AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch 62

1. SUBJECT CLASSIFICATION

A. PRIMARY: Food production and nutrition — AF00-0120-G140

B. SECONDARY: Plant production-Cereals-Maize--Kenya

2. TITLE AND SUBTITLE
Corn in Kenya

(101) 3. AUTHOR(S)
AID/AFR/USAID/Kenya

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1969	81p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
AID/PPC/EMS

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In AID Spring Review of the New Cereal Varieties,1969. Country crop papers: Kenya)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAD-998

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Kenya
Maize
Varieties
Yield

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/PPC/EMS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Spring Review

New Cereal Varieties

CORN in KENYA

May 1969
USAID - KENYA

draft

This volume includes the Country Crop Paper, prepared by USAID, and sections on Research and the Kenya Seed Company by a USDA research geneticist formerly stationed at Kitale, Kenya.

TELEGRAM

DEPARTMENT OF STATE

UNCLASSIFIED

CLASSIFICATION

For each address check one ACTION | INFO

TO - AID/W TOAID A-226 X

DATE REC'D. 1969 MAY 22 PM 3 18 AID

DISTRIBUTION ACTION AFR INFO. AAPC WOP AWOH SRD

FROM - NAIROBI

SUBJECT - Spring Review -- New Grain Varieties

REFERENCE - A. STATE 030045 B. AIDTO A-45

The attached paper on Corn Production in Kenya gives a review of the hybrid corn development in the country as we have found it to date. USAID regrets the delay in getting the review to AID/W but shortage of staff and new program documentations for FY 1969 obligations together with other reporting requirements have delayed the production of this paper.

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PAGE 1 OF PAGES 34

DRAFTED BY	OFFICE	PHONE NO.	DATE	APPROVED BY:
EESmith/bdm	F & A		5-13-1969	Harold D. Snoll, Director

AID AND OTHER CLEARANCES PROG:WASponsler

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CLASSIFICATION

AID-5-39 (9-62) (Do not type below this line)

PRINTED 3.

SPRING REVIEW - NEW GRAIN VARIETIES

Corn Production In Kenya

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The new variation corn production program has been one of the great stimulants in bringing hundreds of former subsistant farmers into the cash economy of the country. The results are not measured in just the increased production of corn which now makes Kenya self-sufficient, but reaches into the social, economic, political and educational fields.

I Record to Date

The production of corn formerly the leading African cash crop has not in any way been at the expense of the Africans' staple food. In 1946 there was a surplus of corn production of 770,000 bags and in 1960 the surplus was much of the same order.

A. Crop Production

Corn is the most important food crop in Kenya. In normal years a large majority of Kenya's families produce enough corn for their own consumption. Its real importance is not reflected in the value of the marketed crop for the highest portion is consumed on the farm, or in the locality where it is produced without being reflected in statistics.

The area planted to corn each year is estimated at 1,200,000 hectares. The total production in normal years is estimated at 15 million 200-lb bags, equivalent to 1.25 to 1.35 million metric tons. This is roughly 1,000 kilograms per hectare or an average output of five bags per acre.

In the late 1940s the British colonialists recognized the importance of corn as the main crop of the country and started to do something about improving the seed. In 1950 the research station at Kitale was established and research started on improved corn seed. In 1955 Dr. Harrison was brought to Kenya to work on the development of improved seed and in 1957 had some improved selections. Simultaneous with the production of improved varieties at the research station, the government extension service started demonstrations in local communities and the acceptance of improved new seeds was started.

The first hybrid corn was developed in 1959 and limited quantities became available for farmers' use in 1961. The Major Cereals Project was initiated in 1963 and a total of 160 hectares were planted that year. Larger supplies of hybrid seed became available in 1964 due to the activities of the Kenya Seed Company. The hectarage of corn grown from hybrid seed has increased rapidly since its introduction in 1961. Table 1 shows the hectares of corn hybrids grown in Kenya since the introduction through the Kenya Seed Company.

Hectares of Corn Hybrids Grown in Kenya

Year	Large Scale Farms Hectares 1/	Small Scale Farms Hectares 1/	Total Hectares 1/
1963	156	4	160
1964	11,400	700	12,100
1965	22,200	8,100	30,300
1966	25,500	15,300	40,800
1967	55,500	46,700	102,200
1968	40,600	52,300	92,900
1969 2/	46,000	58,000	124,000

1/ Estimates are based on hybrid seed sold to farmers.

2/ Preliminary estimates for 1969

There were approximately 3,500 large-scale farmers in Kenya during 1960. The area planted to corn on their farms was 56-60,000 hectares. Owners of this proportion had been planting improved corn seed for a number of years prior to 1963, so they were ready to accept hybrid seed as soon as it became available. They had been instrumental in the Government carrying out the research work at Kitale and in obtaining the improved seeds. Therefore, the acreage of hybrid corn increased rapidly as soon as the seed became available. In four years time practically all of the acreage of corn on the large-scale farms was planted to hybrid seed (1967).

The small-scale farm area was estimated to be composed of over 3 million families, living mostly on individual tribal lands in 1960. Only 130,000 families were actually on consolidated properties and those who had free-hold titles averaged approximately four hectares per farm. The small-scale farmers were raising one-third to one-half hectare per family but in the aggregate this amounted to over 1 million hectares, or twenty times the corn area raised by the large-scale farmers. The improved hybrid seed was purchased by a surprisingly large number of small growers, starting in 1964, increased rapidly each year. During 1967 considerable activity took place in the taking over of large farms by Africans, either in corporations, cooperatives, or small groups. This in addition to certain large farms being taken over for resettlement purposes, accounted for some cut back in the plantings of hybrid corn on the large scale farms in 1968. 1969 is showing some increase and it is estimated that 90 per cent of the corn planted on the large farms is with hybrid seed.

B. Input Utilization

1. Research and Production of New Seed Variation

Ecological conditions in Kenya require corn breeding programs for three distinct regions: (1) a long rainy season occurring west of the Rift Valley where most of the corn is grown between 4,000 ft and 7,500 ft elevation; (2) east of the Rift Valley at similar altitudes, but where there are two distinct rainy seasons during the year, hence the medium maturing varieties are required to permit two crops a year in this area; (3) the drier parts of the eastern region requiring earlier maturing varieties to escape periodic droughts.

A very extensive breeding program has been underway since 1955 and several new hybrids and improved varieties have been released. The high lysine content genes Opaque 2 and Flory 2 have been bred into these varieties, starting in 1966. It is anticipated that all hybrids will have the qualitative genes for the lysine content incorporated into them during the next three years.

An important aspect of corn improvement has been in seed production and distribution. The research and breeding work to produce the new improved varieties was earlier recognised as being of little real value unless it had connected with it a system of getting the seed to the farmers and showing the farmers how best to use it. The Kenya Seed Company of Kitale which had had eight years experience of growing grass and sunflower seeds took on the job of bulking the improved seeds and distributing them, starting in 1961.

The Kenya Seed Company had been started as a private company in response to requests by European farmers for grass seed. With the research station developing the hybrid corn the Company soon saw the possibility of producing this corn seed. The demand for the hybrid seed was so great that it taxed the company's facilities, both financial and physical, and eventually the GOK took stock in the company. The company is, however, continuing to run as a semi- private organization, even with the GOK 30 per cent interest in it.

The Company rapidly learned the new techniques necessary for the storage, treating and handling of corn seed, in addition to the proper field production controls. It has done a very good job in increasing its production capabilities and in developing a sound marketing program through established private business and cooperative channels, so that the seeds are available to the farmers when they need them.

The Kenya Seed Company is producing some hybrid seed for use in other East African countries. In 1968 seed was sold to Tanzania for 60,000 hectares, Uganda 270 hectares, Ethiopia 270 hectares and a small quantity for Somalia and the Congo for research purposes.

The Kenya Seed Company contracts with selected farmers to produce hybrid seed at a guaranteed price of £12.30/quintal ($3.16 a bushel). The seed production is done under certification standards equal to or above those of the International Crop Improvement Association and inspections are carried out by government inspectors. The company maintains an advisory extension service to help the farmers meet the high standards. The company cleans, grades and treats the seed with seed dressing and packages it in appropriate sized bags. Approximately one-half of the farmer-seed growers are now African.

The principal distributing agents for the Kenya Seed Company are the Kenya Farmers Cooperative Association and Dalgety's, a private company. These organizations handle fertilizer, hand tools, insecticides, small farm supplies and overall major requirements of the African farmers. They have retail stores of their own as well as contracts with small shop-keepers scattered throughout the reserve areas where the subsistant farmers live. This makes it possible for the small-scale farmers to obtain their basic requirements within 16 kilometers of their homes.

The details of seed production are given in Table 2. Severe shortages of hybrid seed produced in 1965 caused the company to triple production in 1966. This resulted in a very large carry-over which made it necessary for the company to restrict hectares grown in 1967-68

Table 2 Hybrid Seed Production In Kenya

Year	Certification Hectares	Certification Seed(q)	Av. Yield q/ha	Number of Growers European	Number of Growers African
		Late Maturity			
1963	116	2,677	23.0	26	0
1964	202	7,308	36.2	29	0
1965	426	9,581	22.5	38	1
1966	1,240	40,225	32.4	69	9
1967	686	22,422	32.7	33	24
1968	466	(15,682)*	(33.7)*	29	17
		Medium Maturity			
1966	24	254	10.6	2	0
1967	15	270	18.0	1	0
1968	34	(610)*	(17.0)*	1	0

*1968 production is estimated.

Investigations have been made by the COK research agronomist at the Kitale station to determine the most important factors affecting corn yields, the optimum level of different factors, and the inter-action of these factors with each other. The main factors are :

a. Time of Planting: Early planting is very important, since it appears that the corn plant is very sensitive to excessive soil moisture and accompanying poor soil aeriation during the first few weeks of growth. Optimum conditions are found during the start of the rainy season. In the short rainy season areas late planted corn suffers from both early excessive soil moisture and from drought later in the season.

b. Plant Population: Trials are continuing on the different hybrids in the different ecological areas to determine the optimum population of plants per hectare. Population has shown a marked influence on yield with a great variation between different hybrid varieties.

c. Type of Seed: The need for using hybrid seed developed for the different ecological zones has been shown in repeated trials. For example, in trials during two successive years, hybrid 611B has out-yielded hybrids 622 and 632 by 50 per cent at 8,000 foot elevation. However, 622 and 632 out-yielded 611B by 20 per cent at 4,000 foot elevation.

d. Response to Fertilizer: In the early work that has been done the response to fertilization have been very small. However, as plant population level increase and genetic potentials of the hybrid rise greater response to fertilization is found.

e. Weed Control: Weed control was the second most important factor to time of planting. The 1967 trials showed that complete weed control by either hand-weeding or chemical methods, increased yields by 50 per cent compared with check plots not weeded.

The objective of this program has been to determine the optimum cultural practices so that recommendations could be made to the growers. The hybrids released by the corn breeders have potential higher yields than the former varieties. This higher potential can only be realized if good cultural practices are used, as there are big inter-actions between genotypes and cultural conditions.

Table 3 Results from Various Combinations of Factors

	Yields in Quintals per Hectare*		
	No fertilizers. Local Variety	Fertilizers** Hybrid 612	Differences.
Planted 4 weeks late, 20,000 plants/ha. Weeded once, late	20.2	28.0	7.8
Planted at start of rains. 40,000 plants/ha Clean weeded.	53.8	85.0	31.2
Differences	33.6	57.0	

* 1 quintal = 100 kilograms or 220 lbs.

** The fertilizer rates were 56 kg/ha of P_2O_5 at planting and 80 kg/ha of N topdressing at knee-high in these trials.

The use of fertilizer and hybrid seed with poor cultural practices gave very little increase in production over local variety seed, planted and handled under like conditions. However, when the fertilizer and hybrid seed were planted at the proper time and weeded it showed an appreciable increase in production over the local variety grown under the same cultural conditions. Similarly, results realized from the use of improved cultural practices is more striking when the crop is grown with hybrid seed and fertilizer. These results show why the impact of fertilizer is often disappointing to new farmers. If fertilizers are used under poor conditions, they will have little, if any effect on yields. Farmers seeing this and not realizing that the cultural factors are limiting the responses to fertilizer will come to the conclusion that the fertilizers are not profitable investments. The package approach with all of the major factors being used at recommended levels is the aim of the extension services in their work with farmers and through demonstrations.

2. Land

It is estimated that 1,200,000 hectares are planted to corn each year. The total hectarage planted with hybrid seed in 1968 was 92,000 or about 8% of the total. There is such a high percentage of the area planted by small-scale growers that there has been little noticeable increase or decrease in the amount of land planted to corn during the past ten years. The small decrease in the large-scale farm plantings in 1968 was a result of change in ownership of the large farms; certain farms being taken over by the Department of Land Settlement. The increased adoption of hybrids has made it possible for Kenya to meet its domestic needs for human food this year. Theoretically, it might be possible for farmers to release a very large hectarage of land now being used for growing corn to some other crop and still produce sufficient corn for Kenya's needs. This, however, will not be possible, as there are so many producers with very small plots who would not be able to raise anything else, and need the corn for their basic family food requirements, relying on a small surplus for their principal cash income.

3. Fertilizer

Phosphorous fertilizers were used in small amounts by the large-scale farmers prior to the introduction of hybrid corn. The introduction of hybrid seed soon showed that it was necessary to add some fertilizer in order to reap the greatest advantage from the improved seed. The large-scale growers caught on to this rapidly. The small-scale growers used no fertilizer until obtaining the hybrid seed, at which time the extension officers sold them on the idea that the hybrid seed was a special commodity and needed some fertilizer to help it produce at optimum. It is estimated that farmers used approximately 7,000 metric tons of nitrogen and P205 on high yielding varieties of corn in each of the years 1967 and 1968. This amount was split approximately equal between nitrogen and P205.

There has been a steady increase in the importation of fertilizer into Kenya since 1961. 35,500 metric tons were imported that year and increased each year thereafter, until in 1965 86,200 metric tons were imported. The main use of fertilizer in Kenya is on coffee and tea with these crops taking most of the nitrogen importation. Phosphorous fertilizers are used extensively on wheat, rice, corn, cotton and some vegetables. Mixed fertilizers are becoming increasingly common. The corn crop is taking about one-fourth of the P205 and Nitrogen fertilizers that are imported. This fertilizer is used 100% on the high yielding corn varieties where the old varieties of corn that are planted have practically no fertilizer applications.

The following Table shows the amount of Nitrogen and P205 used in Kenya for the years 1961 through 1967:

Table 4

Fertilizer Consumption of N & P205 (US) KENYA.

