587	167%	15%	$ 4.84	$ 308	< 1%
Simultaneous Production with Second Crop Seeded before First Crop Harvested						
Potato-Pea; Corn-Broad Bean	$ 521	95%	7%	$ 2.50	$ 37	< 1%
Interrow Cropping						
Potato-Bean b/-Pea; Potato-Bean b/	$ 607	69%	6%	$ 1.72	$ 55	< 1%

*/ The local labor wage rate is $1.04 ($Cdn.) per man-day.
a/ Runner Beans
b/ Bush Beans

The two preceding tables clearly show the complexity of the decision-making process which confronts the small farmer of Caqueza. Obviously, increased returns are obtained as he moves from potato or corn production to horticultural production. However, the level of investment required also increases, which may become a limiting factor which prohibits him from moving in this direction. It should also be noted that the comparison of returns to factors are very sensitive to price changes. Nevertheless, given the range of prices the farmers have received over the past two years, the returns to horticulture (less cabbage) will still remain above the returns to corn, potatoes and legumes. The major conclusion which has been drawn from these studies is that the level of cash inputs is the key factor in choosing which crop to cultivate. High cash inputs can increase the value of the loss function and may therefore increase risks even though production variances are relatively similar. Hence, it is not so much the variance of the production function, but the portion of the distribution of that function in which losses occur, and the value of these losses, which bring out risk-aversion characteristics among low wealth-level farmers. The frequency study supports these conclusions by showing that the staple crops, which have lower cash costs are those most frequently grown, and that much less acreage is dedicated to the production of horticultural crops, which have substantially higher cash costs.

3) Marketing

The preceding section shows that horticulture production gives higher returns to capital and labor than staple crops. It was also mentioned that the levels of returns to factors was highly sensitive to price changes. At several points in time, farmers from the Caqueza project area complained that the low prices were the fault of oligopolistic behavior on behalf of the marketing middlemen serving the region. The conclusions, which were drawn a priori, were that marketing margins were excessive and that the middlemen would have to be eliminated.

Before embarking on a marketing program, however, it was deemed necessary to investigate the marketing system in order to be in a position to refute or substantiate these conclusions. The marketing study estimated the truck capacity serving the area, the number of middlemen available, the amount of product leaving and entering the area, and the gross value of commercialization. Truck capacity was found to be substantially underutilized. Only 60% utilization was observed during the major harvest season. Returns to marketing agents averaged $200 per month*/ The data from this study completely reversed the a priori conclusions drawn before the study. Instead of large marketing margins and high returns to marketing sector inputs, a structure of "atomistic" competition was encountered, with over-capacity of equipment and labor, which gives rise to low returns to factors. The action programs in marketing required in order to improve farm-door prices in this situation, are quite different to those capable of modifying oligopolistic market structures. Vertical and horizontal co-ordination are required for atomistic market structures in order to reduce marketing costs, whereas decreasing entry barriers are the major techniques needed to be employed in order to improve farm-door prices in oligopolistic situations.

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*/College graduates earn $450/month, and bilingual secretaries earn $250/month.

4) Labor Supply and Demand

The paper on corn production by Zandstra showed that the new technology for corn requires a 70% increase in labor. Zulberti has also shown that available farm labor may be a constraint on the small farmer's opportunity package. The research staff of the Caqueza Project found that it is quite difficult to hire labor during certain periods. Thus, in spite of the general assumption that rural areas in developing countries are imbued with a high degree of real or disguised unemployment, there may be specific time periods when full employment does exist.

The Project's research findings, however, suggest that the economically active population in the three principal municipalities studied supplies more than sufficient labor to perform the work required. Not even a 70% labor increase for corn production would create full employment. Rough estimates show that unemployment rises to about 40% during peak periods of labor employment. Although unemployment is high in spite of the fact that people feel that there is full employment during certain periods, the labor study does show that the supposed pinch on hired labor would not be felt if the alternative income activities (horticultural production) were increased. This would have the effect of spreading the demand for labor because high labor demand in horticultural crops occurs at a different time than the high labor demand period in staple crop production. Another aspect which surfaces at this point is that the impression "full employment" may be due not to the fact that no laborers are available but that the opportunity cost for labor felt by the laborers is greater than the existing wage rate, and substantially higher than the value marginal product of labor.

In conclusion it should be stressed that this study provides yet another demonstration of the need for continued analytical evaluation. The interpretation given to farmer responses was shown to be erroneous with respect to the actual labor supply, and might have led to errors in programming had the matter not received further attention.

5) Nutrition

Traditional programs of nutrition education were carried out by the home economist in the Caqueza project, with very poor results. Project personnel assumed that there existed inadequate consumption of all nutrients. Nevertheless, the lack of enthusiasm shown by the farm families for the nutrition education programs led us to re-examine their basic tenets with a view to formulating an acceptable nutrition policy.

In August 1973, a 24-hour recall consumption survey was carried out on 259 farm families. The findings showed that in the higher income potato production area, the nutritional status of the average family was adequate except in the case of calcium intake. The corn zone families, however, lacked adequate intakes for protein, calories, calcium, vitamin A, and riboflavin. For the subsample of preschoolers, calcium and vitamin A were lacking in both zones, in both of which cases, however, protein and calorie intakes for this age group were adequate. Regression analyses showed that income levels were much more closely correlated to protein and calorie consumption than they were to other nutrients. From the policy standpoint, it appears that protein and calorie intakes are only likely to be raised by generating higher incomes (which is the responsibility of the economic programs of the project), whereas calcium and vitamin A deficiencies could be delt with through nutrition education programs. Thus, by designing specific nutrition education programs which deal directly with real nutrition deficiencies, the potential farm family response would become much higher than that observed during earlier stages of the project.

III. CONCLUSIONS

The evaluation program of the Caqueza project has been designed to measure the degree of attainment of increased levels of rural well-being resulting from project activities. This objective has required substantial efforts in the design and measurement of base-line levels of several well-being variables, among others, farm size, family size, and per capita income. The impact evaluation carried out to date, has identified several specific problem areas, which have created resistance to rapid development. These special cases have been subjected to analytical evaluation, which have revealed many of the basic causes of such resistance. The development of action programs designed to resolve these problems has been a valuable exercise for project staff and students, in that it has familiarized them with the dynamic nature of rural development.

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