Year	N m/tons	P205(US) m/tons	Total N & P205 m/tons	N AS % of Total
1961	4,710	7,866	12,576	37.4
1962	4.842	6.386	11,228	43.1
1963	5,328	7,194	12,522	42.5
1964	9,302	9,904	19,206	48.2
1965	13,019	12,793	25,812	50.4
1966	9,752	20,782	30,534	31.9
1967	9,810	18,055	27,865	35.2

As a result of fertilizer trials in ten different areas of Kenya the research men have found a wide variation in the requirements of P205 and Nitrogen in different soil type areas. Their recommendations vary from 44 to 220 pounds of P205 per hectare, depending on the area. The recommendations for the use of Nitrogen do not correspond to the same area or soil types that require P205, but vary from 0 to 260 lbs per hectare for the different areas.

The application of P205 is recommended for application at the time of planting; in the case of large-scale farms band application slightly below the seed level and in the operations of the small-scale farmers placed in the hill slightly below the seed, as the seed is planted. The application of Nitrogen is generally recommended to be applied as a top dressing before the corn is knee-high. More research work is needed before firm recommendations can be made as to new hybrids adapted to higher plant population per hectare will require more Nitrogen to reach their optimum growth.

4. Insecticides/Herbicides

Relatively small amounts of herbicides are used by the large scale farmers to control weeds.

In the recommendations for care of the hybrid corn small scale growers are advised to apply a 2% dust in the funnel of the corn plant after singling, if there is any sign of stalk borer.

The totalmount of insecticide used in growing the high-yielding varieties of corn is small and of very little importance in the overall cost.

5. Equipment

The large-scale farmers are amply supplied with modern farm machinery. They have up-to-date two to six row corn planters with fertilizer attachments. They have tractor cultivators and many have [illegible] sprayers for applying herbicides if required because of wet seasons.

Small scale farmers rely upon turning their soil with a six-pound mattox by human labor (women and children and men). They usually work the land up once after the original turning. They plant the corn by hand, making a small hole with the use of a machete, dropping a little fertilizer in the bottom of the hole and then one or two kernels of seed on top, covering it all with the same machete. They do all of their weeding by hand with the use of the machete.

6. Water

In Kenya rainfall is the most important climatic factor influencing the growing of the corn crop. Both the amounts and distribution during the growing seasons influence the yields that can be expected. In the Western region where the long season corn hybrids are used there is an annual rainfall of 40-60 inches. In the Central region, rainfall varies between 20-40 inches and in the Eastern region the annual rainfall is about 22 inches. High yielding varieties of corn have been produced for each region.

The farmers' experience with the new short season corn hybrids in the Eastern region has caused an extension of the corn growing area into still further dry areas where sorghum or millets might be safer to grow.

Corn is not grown under irrigation as a common practice in Kenya.

C. Profit Calculation

1. Output Prices

Corn prices in Kenya are government controlled and all inter-provincial or exterior marketing is done through the Maize and Produce Board. The Government of Kenya sets the market price which is to be paid to the producer and also sets a ceiling price on corn meal charged to the consumer. Wheat is the principal competitor for land acreage with corn.

The following Table No. 5 gives the general relationship between wheat and corn returns to farmers during the past ten years.

Table 5

Average Yield Per Acre and Net price in Kenya Shillings per 200-lb Bag

	WHEAT			CORN		
Year	Yield	Price	Return	Yield	Price	Return
1958	4.36	51/50	224/54	6.02	27/00	162/94
1959	5.43	48/62	264/00	5.79	32/00	185/28
1960	4.75	46/62	221/44	6.18	35/50	219/39
1961	4.03	46/93	189/12	5.37	35/50	190/63
1962	5.13	47/17	241/98	7.02	24/00	168/48
1963	4.91	47/92	235/28	5.21	27/00	140/67
1964	5.31	47/00	249/67	8.48	32/50	275/60
1965	4.53	47/00	212/91	6.03	32/50	195/97
1966	5.84	51/10	298/42	9.60	32/50	312/00
1967	6.70	51/10	342/37	11.00	28/00	318/00
1968	6.16	48/00	295/68	12.00	28/00	336/00

The increase in the number of hectares of hybrid corn being produced by the small-scale grower makes the relationship between corn and wheat less important than the overall production of corn in Kenya. There is no real competitor for corn on small-holder farms

2. Input Prices

The government has carried out a system of subsidising certain of the inputs, principally fertilizers, each year, for the past 10 years. In 1969 the subsidy on phosphate fertilizers has been increased to 85/- from 80/- in 1968, per unit of P_2O_5. Nitrogen fertilizers will be subsidized for the first time in 1969 at a rate of 820/00 per ton of elemental nitrogen. These inputs will be affecting future crops, but the input on phosphoric fertilizers in the past has been an important factor in influencing large-scale farmers to use more fertilizer. It has not affected the use of fertilizers by small-scale farmers to date.

In addition to this, the government has guaranteed a minimum return for both wheat and corn which is based on a per-acre basis. This Guaranteed Minimum Return is also beneficial to large growers since no one with less than 15 acres can qualify. In the 1969 program for the first time there will be no Guaranteed Minimum Return by the government for anything, but the hybrid corn. This guarantee is 825/75 per acre. The Guaranteed Minimum Return is advanced at the beginning of the growing season to assist farmers in paying for fuel, fertilizer, seeds, insecticides, contract cultivation, repairs and spare parts.

The general trend in prices for principal inputs has remained roughly at the same level since 1967.

3. Net Return

The following Table, No. 6, gives a comparison of the main factors in corn growing, relating the improved procedures with the high yielding varieties and showing the relative differences in cost and return.

Table No. 6

Factor	Level	Yield bags/ acre	Increased yield	Cost Difference	Increased Return (s)	Profit (s)
Time of Planting	Dry Planting vs 2 weeks late	20.4 11.1	9.3	Nil	260/40	260/40
Plant Population	14,520 plants vs 7,260	17.6 14.0	3.6	8/-	100/80	92/80
Type of corn	Hybrid 511 vs Muratha	24.94 20.98	3.96	12/-	110/88	98/88
Standard of weeding	Clean weeding 1 late weeding	16.4 15.2	1.2	20/-	33/60	13/60
Single Super	260 lb/acre 0	17.1 14.4	2.7	32/-	75/60	43/60
Nitrogen A.S.N.	270 lb/acre 0	15.9 15.6	0.3	80/-	8/40	-71/60
				152/-	589/68	437/68

There is no crop that the African farmer can plant on an extensive acreage that can compare with his returns from corn.

Table No. 6 shows that very little was gained on the average for the two years, 1966 and 1967 in applying nitrogen. However, when this same factor was tried on a plot with high-population in Western Kenya, the average increase was six bags per acre.

D. Policies

1. Promotional Campaign

The promotion and encouragement to start improved corn seed came about through the colonial government's interest in the early 1950s. The success that has been evident in the production of hybrid corn during the last four years is the result of a long series of actions that had taken place, starting back in 1955. The colonial government of Kenya and the large-scale farmers were very close in their aspirations, objectives and their individual welfare. The actions taken by the government in assisting the farmers in developing cooperative marketing and supply organizations was basic to the farm inputs and outputs requirements. The Kenya Farmers' Association (KFA) became one of the principal avenues through which farmers obtained their input commodities.

Private industry started working at the same time as the KFA with two large commercial firms. These businesses were interested in supplying agricultural machinery and supplies to the large-scale farmers and one of them dealt with cattle sales as well as land. This development was encouraged by the government.

Research into the possibilities of obtaining better grass seed, wheat, as well as corn, was promoted and the government set up special research stations for the development of these seeds.

Immediately there was a close tie between the farmers and the research organizations, so that the farmers knew what was being developed and could try it out on their farms as the development took place. The government recognized the need of, not only serving the large-scale farmers with some form of agricultural technical advice, but realized the importance of helping the African farmer in his aspirations to come into the cash economy and improve his lot. A very ambitious program of farm service was developed in the late 1950s. It required refinement and reorientation to an extension type service, but was a start of the organization that would take the information from the research workers to the farmers. It was a beginning and a framework was set up on which extension could be developed.

The research workers at Kitale Research Station started to make contact with research workers in the Western world and imported certain improved varieties of corn from South America to cross with the local seed stocks. A few hybrid varieties were developed before the U.S. technicians came to Kenya to assist in this program in 1963.

The government encouraged certain agricultural officers to go to the U.S. for training and observation as to extension methods and procedures in the States. Upon their return, the GOK requested advisor assistance to their government and AID supplied advisors that helped the government officials in developing an extension field service fitted to the existing conditions in Kenya. A few participants came back to Kenya and instituted crop demonstrations in corn, patterned on what they had learned in the U.S.A. Over 5,000 demonstrations were carried out with improved corn seed in different areas of the country.

One extension officer was responsible for promoting 500 one-acre plots in the Central Province. This action had a great effect on opening the door, so that once hybrid corn seed was available there was a demand for it by the African farmers.

Another important link in the success of getting farmer acceptance of hybrid corn was the fact that a private group of farmers had established a seed company in Kitale, principally for the purpose of obtaining improved grass seed. When they saw the advantages of hybrid corn they took on the job of bulking the hybrid seed and selling it. The government encouraged them to do this and did not compete by establishing other avenues of development. When there was so much demand for the hybrid seed, that the Kenya Seed Company did not have the finances with which to expand to meet the demand, the government stepped in and invested money in the company to assist it in fulfilling the requirements.

2. Price Policy

The Government of Kenya has consistently established a price for corn that they considered somewhat promotional and an incentive to the producer. You will notice in the prices outlined in Table No. 5 above, the relative prices paid for corn. During favorable years of surplus the government has still continued to pay a good price. The development of the hybrid corn has brought Kenya to the position where it is self-sufficient in its internal requirements and should have an exportable surplus most years in the future. The export of corn this year has shown a huge loss to the Kenya Treasury. The impact of this loss, together with economic policy papers prepared by U.S. agricultural economists has brought about a change in price policy. The GOK has now established a level that will allow them to export corn at world market prices without a loss.

The past twelve months has seen a change of attitude and the government has been examining ways in which savings might be accomplished without lowering the price to the producer. The 1969 producer price has been set at Sh25/- per bag, Sh3/- per bag less than the 1968 price. The small grower will not be required to pay the County Council tax of Sh1/- and the subsidy on fertilizers. There is also a new regulation on the transport from the farm to the Maize and Produce Board. These actions will in effect give the small grower the same approximate return per bag as he received in 1968. In addition the producer who has over fifteen acres can obtain a Guaranteed Minimum Return as an advance amounting to Sh180/- per acre, if he plants hybrid corn. He will not be able to obtain this advance or guarantee on synthetic or ordinary corn.

Another important factor in the production and acceptance of hybrid corn was the ruling by the government, soon after independence in 1963, that all families would have to pay a school fee for sending their children to school. All schools would be regulated under the Federal government. This immediately became a motivating factor and with the advent of independence there seemed to spread about the country the anticipation by the people of something new. They wanted all their children to get an education. In order to get an education each family had to find some additional money to pay the school fees. In innumerable instances this caused the family to raise an extra quarter acre of corn. The chain reaction to this was again a motivation on the part of the family to acquire a little more money and so hundreds of people who had never concerned themselves with money before started to use money as a medium of exchange and became acquainted with the cash economy of the country.

3. Fiscal Policy

During 1969 the government has studied changes in policy which might be made that would encourage the continuation and expansion of hybrid corn growing, but at the same time place the industry on a sounder financial footing. The reduction in price to the farmer was only one step, they propose that corn be sold to licensed feed manufacturers at a subsidized price of Sh22/- per bag, that they try to reduce farm input costs on diesel fuel, fertilizer and vehicle registration. They have worked on plans to reduce the marketing costs and through a combination of all these factors, believe they can continue the farm price at between Sh22/- and Sh25/- per bag and still meet the foreseeable export prices with no loss to the government.

4. Fertilizer and Other Inputs Policies

The Government of Kenya has been continuously trying to see that sufficient fertilizer supplies, credit and farm machinery were available for the efficient production of this crop. They have allocated foreign exchange monies freely to individual enterprises for the importation of such commodities. They have been very free in extending credit for the promotion of the improved farming and have realized that there needed to be a more concentrated and more efficient credit operation developed in the country. They have recently requested from USAID assistance in helping them in the field of farm credit.

5. Markets

It has long been recognized that Kenya is an agriculture producing country and its foreign exchange must be obtained from the sale of agricultural products. There has been no inclination on the part of the government to curtail corn production. All of their efforts now are aimed at getting the balance of cost of inputs into corn production down to a level at which the farmer can produce with a reasonable profit and sell in the government marketing organization at a price which will allow that organization to export corn in competition with world markets. Studies that are now in process indicate that Kenya may have as much as 200,000 metric tons of corn for export per year by 1975. The estimates show that with the improved handling facilities, and adjustments in inputs, they can maintain a price to the growers of $22/- to $25/- per bag and market at world prices without loss to the GOK.

6. Discrimination

Kenya has been fortunate in having an agricultural organization built up under a colonial government on the basis of private enterprise. The distributors of agricultural supplies are either cooperative organizations or private businesses. Farmers have been free to handle their own business and encouraged to use high yielding varieties of corn. The government has not stepped in and tried to impose government restrictions or operation in any perceptible degree, that would hurt private industry from operating. The grain merchants are private organizations and have been supported for years by the central government allowing them overhead costs and favorable handling charges. This area might have been granted too much in the past and may have to be cut back as price differences arise between cost of production and the sale prices at port of exportation.

E. Institutions

1. Research

The research station at Kitale played a most important part in starting hybrid seed corn. They imported parent stock from South Africa and South America and crossed those varieties in their various tests at the station. In addition to the station's work small trial operations were carried on with the large farmers in the vicinity of the station. Early trials showed that the parent stock from South Africa was strong and adaptive. The South African varieties crossed with South American varieties gave an increased vigor and the first hybrids developed in 1956 proved very productive. Starting with the assistance of the U.S. scientists in 1964 the hybrid program received additional impetus. Conventional double-cross hybrids involving four inbred lines were used at the start of the program. This has now progressed to the point where inter-varietal hybrids (crosses between varieties, two hybrids or a variety and a hybrid) between some of the better local varieties and a Central American variety are yielding 50 - 100 percent more than local varieties compared to a 25-30 percent increase in yield for the conventional hybrids. Continued selection within the parent varieties are anticipated to show further increased yields. Inter-varietal crosses are now accounting for the bulk of the hybrid seed being used in Kenya.

Research on agronomic practices has been found to be nearly as important a factor in increasing the corn production to date as the development of hybrids. Work has been carried on in this area of research through the assistance of the Rockefeller Foundation to the GOK. Extensive field testing has taken place in addition to the work being done at all corn improvement stations in Kenya, namely Embu, Katumani, Endebess, Kitwapa, Kjoro and Kakamega. Considerably more research is necessary to determine the fertilization and agronomic practices which are necessary to fully utilize the genetic capabilities of the hybrids being developed.

The research institution at Kitale has built a good reputation and is becoming known throughout eastern Africa. It is improving, and African scientists are moving in to take over the entire operation. They do have sufficient funds for the progress that needs to be made.

2. Extension

The Kenyan Extension Division or field service of the Ministry of Agriculture started to assume an important role in the promotion of hybrid seed corn in the very early stages of its use. Through the association of research with extension the field service established over 5,000 small demonstration plots on the lands of subsistent farmers.

They would pick leading small farmers in the reserves and if they would buy the hybrid seed and fertilizer and carry out the recommended practices the agricultural instructor would advise them at all stages. Then the farmers in the community would be called to see the plot as it was growing. The extension officer would hold periodic meetings to show what was happening and how it was progressing. These plots invariably had a combination of the hybrid seed corn with fertilizer and planted alongside a native stock variety of corn.

The extension service has continued to improve and to be one of the great promoters of a "package" deal for the promotion and use of hybrid seed. They encouraged farmers to buy the seed together with fertilizer and a bulletin was always issued with the package to explain to the farmer how he should prepare the soil, plant the crop, and what he should do to take care of it. The change in cultural practices has been stimulating and important in the overall increased production that has been obtained. This same activity had a side effect in the growing of some of the common vegetable crops that the farmers grow for home use. The practice of regular weeding proved beneficial in the production of all crops.

The development of a division of Home Economics in the extension service played its part in getting the small farmers to use hybrid seed as the women are the main producers of the crop. They learned of the hybrid seed at the Farmer Training Centers and saw demonstrations there. This was a stimulating factor in their obtaining seeds for their own home plantings.

The development of the 4-K activity also added to this process of rapid acceptance of hybrid seed, for many of the young 4-K boys and girls obtained small quantities of hybrid seed and planted it on their plots. When the parents observed the additional growth and yield of these s seeds it caused them to want to use the seed themselves.

AID has been instrumental in the development of the three divisions of the extension service and its influence has been felt in all parts of the country. The training of African extension officers in the methods of result demonstrations has been a major factor in the successful demonstrating of hybrid seeds and their ultimate adoption by farmers who saw the result demonstrations.

The Kenya Seed Company started with three acres of hybrid seed corn in 1962. They soon learned the importance of packaging the corn seed in such a way that it was easily used by the subsistance farmers for an exact area of land. Many of the early packages were set for the size of ½ acres. All of the seed was treated and the directions of how it was to be used were given to the grower with the package of seed as he bought it.

He was also told how much fertilizer was needed to be planted with the corn.

This Company's actions were largely responsible for getting the seed to the farmer through th[illegible]r method of putting the seed in easily handled small packages, together with full information on how the small grower should work his land, plant, and take care of the crop. They also supplied extension workers who assisted the regular government extension officers in advising farmers in the different areas. Company personnel worked closely with the research people at the Kitale Research Station.

The Kenya Seed Company developed distribution points through Indian traders who in the early days had the major contact with the small farmers. This later grew into a more sophisticated and larger business with the two large commercial companies who supply agricultural inputs to the small shop owners in the country communities over the entire farming area.

In addition to this, the Kenya Seed Company developed an immediate relationship with the Kenya Farmers' Association which worked through the various cooperatives in supplying seed and fertilizer. In this way the variety of hybrid seed adapted to a certain area of the country was sold there and not a variety that was suited to some other region. The Kenya Seed Company has had very close control of its distribution. Fertilizer has also been available to farmers through the same commercial channels and has aided in the adoption of the hybrid seed. It has been found in a number of instances that the farmer would not buy hybrid seed unless he could buy fertilizer to plant with it.

4. Credit

The Government of Kenya has had a program entitled Guaranteed Minimum Return (GMR) to the farmer for many years. This guarantee was in the form of a stated number of shillings per acre that the farmer would be guaranteed if he grew a crop of corn. This was administered through a local committee that approved the first advance arranging roughly around Sh100 to Sh150 per acre that the approved farmer could obtain prior to the preparation of his land for planting and the purchase of his seed and fertilizer. In 1966 the GMR rose to Sh180 on hybrid seed corn, but dropped to Sh100 for ordinary corn. In 1969 the GMR is Sh180 for hybrid corn and nothing for regular corn. One disadvantage of this was that the small farmer who had no status in the local community and no record of having grown and marketed a certain volume of corn could not get this GMR. The past two years has seen a slow change and the scrambling of many farmers to get recognition by the local extension officer as being a grower of corn so that he might get the GMR to buy seed and fertilizer

The large-scale farmers needless to say, did not have this difficulty, as they had all been in the marketing scheme through the Maize Marketing Board, and there was a record of their activities. The credit facility for the subsistance farmer is still being improved and worked on by the Government of Kenya which no doubt will assist in the adoption of the use of more hybrid seed by the small grower.

5. Marketing and Storage

There has been very little difficulty in the marketing of corn in Kenya. Since the early 1950s the government has had a guaranteed price per 200-lb bag of corn. They have a marketing board which agrees to buy all of the corn offered. This marketing organization has developed a very sophisticated method, though costly, whereby the small grower can bring his corn in to the various small local markets and sell to a buyer at that point. The buyer grades the corn and bags it and the marketing board makes regular collections with a truck through these various small markets, picking up the corn and paying the local merchant a fee for his purchasing as their agent. Storage has been a factor in the purchasing of corn by the Marketing Board until 1968 when a program was instituted to build storage for over 100,000 tons. This storage is not complete as of this date, but is fast moving in that direction. Whereas large farmers in 1967 had to keep some of their crop back on the farm awaiting storage space, now they are in a position that the Marketing Board can accept the corn as rapidly as it is ready for market.

Kenya has periodically gone through periods of large exports(corn surplus) and periods of large imports (deficits), see Table 7. The in-country purchases of 325,600 tons with subsequent exports of 271,000 tons by the Maize and Produce Board in 1967-68 greatly exceeded any previous purchase or export. These data together with the average yields per hectare shown in Table 2 suggest that henceforth Kenya will have the potential for annual production of corn greatly exceeding the amount required for internal human consumption. Agronomic research and further genetic improvement in the hybrid varieties plus continuing increased acceptance of hybrids and improved practices by the small farmers indicate that greater production of corn can be expected in Kenya in years to come.

Table 7. Corn Handled by the Maize and Produce Board Annually
(metric tons)

Year	In-country purchases (tons)	Export (tons)	Import (tons)
1959-60	150,825	9,132	-
1960-61	144,200	228	17,035
1961-62	149,375	9,168	64,817
1962-63	203,000	87,071	-
1963-64	97,550	53,182	-
1964-65	106,400	-	13,598
1965-66	134,025	-	191,864
1966-67	228,050	63,122	-
1967-68	325,600	271,435	-
1968-69 (est)	(318,000)	(218,000)	-

6. Cooperatives

The Maize and Produce Board has operated somewhat as a cooperative. The wide fluctuations in volume (see Table 1) have caused difficulties together with the disparity in prices between external and internal sales and required government subsidies to make up losses. The small cooperatives, mainly supply and marketing units, have played an important part in the adoption of hybrid seed corn. They have been instrumental in getting the seed and the fertilizer out into the very small communities and have handled the sales on small volume so the benefits of the hybrid seed have accrued to the very small producer. Without this unit the amount of hybrid seed used in Kenya this past year would have been cut by at least 15 per cent to the small producer.

7. Agricultural Education

The important part played by agricultural education in the process of increasing the use of hybrid seed corn has been through those persons in the extension field who have taken Agriculture in Egerton, Siriba, Embu or Makerere. They have understood the value of improved seed and cultural practices through their associations with Egerton College or the various training courses held in the Farmer Training Centers. There has been very little influence of adoption by persons who have actually graduated from a diploma school at Egerton or other schools, as these persons are not producers.

The large farmers who accepted the hybrid seed rapidly and were part-promoters in the actual process of getting hybrid seed into Kenya and developed were white farmers with some education.

F. Weather

Weather has not played a tremendous part in the increased use of the hybrid seed corn as there has been very little change in the irratic rainfall conditions in Kenya. The fact that hybrid seed corn has been developed which will grow in areas with small amounts of rainfall over short periods of time has been an important factor. The short season, early-maturing hybrids developed in the lower altitudes have shown a tendency to take over land areas which were formerly used for sorghum as the farmers prefer corn for food. Corn also has a ready market and any surplus they can produce can be turned into cash.

II ASSESSMENT OF CAUSES

A. Early Activity

The success in the adoption of hybrid corn can to a large extent be attributed to the original impetus given by the large-scale white farmers in the White Highlands of Kenya. These men knew the needs and advantages of improved seed and were instrumental in getting the government to start research work for them in the development of such seeds. When the seeds were developed in 1960 there had already been formed a small private company composed of some of these same farmers for the production of grass seed. It was relatively easy for this private company to take to the idea of producing hybrid corn since there was a ready market among the large-scale farmers for a quantity of hybrid seed sufficient to warrant the private industry investment in its development. The fact that considerable initiative towards the development of hybrid seed came from the producers was a stimulating factor and the government was not the promoter but more the implementor of desires arising from the farming community.

B. Stimulators

1. Market

The importance of a ready market at a fixed price for the corn cannot be over-emphasized in the cause of development. The large-scale farmers could raise extensive crops such as wheat and corn on their large estates and without a ready market they would not have been interested in promoting additional yields and acreages. The small-scale farmer also found that any surplus corn he had he could take to the market and get cash for it, whereas none of his other crops were readily marketable.

2. Education

With the advent of independence there spread across the country the importance of education. Every family wanted their children to receive some education. The government instituted a policy whereby each family must pay a certain school fee for any child going to primary school. This combination of desire for education, and requirement for school fees stimulated many families to grow an extra acre or two of corn. They knew there was a ready market for the commodity and they could get cash for it. This requirement for school fees also caused development within the subsistance communities by bringing these families more and more into the cash economy of the country, after they once had experienced a little cash in their pockets.

3. Extension

The development through the extension service of the small demonstrations in the reserve communities was a stimulus which added to the above causes and produced the effect that farmers soon saw that they could grow more corn on the same acreage without any more labor. One of the greatest drawbacks in this was in the matter of finding enough money to obtain the seed but the demonstrations caused the desire which has been found to be so great in cases that families went without sufficient food for a time in order to use the funds to buy the hybrid corn, realizing fully that they would obtain a bigger crop from it, than if they used their own seed.

4. Overall Assessment

In order to fully give credit to each step and factor of the development in Kenya one must say that it was the inter-relationship of the various factors, and the working together of government with private enterprise that caused the great advance, in the use of hybrid seed corn to date. On its part, the Government has maintained a reasonably high price for corn and fully supported the research work. Private enterprise on its side, through the efforts of the Kenya Seed Company and the institutions distributing fertilizer and seed made the inputs readily available. The extension service consistently demonstrated the importance of the hybrid seed and improved cultural practices. Finally, the fact that there was a ready market for the product added to the farmer's willingness to take the risk of growing it.

III The Role of USAID

A. Policy Influences:

U.S. Influence has shown up in this development in many ways. The U.S. offered Kenya U.S. scientists in research, soils and other activities, as early as 1955. In 1962 USAID sent important leaders to the U.S.A. for observation tours on how crops were grown in the U.S., marketed, and how U.S. educational institutions worked, with special emphasis on the extension service. We were then able, at the request of the GOK, to bring a team of extension specialists to Kenya to work with the local people on the development of an extension activity in the Ministry of Agriculture.

This extension team slowly built the foundations of an extension service through which the vital result demonstrations could be planned and promoted, without this background it would not have been possible for the field service to fill the gap and stimulate the small growers in the use of improved seeds. This same extension service developed the Home Economics and 4-K activities which have increased to very large proportions and are continuing to be a factor in improving agricultural production, not only in corn, but in other commodities as well.

AID then supplied research scientists in soils fertilizers and agronomy. A corn geneticist under the AID/USDA project was supplied in July 1964 to work with the scientists at Kitale Research Station. This close association with the Kenyan research staff has been a most important activity in the development of the more recent high-yielding hybrids. The U.S. influence has consistently followed the line of assisting the Kenyan counterparts in seeing the advantages and developing new ways and never procuring them into an activity.

B. Capital Inputs

USAID's contribution for seeds, fertilizer and general supplies to the hybrid seed corn program has been relatively insignificant, insofar as direct contribution has been concerned. AID's principal capital input has been through its assistance in building up the institutions which have aided in the adoption of the hybrid seed varieties and the movement of the African farmer into the cash economy. AID has supplied approximately $135,000 in miscellaneous supplies, equipment and assistance to the Kitale Research Station for the work of the one scientist that we have had stationed there during the years 1964 to 1969.

During the 1966 season it was determined that Kenya needed more storage space for its corn crop and the U.S. Mission agreed with the GOK that they use 425,000 dollars of the PL 480, Title IV funds for the building of forty cyprus bins. These are partially underground storages hermetically sealed, holding 1,500 tons each. At the present time there are only two of these bins in use as the government has been proceeding very slowly in the building of them and in their operation.

C. Technical Assistance Inputs

The technical assistance which AID has given to Kenya since the first technician arrived on August 1, 1957, has been of such a nature in its influence on the adoption of the hybrid seed corn varieties that it is difficult to evaluate. The influence on the research institution of Kenya was very pronounced by the arrival of the Land Classification scientist in February 1958, the soil chemist in Aug. 1957 and this being followed by a soil physicist and a soil mineralogist from 1961 to 1966.

The methodology and organization of research that was effected by these scientists during the periods they were in Kenya had a vast impact on the extent to which the research organization was developed and spread to different ecological zones of the country.

In 1962 AID supplied a technical team of extension advisors, comprised of a general extensionist, a communications visual aids specialist, an an extension training specialist, a rural youth specialist and a home economist. This team of specialists helped develop a field service together with a field training organization for extension in Kenya. It was through their training efforts that the African extension organization learned how to put on successful result demonstrations. This paved the way for the 5,000 demonstrations put on in different parts of the country in improved corn varieties and cultural practices.

AID assisted the GOK in the development and building of fourteen different farmer training centers throughout the agricultural areas of the country. These training centers became focal points for training, not only of extension officers, but the more progressive subsistent farmers in new methods of agriculture and the importance of improved seeds.

The rural youth advisor made excellent progress in developing a farm youth progrem known as 4-K and started the first club in April 1963. These clubs grew rapidly and in two years time there were over 300. The young men and women in these clubs soon learned the importance of proper cultural practices and improved corn seed so that their activity was a motivating factor in getting many of the old subsistent farmers to change and grow the new hybrids. The 4-K activity is still growing with more than 3,600 clubs in the country today.

AID supplied technical assistance to the Cooperative movement in the years 1963-66 during which time a foundation was laid for organization of district unions and for better control of the cooperatives monies. This allowed for the small marketing cooperatives to handle certain agricultural inputs at the small community level. The Nordic Group who came in with a very extensive program to assist the cooperative movement by supplying fifty specialists has continued the development that was started by U.S. technicians.

D. Overall Effectiveness and Lessons

The success attained in the rapid adoption of hybrid seed corn in Kenya has been largely due to the side-inputs that AID has made into the over all agricultural development of Kenya. I believe AID's role in extension development and early research activities was more important in the final adoption of hybrid corn by the small producers than the process of breeding the improved varieties. One without the other would not have been as successful. AID's influence through sending African participants to the States to view U.S. agriculture and in attending our universities was no small factor in the overall acceptance and support that this program received from government personnel.

Every country is different in the state in which its farmers are moving or are being motivated. There must be some motivation on the part of the producer together with a will to move and do something before progress can be made. The fact that hybrid seed corn was partly known and developed before independence of the country was an important factor. During the years 1960 to 1963 the African farmer started to awaken to his role as a member of the community. As President Kenyatta took office and assumed the reins of the government of the country in December 1963, one of his first directives to his people was to increase the production and work the land. From our experience in Kenya we find certain basic stages that people go through which assist in getting them to adopt improved cultural methods and use hybrid seed. They are briefly as follows:

1. The first is creating a desire on the part of the producers to raise more produce and to improve their livelihood.

2. There must be sufficient research to determine the improved seeds and cultural practices that should be used in the different ecological zones to obtain increased returns.

3. There must be a sufficiently well organized type of field service to reach into the small communities and to show the producers through result demonstrations the advantages of these improved seeds and cultural practices.

4. There needs to be a ready market for the crop as it is harvested and some assurance of a reasonable price. The farmer must be able to see where he can immediately turn his crop into money.

5. To continue in developing, there is the need for the ready availability of the required inputs into the production. The improved seeds, fertilizers, hand equipment etc., must be close to the farms and available at an economic price.

6. As the farmer shows signs of increasing his output there needs to be available a source of credit to him at a reasonable rate with repayment scheduled to the time he can expect to sell his crop.

E. Operational Problems

USAID's role in the implementation of the hybrid seed corn program cannot be considered as a direct one. We furnished a corn geneticist who came in after the hybrid seed program was started and assisted the Kenya government in improving its corn breeding methods. This assistance has resulted in the obtaining of higher yielding hybrids more rapidly than could have been anticipated before with the methods that were previously being used. The indirect role that AID has played in the building of institutions is of far greater importance to the overall effectiveness and progress of the program than that of the breeding activity. However, the corn geneticist did assist a great deal in building up the adaptation trials in the different ecological areas so that the extension service had a well-founded, proven research recommendation back of them when moving into the result demonstrations with the farmers. His activities with the Kenya Seed Company in advising and encouraging them was another major factor in the willingness of that company to play its important part.

The success of the program from an operational standpoint was contributed to by the excellent cooperation from the cooperating country in addition to the cooperating agency in East Africa, the East African Agriculture and Forestry Research Organization, where funding and operational support was arranged. The Mission's close connection with the project to maintain administrative support and iron out small problems that arose from time to time was a valuable contribution to the overall coordination with the government agencies.

IV Social, Political and Economic Considerations

A. Differential Adoption of New Technology

The large-scale farmers took to the high yielding hybrids immediately as they themselves were part of the motivating force which caused the development of the improved seed. They had continued close contact with the research station and the performance of the hybrids. They also adopted the cultural practices which were so quickly shown as being important factors in getting the desired improved yields. They were growers of large acreages and any improvement in yield made a considerable impact on their income.

The small-scale farmers have taken to the use of hybrid seed corn due principally to a number of factors, namely:

(1) extension demonstrations showing increased yields.

(2) a Guaranteed price for the corn

(3) A ready market for the crop.

The availability of the hybrid seed and fertilizer close to the farms was a more important factor in the increased number of small farmers choosing the hybrid seed. Greater use can be expected also because of the government's new policy that the Guaranteed Minimum Return for corn can only be given on a hybrid crop. None ofthe farmers will be able to get this GMR for the common seed corn.

B. Differential Availability of Inputs

The first adoption of the hybrid seed by the small farmers took place around the research station and close to the large farming area. This proximity of information in addition to the fact that the improved seed was available at those points was a big factor in early adoption by the subsistent farmers.

C. Employment Effects

The hybrid corn program has not caused any great increase in employment. The women of the families have historically been the ones to plant and take care of the crop. The men have helped the women in the initial period of turning the land from the sod, so that the land could be planted. As the small farmer started to raise an additional acreage, it meant that the same family labor was used but worked a little longer. On some of the middle-size farms that have evolved we are now finding where the owner is hiring some local labor for weeding and cultivating of the crop in order to maintain the cultural practices at a high level.

The requirement for early planting has also shown an increase in the number of middle-size farmers who are now living tractors to plough the land. The government has a mechanization program in a few regions and there is a decided increase on the part of the former small farmers to hire a part of their land ploughed. We are finding where the family is still turning over an acre of land and possible hiring another 1½ to 2 acres ploughed by the government or a local farmer.

D. Income Effects

One of the motivating factors that caused the increase in the utilization of hybrid corn seed was for the farmer to obtain enough funds to send his children to school. This is still very dominant. Beyond this level, there are progressive farmers showing up who are using their money in different ways. One group is seeing that the wife and the man of the family are getting somewhat better clothing, then there is a certain percentage of the families that are saving their money and starting small stores in the isolated communities. There is a decided change in the small community center which formerly had one or two Asian dealers among a total of six stores. We now find that there are 10-12 stores being operated by Africans. Usually one of the Asians has left and the other is going to leave in a short time.

It must be mentioned that a certain group of the farmers who have been successful are spending their additional income on drink and for moving about the country. This, however, is a relatively small percentage of the total.

E. Social Effects

Since the man has historically been the principal person holding the money in the family, we find this continuing a nd there is some tendency towards the man taking a second wife so that he can increase the lands that are being worked and raise more corn. It is also found that the area of social contact is being extended and more people are visiting the larger centers of population as a result of their having more capital. Just how much of this can be attributed to the increased income from hybrid corn is difficult to say, but there is no doubt it is a contributing factor. A very rapid africanization of small business is taking place. The small farmer is anxious to obtain information to move ahead and improve himself and his family. This attitude of progress is permeating the entire social structure of the country. It seems more pronounced in areas where there is more income, but it is now difficult to find many locations in the cropping area of the country where this spirit is not existant.

F. Political Effects

The large farm operators have generally lost political influence during the past seven year period. This has not been due to the hybrid seed corn program that they carried, but more in the overall political aspirations of the native farmers and the rulers of the country. The small growers are more in the lime light and politicians are trying to do more for them. It is noticed that as the small growers, such as those who raise increased acreages of improved corn, have more money and move about in a wider sphere of communication with their neighbours, there seems to be a strengthening of political stability in the area. When a farmer realises what improvement he can make on his farm with little changes he becomes part of a broader community and is interested more in the affairs of the country. He is not as easily swayed by demigods.

G. Economic Costs

1. Substitution Effects

There is no real substitution for corn on the subsistent farmers' lands. Wheat can be grown on larger farms as a substitute for corn. However, if one would turn to Table No. 1, the relationship of the acres of wheat and acres of corn grown on the large farms since 1958 is apparent. There has actually been very little difference. Certain scientists and statisticians have pointed out that Kenya could look forward to the time when it would produce all of the corn required for internal consumption on half the present acreage. This time is a long way in the future, as so much of the corn is grown in small plots and these small farmers will necessarily continue to raise corn on these plots for their own consumption and depend on some surplus for their cash needs. Many of these farmers now raise a small amount of coffee, tea, passion fruit, or pineapple on their farms, depending on the area of the country, however, they are still continuing to raise the same amount of corn, or slightly more, with the improved seeds.

2. Foreign Exchange Costs

The foreign exchange cost in the development of the hybrid seed corn program has been very minor in relation to the total. Corn has been a foreign exchange earner for Kenya periodically over the past fifteen years. This does not mean that the government has not lost money on the export of corn, but it has earned many thousands of Kenya £s in hard currency. The following Table gives a report prepared by the Ministry of Economic Planning on loss through export of corn by the Maize and Produce Board.

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TABLE 8

Maize and Produce Board Statement of Losses on Corn

	Accumulated Losses as at Aug. 1, 1967. (£.m)	Losses to be collected Aug. 1.67 to July 1 1968 (£.m)	Losses incurred Aug. 1, 1967 to July 30, 1968 (£.m)	Estimated Accumulated Losses July 30, 1968 (£.m)
1. Imports	18.0	1.6 m bags x 4.50 = 7.2	-	10.8
2. Export 1966 crop	-	-	1.1m bags x 15/50 = 17.1 0.9m bags x 17/50 = 15.7	32.8
3. Exports 1967 crop	-	1.6m bags x 9.00 = 14.4	2.2m*bags x 15/50 = 29.7 0.2m bags x 11/00 = 2.2	17.5
4. Other Board Losses	0.1	1.6m bags x 0.5 = 0.8	-	+0.7
	18.1	22.4	64.7	60.4

*All of the export surplus may not have been sold by June 1968 and the contingent loss shown may now all have been debited to loss account.

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Investigations are now proceeding to determine how the marketing costs of corn can be reduced. Kenya farmers can produce corn in competition with world producers at $23/- per bag. The price for the 1969 crop is $25/- assured. Preliminary estimations are that the marketing costs can be reduced so that corn can be sold by Kenya on the world market and clear all costs with a producer price of approximately $24/- per bag.

V Projections

A. Self-sufficiency

Kenya farmers have already reached the stage where they are producing sufficient corn for the internal demands of the country. Kenya will be an increasingly larger exporter of corn over the next decade, provided the dynamic action that is now taking place in the country continues unabated. The speed with which the government solves the handling cost of corn from points of production to shipside at Mombasa will greatly affect the volume of these exports.

The government of Kenya has established the policy that farmers must be prepared to meet the price of world competition in crops that are exported. They seem to be approaching the problem realistically from both the angle of input costs and costs of handling to export. The trend that has started can easily result in Kenya having an average of over five million bags of corn per year for export over the next decade.

There is a far-reaching transition taking place in the small-scale farming areas of this country. There is a vitality for change among the producers that is resulting in the production of more food and fiber than any of the earlier estimates conceived of. These five and a half short years of independence have produced an awakening among the small Kenya agricultural producers that will, in the next few years, uproot many of the old pricing and marketing procedures.

B. Assistance to Hybrid Corn Program

Since Kenya is undoubtedly self-sufficient in the production of corn one may ask why we continue our assistance. The assistance that we are giving here is for the benefit of East Africa. We need to continue our corn geneticist for a period of at least two more years in order to assure that there are trained Africans who can take up these positions and carry on a program of improved seed development, for the future. The development of hybrid corn seed at Kitale, Kenya, is having a far reaching development effect in Malawi, Congo, Zambia, Somalia, Tanzania, Uganda and Ethiopia. Improved seeds are being sent to these countries for trials and adaption.

This station is collecting important corn plasm from many parts of the world and using it in breeding new hybrids that are adapted to the different regions in Eastern Africa. African scientists should, and are being trained, who will take this program and carry it on in producing new seeds that will be superior to any now being grown.

Another important reason for the presence of a corn geneticist here is the breeding work necessary for the incorporation of the high lysine genes Opaque 2 and Flory 2 into all of the hybrid varieties. Lack of protein is one of the biggest deficiencies in the diet of the East African people and it has been found that the incorporation of the high lysine genes will increase the protein content of corn for human consumption by 20-40 percent. This program has already started and it is anticipated that the first general distribution of the high protein hybrids will be available in the Central and Eastern Provinces of Kenya for the 1970 crop. It will be year to two years later before they are available for the higher altitude, longer-growing season hybrids. This development will be of such enormous benefit to human nutrition that no one can truly estimate its value.

RESEARCH

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(The following section on corn research in Kenya is excerpted from the Global Crop Paper - Corn, another paper prepared for the Spring Review of the New Cereal Varieties. Dr. Eberhart was formerly stationed at the National Agricultural Research Station at Kitale, Kenya, as a menber of an A.I.D. research team.)

29. A more useful breakdown from a research worker's point of view would be Plant Breeding Research and Agronomic Research. A sound research program includes both basic and adaptive projects. But the research itself falls into the category of breeding or agronomic practices, each of which requires a different staff and project orientation.

BREEDING RESEARCH

30. Breeding research is the foundation of corn improvement. Although agronomic practices will usually give greater increases, it is usually not possible to get the small-scale farmer to change his agronomic practices unless you have some sort of lever. An effective extension program properly oriented can convince him that, like a new crop, this new variety can not be handled in the traditional fashion.

31. Synthetic varieties and variety crosses produced from very divergent source materials have a wide range of adaptation and can often be used over wide areas within similar ecological zones. The factors that seem to determine adaptation in corn are altitude, length of rainfall season, daylength, and diseases and pests. Corn breeding centers should be operating in each of the main ecological zones in Africa, Asia, and South America. Formerly the Rockefeller Foundation and now CIMMYT has a major International Program of Maize Improvement centered in Mexico City with additional programs in Colombia, Thailand, Nigeria, and Kenya. Any expansion in maize breeding should be in close cooperation with CIMMYT utilizing their experience and resources.

32. The AID-ARS major Cereals in Africa Project is an example where it has been necessary to supplement CIMMYT's activities. Although improved varieties and hybrids had been developed in Kenya prior to the initiation of this project, the AID-ARS research has increased the efficiency of the previous program and extended the results throughout Eastern Africa.

33. The traditional inbreeding and hybridization method of corn improvement in the U.S. made large initial gains, but has made very little progress in more recent years. Basic quantitative genetic studies in the U.S. have shown that the development of corn populations (varieties) and population improvement through recurrent selection must be the basis of modern breeding programs. The project in Kenya has been most useful in obtaining information on how to increase the efficiency of recurrent selections and which methods are most effective under different conditions. This information has been disseminated throughout Eastern Africa and to Nigeria; and the breeders working in the national programs are making use of this information with a great increase in the effectiveness of their breeding programs. Since corn is a major food crop in East Africa, most of the countries have national breeding programs with varying levels of experience and size of projects. Kenya was chosen as the location of the AID-ARS research activities because of the strong maize breeding program of the Kenya government assisted by the Rockefeller Foundation and the British Ministry of Overseas Development. The contribution by AID has not only strengthened Kenya's program; but as mentioned above, has had a big influence on the programs of surrounding countries. As Kenya has been able to provide her own maize breeders, the former Kenya

maize breeder, Mr. Harrison, has now been employed by CIMMYT as the Regional Maize Coordinator. The success of the regional program has been due to the close cooperation of the AID-ARS and CIMMYT personnel.

34. A few of the results from the Kenya and Mexican breeding programs will illustrate that large improvement can be made in corn varieties. In most developing countries the improvement has been even greater than in Kenya where the large scale European farmers had done considerable variety improvement on their own farms by mass selection prior to the initiation of the breeding program by the Kenya government in 1955. The results of the yields from the national maize variety trials in 1966 and 1967 are shown in Table 5. Kitale II was the first synthetic variety developed and in previous trials has proved to be 7 to 8% superior to the best farmers strains in use in European farming areas. H622 and H632 are a double cross and a three-way cross hybrid developed by the traditional inbreeding and hybridization method and they show the usual 25-30% superiority over the parental varieties. The variety cross hybrids H611B and H613B show similar or even greater superiority. As evidenced from the experience in the U.S. and Rhodesia, it would be very difficult by traditional breeding methods to produce further improvement over H622 and H632 by selecting new double crosses or three-way crosses from the same breeding material. However, a variety-cross hybrid can be used to make available to the farmers the improvement in the parental varieties obtained by recurrent selection. The first variety-cross hybrid, H611, is the cross of Kitale II and Ec. 573. Ec. 573 is a race collection from Ecuador from the race Montano. Ec. 573 was improved by 1 cycle of selection in the AID-ARS breeding method evaluation program to produce Ec. 573 (E1) C1 and Kitale III was the next cycle of selection by Mr. Harrison. Kitale III x Ec. 573 (E1) C1 (H611B) shows a 10% superiority over the original 611. Figure 1 illustrates the improvement that was made in the AID-ARS reciprocal recurrent selection program. Since Ec. 573 was an unadapted variety, very great improvement was made in the first cycle of selection, but less improvement is expected in subsequent cycles. However, quantitative genetic theory indicates that similar improvement can be made for a rather large number of cycles. Hence, an effective breeding program will produce even greater genetic superiority of synthetics and hybrids over the unimproved varieties previously available to the local farmers.

Table 5. Yields of the National Maize Variety Trials in Kenya (q/ha)

Variety	1966 (27)	1967 (22)	Mean (49)	% of Kit. II
Kitale II	46.2	53.0	49.6	100
H622	58.1	68.9	63.5	128
H632	61.2	68.4	64.8	131
H611B	61.9	69.7	65.8	133
H613B	67.0	71.1	69.0	139

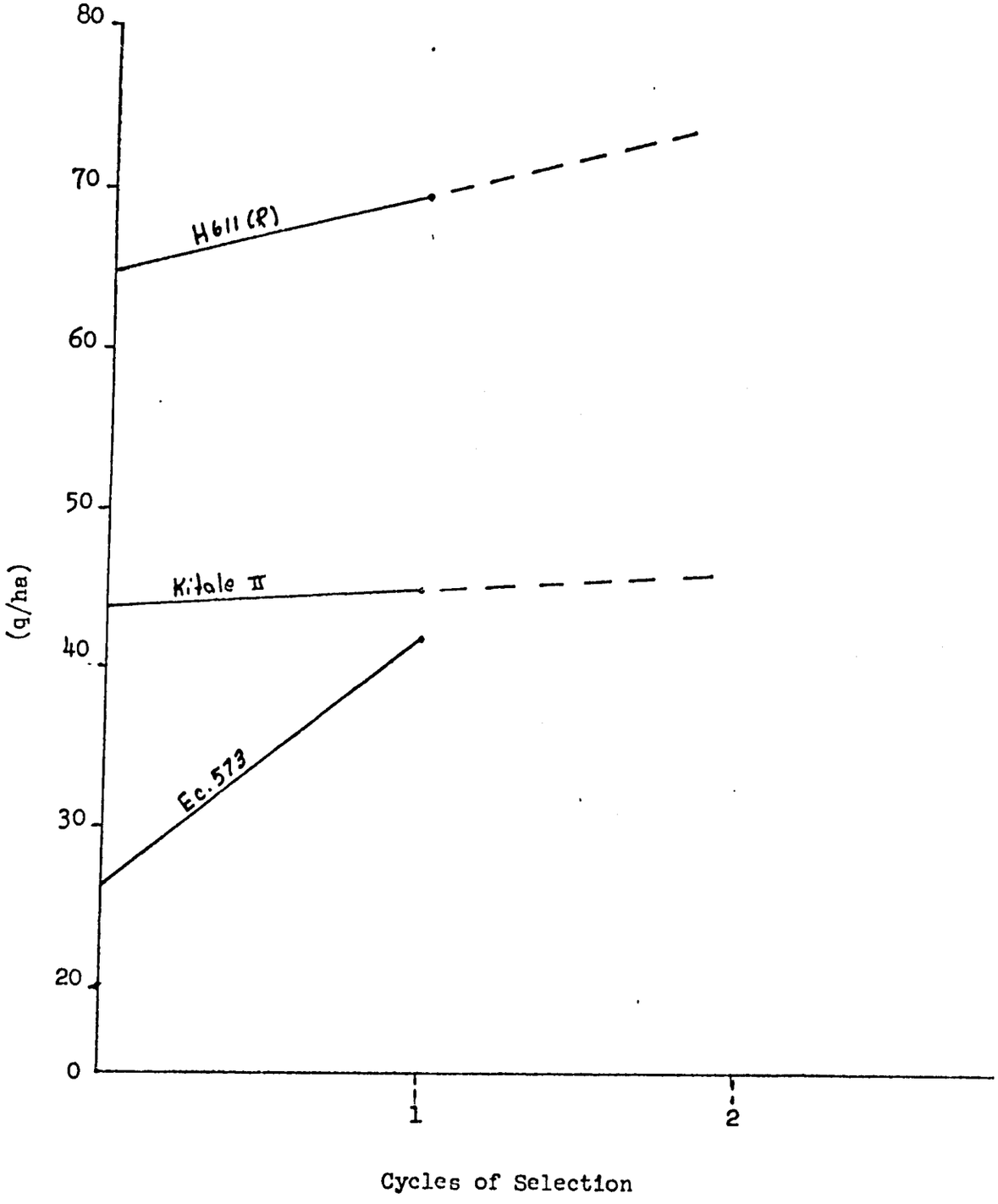

Figure 1. Improvement in Kitale II, Ec. 573 and H611 by 1 cycle of recurrent selection under average conditions at 6100 feet.

Similar progress has been made in V520C (Tuxpeno) in Mexico by mass selection as shown in Figure 2. But this improved variety has not been utilized in variety cross hybrids as yet. Thailand introduced an improved variety, Tiquisate Golden Flint, developed at the Tropical Research Center in Antigua, Guatemala from a variety cross--Cuban Yellow Flint x Guatemalan Dent. Further improvement in yield and percentage flint kernels are being achieved by recurrent selection in the Thailand Research Program. The possible use of this material and other material in variety-cross hybrids is also being investigated.

35. Figures 3 and 4 illustrate the value of the basic investigations by the AID-ARS program. Under conditions that exist at Kitale in which 3 seasons can be obtained in 2 years with dry season irrigation, S_1 testing is considerably more effective than full-sib testing. However, in conditions that exist at Mwanza, Tanzania, where they can get 2 seasons each year with irrigation, full-sib selection becomes much more effective than S_1 testing.

36. The Comprehensive Breeding System proposed by Eberhart, Harrison, and Ogada (Der Zuchter 37: 169-174. 1967) gives flexibility in that both improved synthetic varieties and hybrids can be produced from the same breeding program. There is considerable debate whether or not improved synthetic varieties or hybrid varieties should be used in corn improvement programs. In Kenya and in most countries where maize has been the traditional food crop, very little improvement has been obtained in corn production until the hybrids have been brought in as a lever to stimulate improvement. In contrast to this Thailand is now getting very good average yields from the introduced Guatemalan Flint varieties. But corn was not a basic food crop in Thailand, and, consequently, there was not the problem of changing the traditional methods of production. Hence, as acreage of Guatemalan Flint varieties was expanded to meet the new market for livestock feed in Japan, the farmers could be encouraged to use improved cultural practices in new areas. But there is now a major breeding program in Thailand under the direction of Dr. Ernest Sprague of CYMMIT and staff of several local Thailand research workers. The development of hybrids with a greater response to improved cultural practices can result in even greater increases in average production, if these are used as a lever to stimulate the further use of fertilizer and higher plant populations.

37. When the seed is efficiently produced by a private company, the additional cost per acre of hybrid seed over unimproved or improved seed from a neighboring farm is very small compared to the total cost of production with fertilizers.

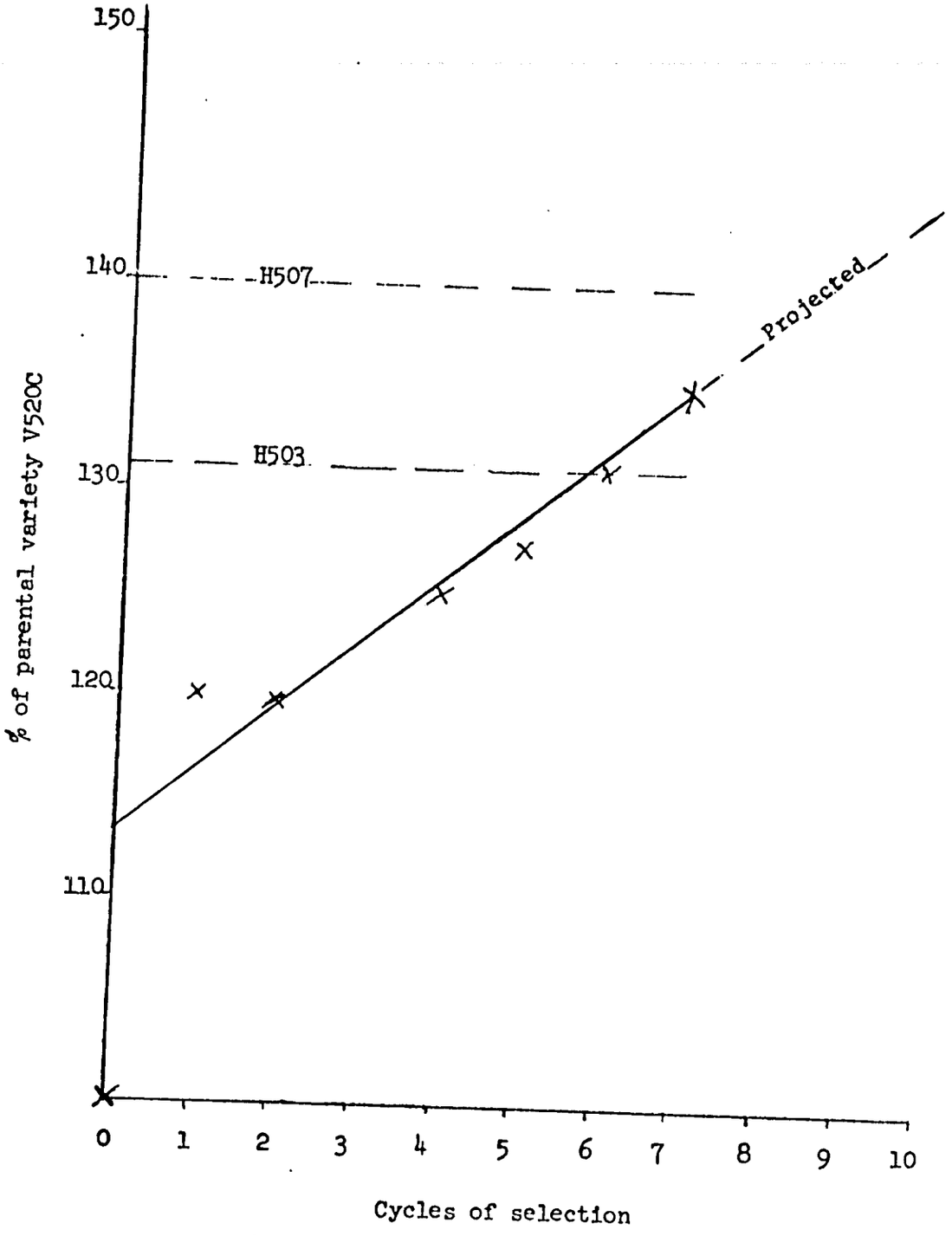

Figure 2 . Improvement of V520C through 7 cycles of mass selection from evaluations with 20 replications in 1965, 1966, and 1967.

Extracted from the 1967-68 CIMMYT Report

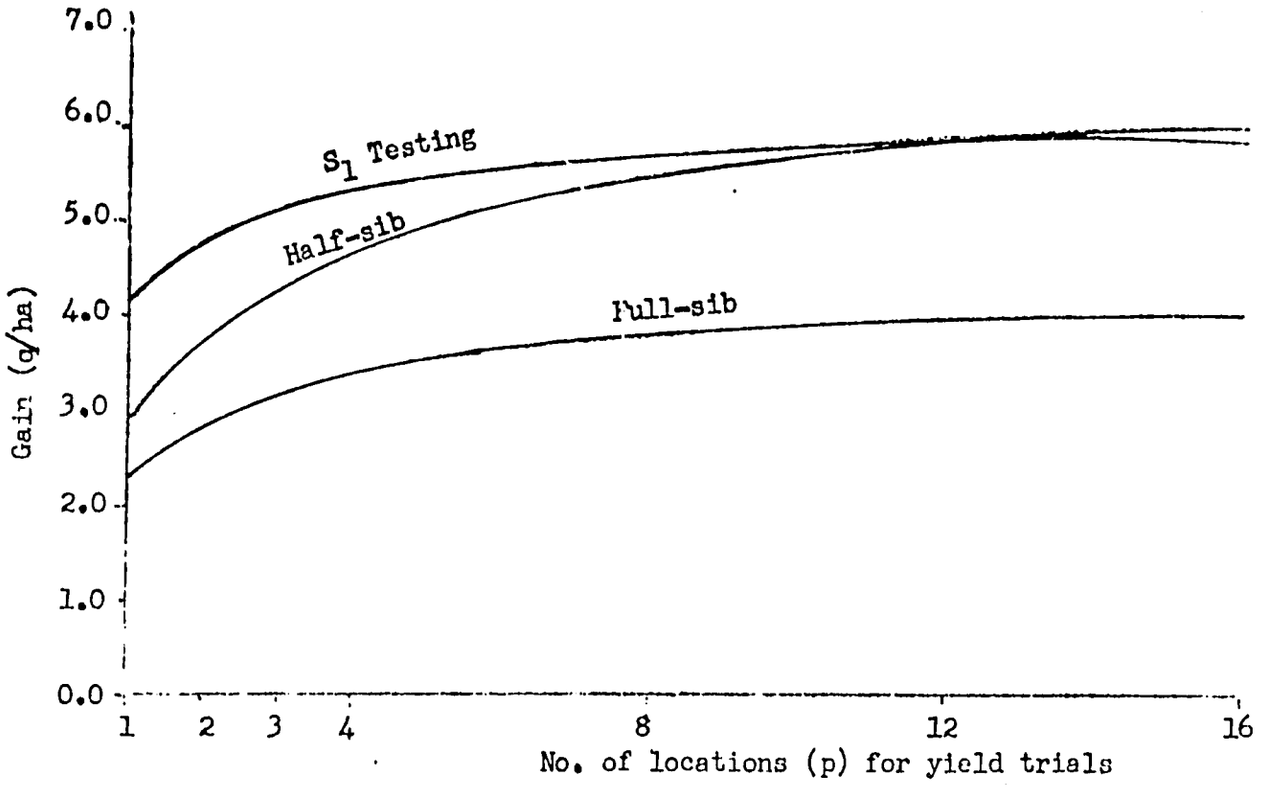

Figure 3. Expected annual gain from selection in KCA with 3 seasons in 2 years.

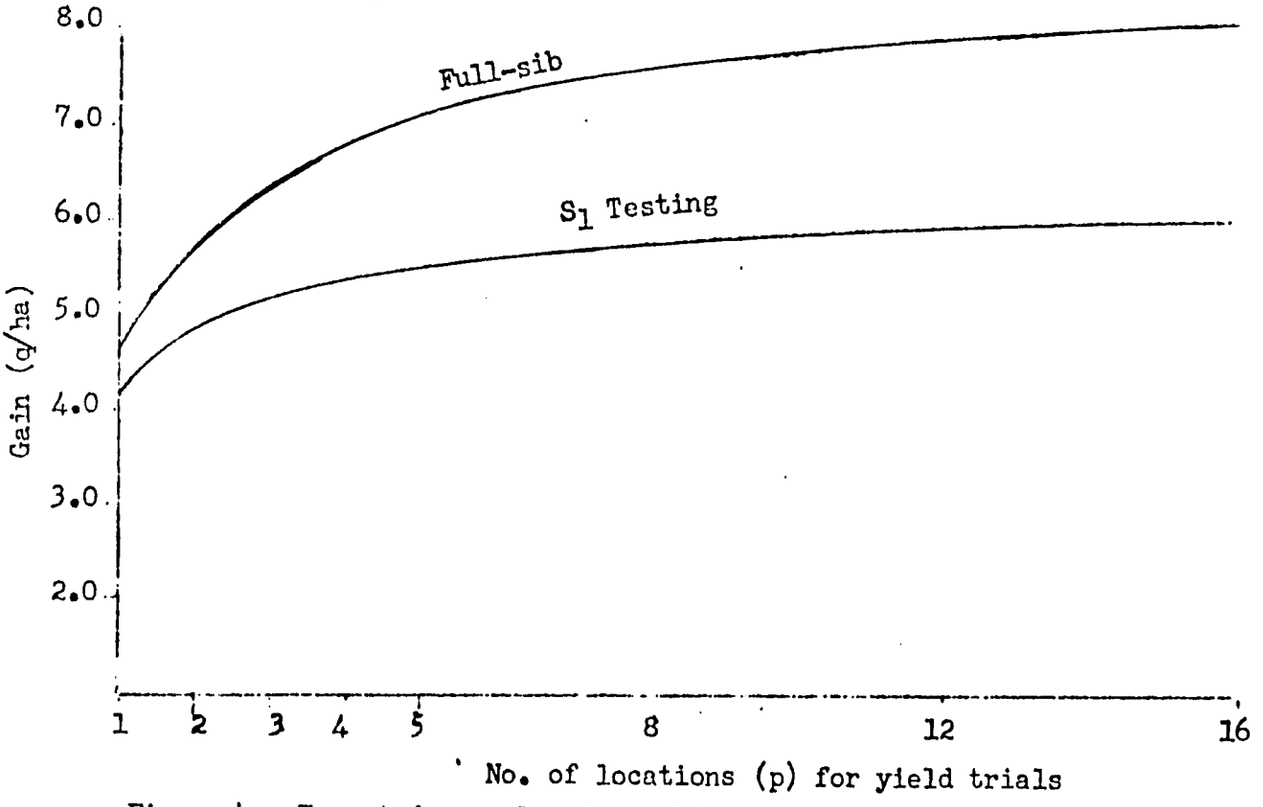

Figure 4. Expected annual gain in KCA with 2 seasons per year.

If the farmer has to spend money for seed, he feels that this is a valuable crop which requires considerable attention: i.e., the hybrid must go on his best land and have fertilizer, it must be early planted with the proper plant populations, clean weeded, etc. On the other hand, if he gets his seed from his own field or from his neighbors (even though it is an synthetic variety with considerable potential when grown under the same agronomic conditions) there is nothing special about it because it costs little or nothing extra and he soon reverts to the traditional methods of production. This tendency to revert to the traditional methods can be overcome to a certain extent if the improved synthetic variety has distinctive morphological characters such as dwarfness of the wheat and rice varieties or as the Katamani corn synthetics in Kenya. These Katamani synthetics were much shorter and earlier and were very distinctive from the previously grown local varieties. Hence, the extension service was able to establish this as a "new crop" that required different agronomic practices than the old varieties even though seed was saved from the previous crop.

38. Once hybrids have been introduced and they are being utilized, it is very simple to get new improvements in the hybrids to the people. When there is an effective breeding program producing genetically superior variety-cross hybrids every one or two years this aspect becomes very important. Also hybrids make it very much easier to produce materials with improved nutritive value such as high lysine corn which will be available with the opaque-2 and floury-2 hybrids. This is also true with the disease resistant varieties which are developed to combat the spread of new diseases.

39. The development and introduction of high lysine corn varieties is an extremely important program for Africa and South America where corn is the basic food crop. As soon as these new hybrids have been developed they can be used as the lever to get the improved cultural practices adopted. These varieties will provide good promotional material for launching a corn improvement campaign. Care must be exercised, however, to make sure that the taste and texture are acceptable and that these new varieties are truly adapted.

40. As part of the regional maize corn improvement program, the CYMMIT regional coordinator and the AID-ARS maize geneticist obtained the cooperation of all corn research workers and established the Eastern African variety trials in 1966. It has been expanded even further in 1967, 1968, and 1969. The results from the

1967 trial are shown in Table 6. Below 6,000 feet, the Kenyan hybrid H632 and the Zambian entry SR52 (a single cross developed by Rhodesia) have given uniformly superior performance and have greatly out yielded all local farmer's varieties. SR52 is sold only in Rhodesia and Zambia, but the Kenya Seed Company has been expanding their sales effort greatly and have been selling H632 in Ethopia, Tanzania, Uganda and even more recently have investigated the possibility of selling seed in the Eastern Congo. Above 6,000 feet the Kenya variety cross hybrid 613B will give the best yields and is recommended wherever the rainfall season is long enough. H511 was developed by the AID-ARS maize geneticist at Kitale for areas having a shorter growing season than the H632 or H613B require. This medium-maturity variety cross hybrid was released in Central Kenya only 3 years after initiation of the project. Yields in the East African variety trial were very good for the most part, indicating that other factors such as late planting, low plant populations and levels of fertility were not limiting the expression of the potential of the improved variety. The one exception to this is perhaps Uganda where additional agronomic research and more careful attention to the yield trials is required to get the maximum potential from the improved varieties.

41. A similar regional trial has been established in West Africa by Dr. J. Craig at Ibadan with the AID-ARS Major Cereals in Africa project. Results from 4 locations in 1967 are given in Table 7. No hybrids are currently available in Western Africa and the yield levels at all locations are extremely poor indicating that other agronomic practices are also limiting yields. Considerable agronomic research is required to identify these limiting factors and to find economic methods of removing these limitations. The AID-ARS team at Samaru, Nigeria is making considerable progress in this area.

42. Similar trials are being conducted in Central America under CIMMYT coordination. Results from 15 locations in 6 countries in 1965-66 are given in Table 8. Yield levels are moderately high with considerable superiority over the local unimproved variety for all maturity groups.

Agronomic Research

43. Most administrative and research personnel without experience in developing countries assume that the only requirements for increased corn production are an improved variety and fertilizer. The error in this assumption has been demonstrated by the investigations conducted by Mr. A. Y. Allan on several farms near Kitale,

Table 6. Yields (q/ha) from the Eastern African Variety Trial in 1967.*

Variety	Ethiopia (3) mean	Ethiopia (3) % of Local	Uganda (8) mean	Uganda (8) % of Local	Central Kenya (3) mean	Central Kenya (3) % of Local	Western Kenya (3) (1200-1500m) mean	Western Kenya (3) (1200-1500m) % of Local	Western Kenya (4) 1800-2100m mean	Western Kenya (4) 1800-2100m % of Local	Weighted Average
H 632	79.1	167	44.1	152	68.4	150	68.8	138	52.3	127	57.7
SR 52	73.2	154	46.8	161	69.1	152	72.2	144	40.0	97	56.0
H 613B	69.2	146	35.2	121	65.6	144	67.5	135	61.5	150	54.0
H 511	52.3	110	35.2	121	63.3	139	46.3	93	43.1	105	44.8
LH 11	37.9	80	40.0	134	51.5	113	44.0	88	19.1	46	37.9
SV 28	37.7	79	37.5	129	47.6	105	40.2	80	23.4	57	36.7
Local syn.	50.5	106	33.1	114	49.9	110	50.0	100	41.1	100	41.9
Local	47.5	100	29.1	100	45.5	100	-	-	-	-	-
Katumani	42.2	89	31.0	107	38.5	85	38.2	76	25.1	85	33.6
L.S.D. .05	14.8	-	4.5	-	12.0	-	20.8	-	14.2	-	-

*Recommended hybrids are underlined. SR 52 is not available in East Africa

Table 7. Yields (lbs/acre) of 1967 West African uniform maize trial entries at 4 locations.

Entry	Origin	Senegal	Dahomey	Upper Volta	Nigeria	Mean*
Composite						
Jaune D'Ina	Dahomey	2536	2715	2300	3448	2750 a
Massayomba	Upper Volta	2341	2800	2320	3250	2678 ab
Aldiobla						
Mais Blanc	Upper Volta	2581	2460	2360	2681	2520 ab
NS 5	Nigeria	2492	2310	1800	3127	2432 ab
NS 4	Nigeria	3097	1850	1540	3003	2372 abc
NS 1	Nigeria	2127	2260	1495	3052	2233 abc
Darsalam	Upper Volta	2314	2100	2040	2442	2224 bc
ZM 10	Senegal	2848	1810	1440	1460	1890 cd
Jaune Flint						
De Saria	Upper Volta	2358	1550	1520	1039	1617 d
Mean		2522	2206	1868	2611	2302

*Means that do not have an alphabetical letter in common are significantly different at the 5% level. Means that have an alphabetical letter in common are not significantly different at the 5% level.

Table 8 . Results of regional trials grown at 15 locations in 6 Central American countries.

Variety	Origin	Yield Tons/ha	Days to flower[1]	% of tester[2]
Late				
Hibrido semi-cristalino	Mexico	4.17	59	103
H-507 (Check)	Mexico	4.04	61	100
H-1 Experimental	Venezuela	3.96	57	98
Tuxpeno Synthetic	Honduras-Mex.	3.52	60	87
Diacol 154	Colombia	3.52	58	83
Poey T-66 (yellow)	Poey Seed Co.	3.62	59	87
Intermediate				
Composite E.S.1	El Salvador	3.30	56	96
H-5	El Salvador	4.60	55	134
H-4 (Check)	El Salvador	3.44	56	100
Yellow Composite	El Salvador	3.52	55	102
H-3 Experimental	Honduras	4.08	56	119
Nicarillo (yellow)	Nicaragua	3.62	56	105
Composite E.S.2	El Salvador	3.33	54	97
Early				
H-3	El Salvador	3.40	53	107
H-1 (Check)	Nicaragua	3.19	50	100
Early Composite	Honduras	2.98	52	94
Synthetic 2	Nicaragua	2.41	49	76
Local Variety	each country	2.28	--	73

1 Averages for first planting cycle (spring) for 1965-1966.

2 Averages within the three groups of varieties--late, intermediate and early.

Extracted from the 1966-67 CIMMYT report.

Kenya. This was a 2^6 factorial trial involving: (1) hybrid variety versus local variety (2) early versus late planting, (3) good stand versus poor stand, (4) clean weeding versus 1 late weeding, (5) 56 kg/ha of P_2O_5 versus none, and (6) 78 kg/ha of nitrogen versus none. The results are given in Figure 5. Even though the low levels were chosen to simulate the farmer's conditions, the yield obtained in the six trials in 1966 averaged 1.97 tons/ha compared to the national average of approximately 1.1. The use of hybrid seed, nitrogen, and phosphorous fertilizer only resulted in an increase of 1.3 tons/ha giving a net profit of $16.13 per hectare. In contrast, early planting with the proper plant population and clean weeding (even with the unimproved variety) resulted in a yield increase of 2.92 tons/ha and an additional profit of $117.00 per hectare. The big interaction factor is seen in that, once good agronomic practices have been adopted, the use of hybrid seed and fertilizer gives 3.14 tons increase in yield compared to 1.30 with unimproved agricultural practices. The hard work required for early planting, good stands and clean weeding gives 2.92 tons/ha increase in yield for the unimproved variety and no fertilizer, but 4.76 tons/ha with a hybrid variety and fertilizer.

44. The futility of using nitrogen fertilizer without early planting is shown in Figure 6. If planting is delayed 6 weeks after the beginning of the rain (as was often done in Kenya), there is no yield increase from the nitrogen. In contrast there is a very great response to nitrogen with the early planting. Figure 7 shows effect of time of planting on yields of the unimproved variety Muratha at Embu in seasons of high and low rainfall. Figure 8 shows the response obtained from 511 to increasing plant populations compared to no response in the Muratha variety. Figure 9 illustrates the increased response to nitrogen from the hybrid variety (SR52) over an unimproved variety in yield trials conducted in Zambia. Figure 10 shows a similar response to plant populations. Figure 11 shows the greater response obtained from hybrid compared to a local variety over a wide range of environmental conditions in Tanzania. Superiority of H622 is much greater when the average varieties in the trial are yielding 60 quintals compared to the superiority at 16 quintals per hectare.

45. To further illustrate the importance of agronomic-entomological research as part of the package deal, the results obtained by the AID-ARS entomologist and soil scientists at Serere, Uganda, with sorghum are shown in Figure 12. With a high level for infestation, there was only a small uneconomic response to nit-

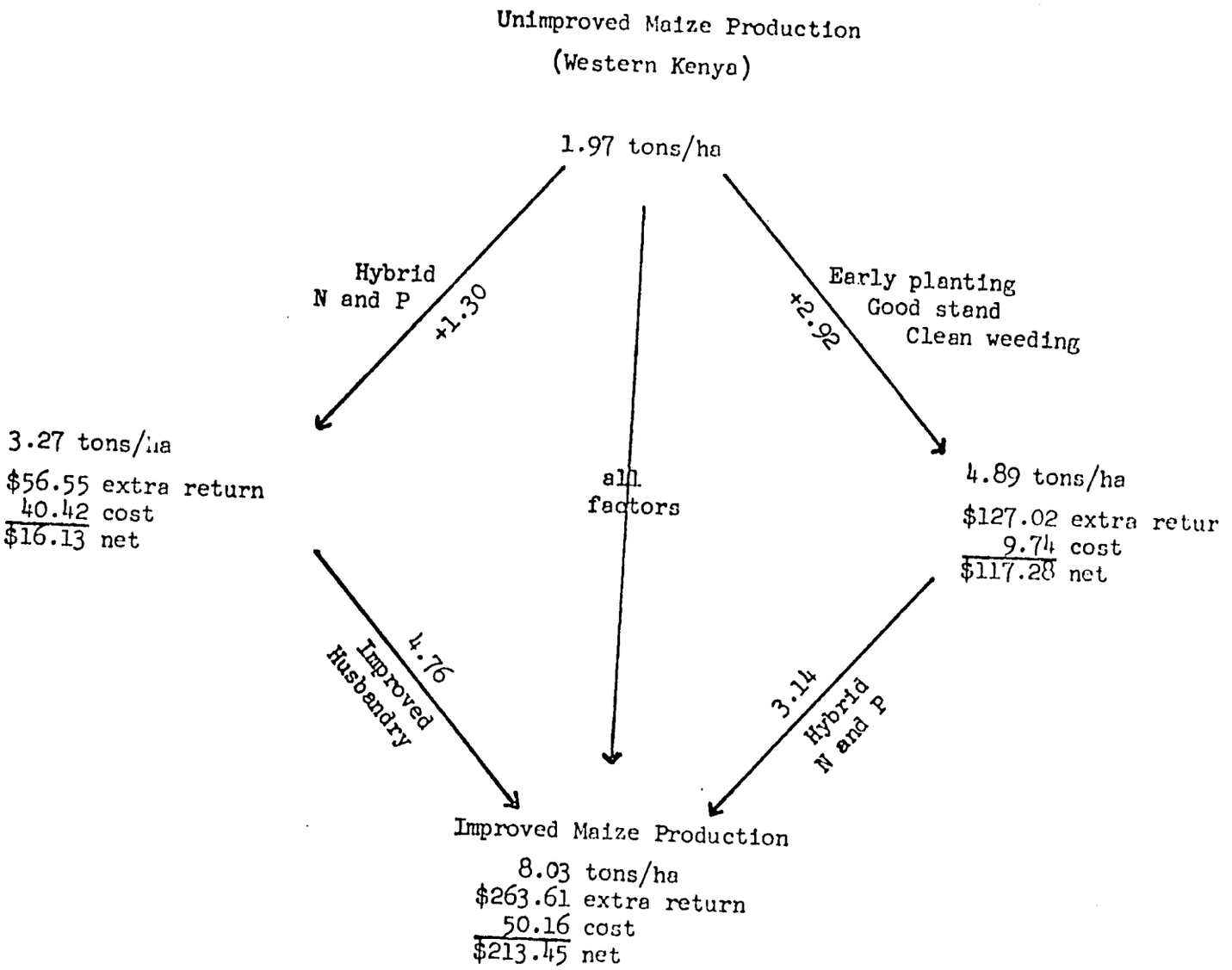

Figure 5. Extracted from a 2^6 District Husbandry trial grown at 6 locations near Kitale in 1966.

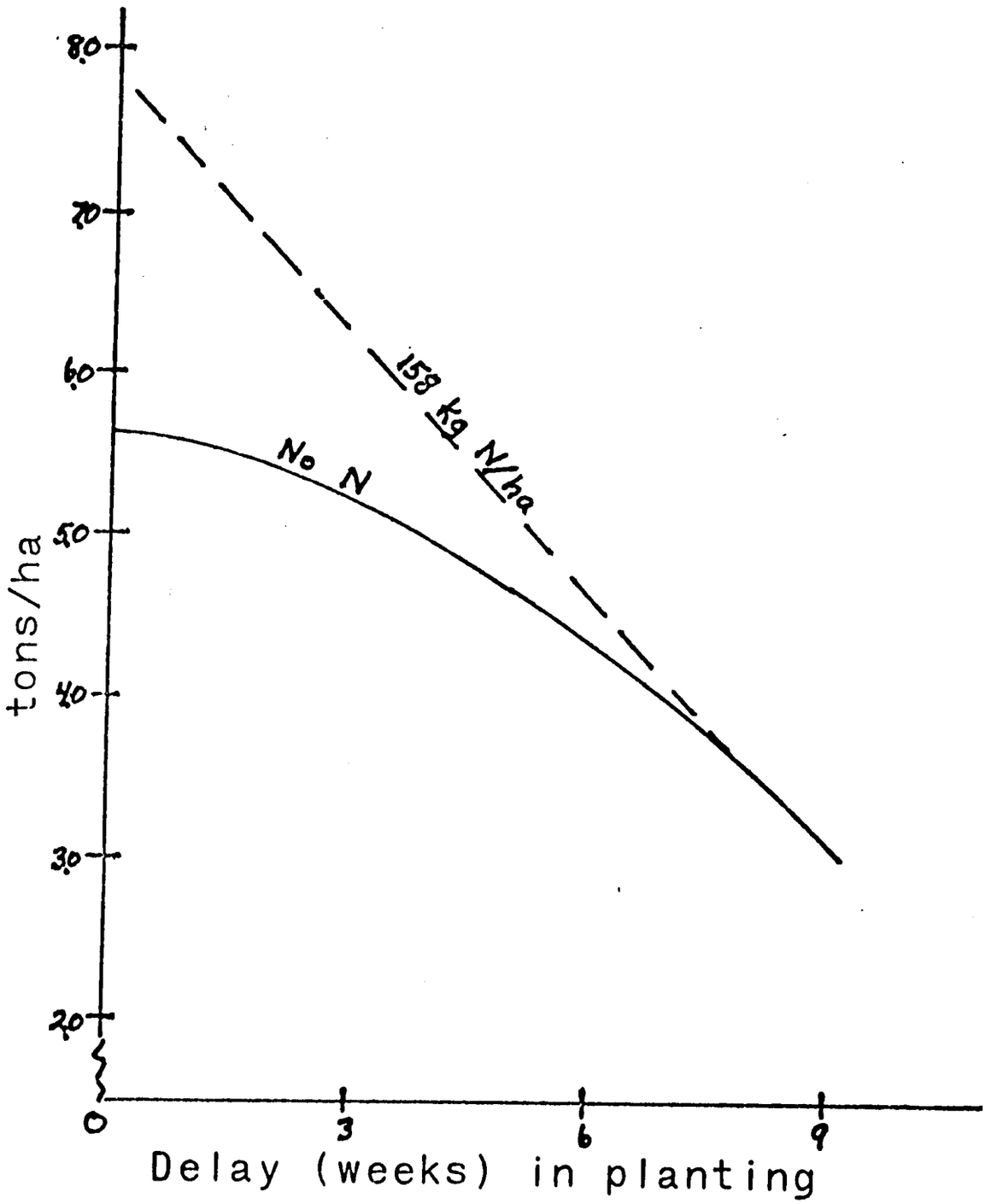

Fig.6 Response to delay in planting of Kenya Hybrids in 1966 (2) and in 1967 (4) near Kitale.

(34)

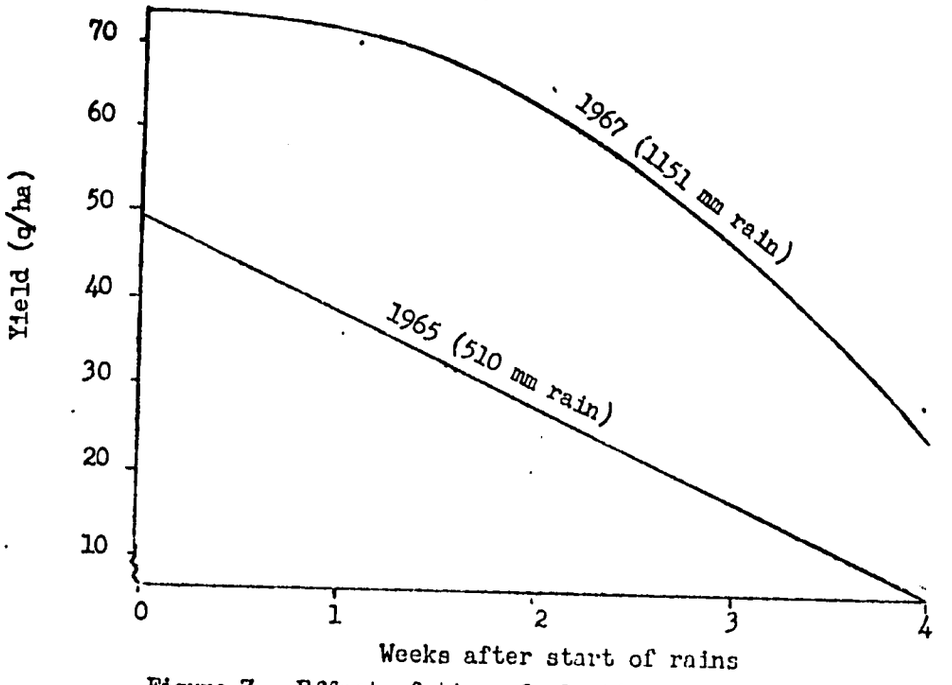

Figure 7. Effect of time of planting on yields of Muratha at Embu

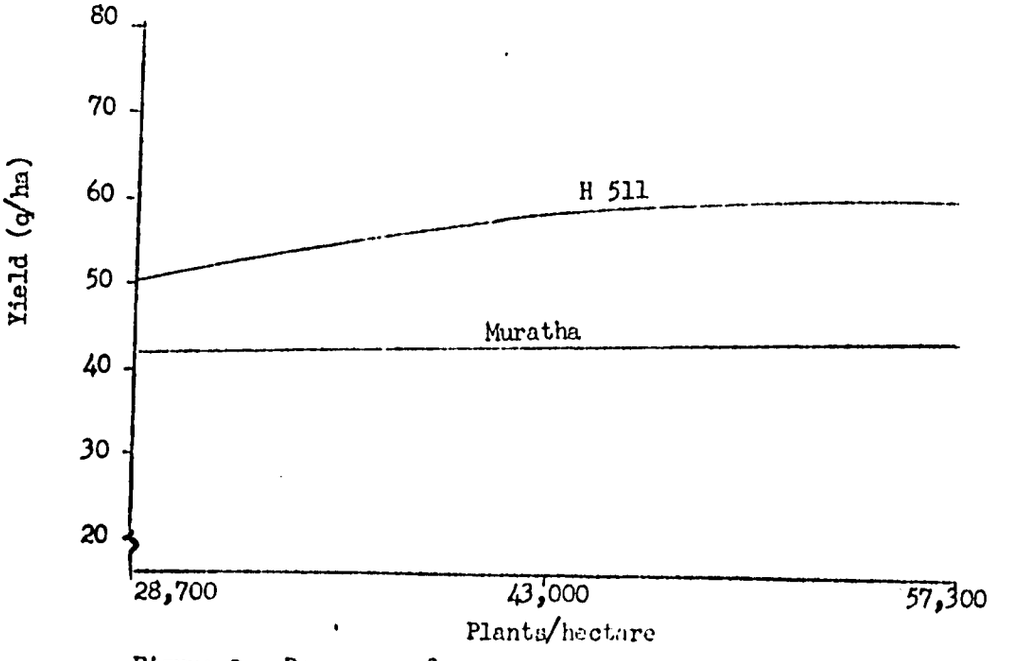

Figure 8. Response of Muratha and H 511 to increasing plant populations at 6 locations in Central Province in 1967.

(48)

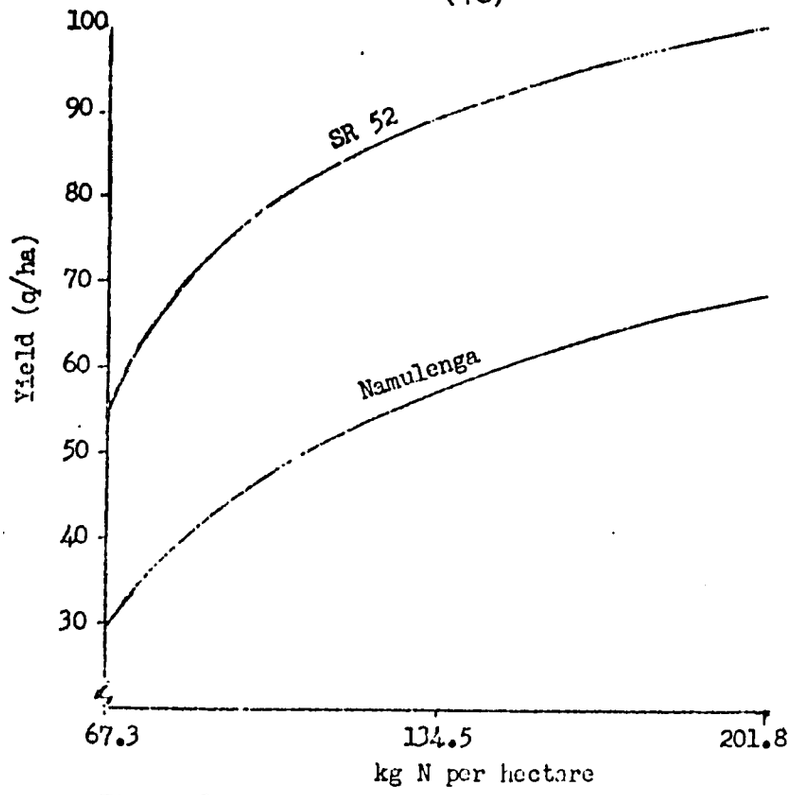

Figure 9 . Response of varieties to N at Lundazi, Zambia in 1966/67

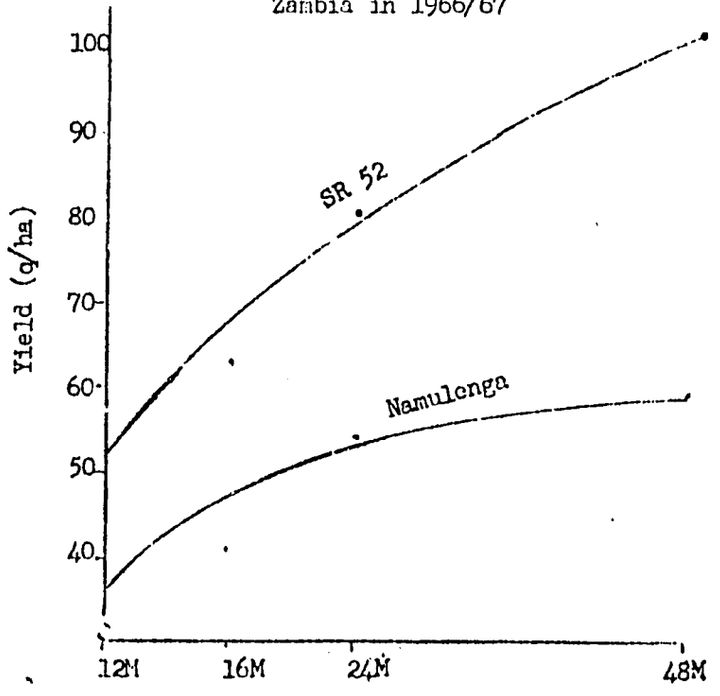

Figure 10. Response of varieties to plant population at Lundazi, Zambia in 1966/67

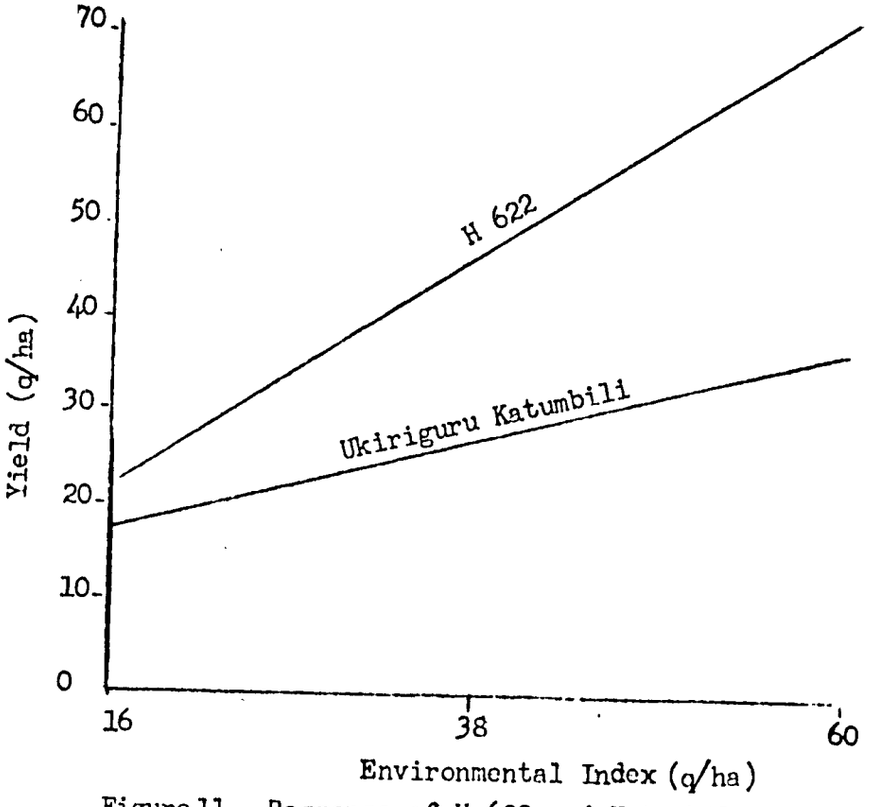

Figure 11. Response of H 622 and Katumbili to varying environmental conditions in Tanzania in 1965/66*

* A. Bolton. E.A. Agric. Jour. (Inpress)

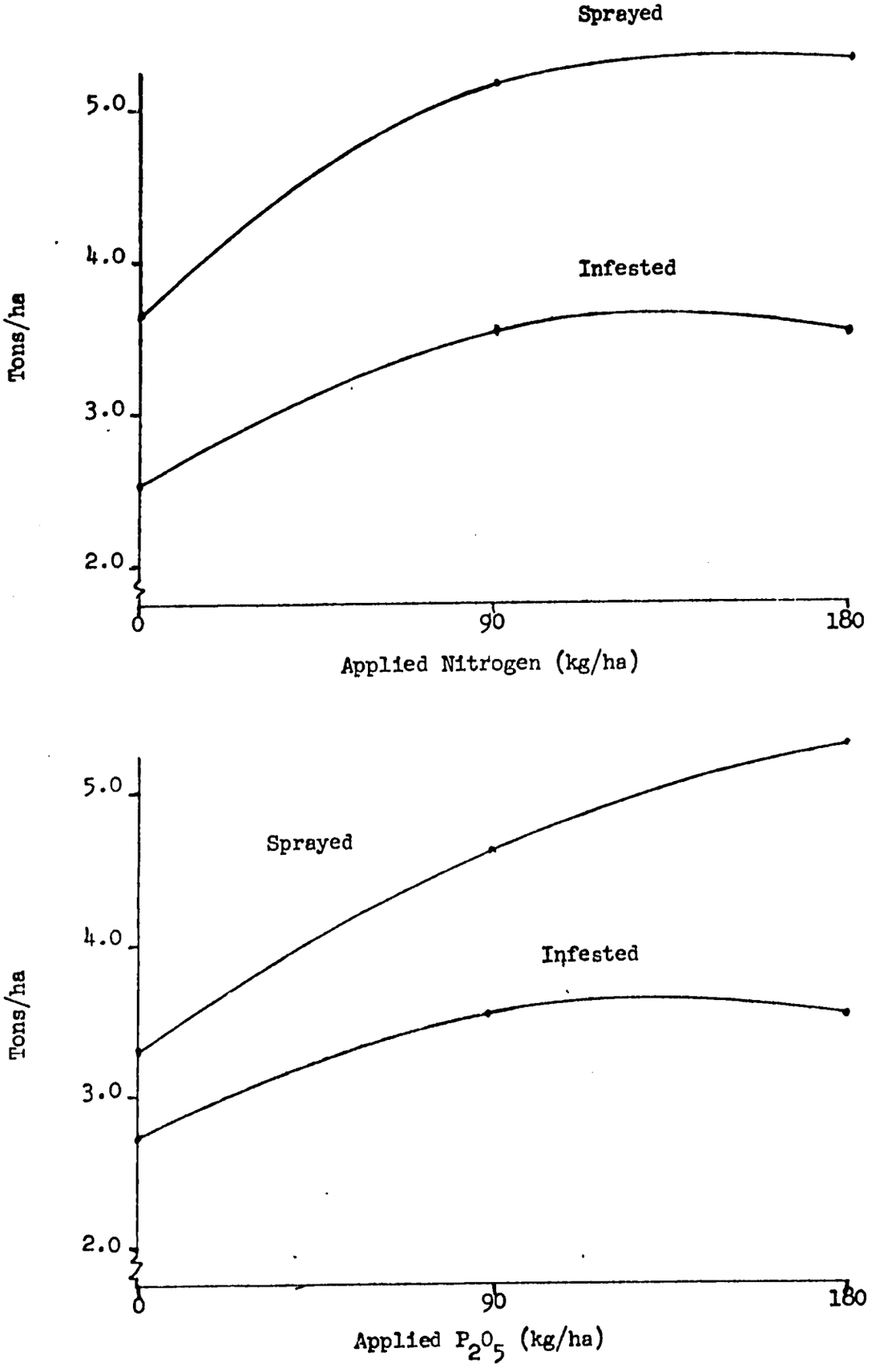

Figure 12. Response of a sorghum variety to fertilizer in the presence and absence of stalk borers (Chilo partellus) at Serere, Uganda in 1968. Results from trials conducted by K. Starkes and G. Schumaker.

rogen or phosphorous. In contrast, when the borers were controlled there was a very large response. If a program of cereal improvement were launched in this area with a package deal of a new introduced variety (without borer resistance), fertilizer, plant populations, etc; and in that particular year there was a heavy infestation of stalk borers, there would be a very disasterous result. At Kano, Nigeria, a fertilizer factorial trial was a complete failure in 1967. In 1968 when lime was included, a response of 580% was obtained from nitrogen and 140% from potassium; but the maximum yield was still only 1.9 tons/ha. A sound research program and adequate national and regional evaluation programs are essential to solve such problems and to develope the recommendations for the package program.

46. The agronomic research investigations at Kitale have now proceeded to the stage that all of the cultural factors affecting yield have been identified and corrected and now attention is given to determining the optimum level of fertilizer. Only three elements have shown to be essential: nitrogen, phosphorous, and sulfur. In the past, the sulfur has been supplied as part of the single superphosphate and ammonium-sulphate-nitrate. However, in 1968 commercial companies had greatly expanded operations in Kenya and were selling mixed fertilizers composed of di-ammonium phosphate with calcium-ammonium-nitrate applied as a top dressing. Since sulfur is not included in these fertilizers there have been some crop failures on newly plowed land in Kenya in 1968 even though generous levels of N and P_2O_5 were used. However, the agronomist promptly identified the source of the trouble and gave recommendations to prevent this from happening again in 1969 and even in time to save some fields in 1968.

47. On the clay soils on 10 farmer's fields near Mt. Elgon, the natural levels of phosphorous seem to be adequate for extremely high yields. Hence, the recommendation is only to replace phosphorous used by the corn crop. The response to varying rates of nitrogen from 0 to 220 lbs/acre are shown in Figure 13. The optimum economic rates are shown when nitrogen costs are \$.126 and \$.098 per lb. Kenya had been subsidizing phosphate fertilizers previously but with the recent reduction in price of corn for the farmers to 25/- per bag (\$38.60/ton) the government has increased the fertilizer subsidy. The cost of ammonium sulphate-nitrate to the farmer is reduced from \$74.73/ton to \$67.45 by a 9.7% subsidy. Single superphosphate is reduced from \$54.25 to \$38.84 with a 28.4% subsidy. An economic response to both N and P with an NP interaction was obtained on 18

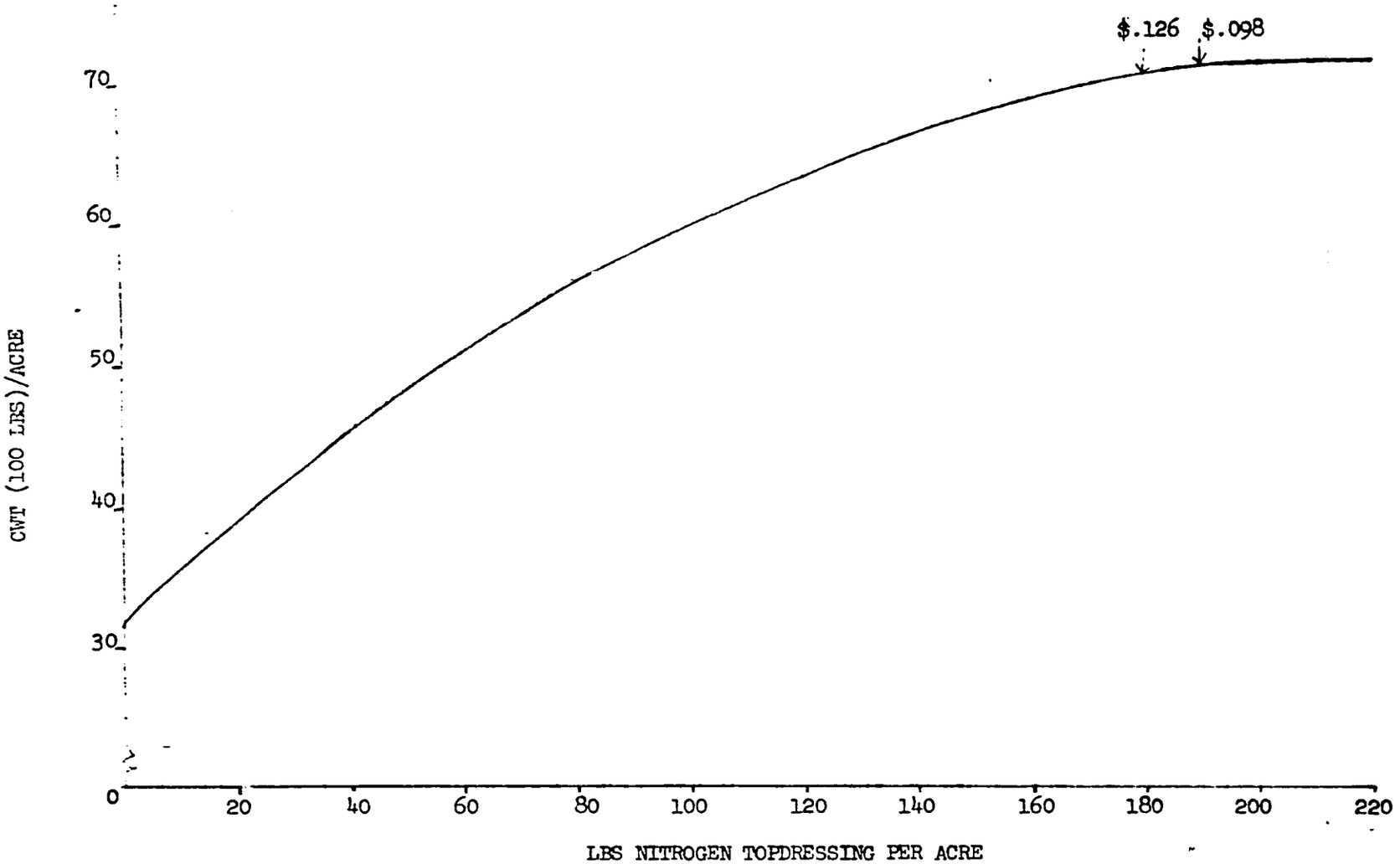

FIG. 13. NITROGEN RESPONSE ON 10 CLAY SOILS, ON OR NEAR MT. ELGON, KITALE, KENYA, 1968.

farmer's fields in other parts of Trans Nzoia with sandy red soils. The response surface is shown in Figure 14 and Table 9 gives information on economic levels and potential profit. These results suggest that although average yields in the Trans Nzoia are only 2.8 tons/ha, these could easily be doubled with careful attention to cultural practices (as was done in these trials) and more generous applications of fertilizer.

48. Extensive trials of a similar nature have been conducted in Mexico by CIMMYT. Excellent responses to nitrogen were obtained for sites with adequate rainfall as shown in Figure 15. Yields without nitrogen gave lower yields than in Kenya but maximum yields were not as high.

Research-Extension Liaison

49. In many countries the coordination between research and extension activities is not as close as might be desired. This is sometimes caused by the fact that they are in completely different ministries or in different agencies within a ministry. The AID-ARS Major Cereals Project is planning to assist in this area by assigning agronomists in certain countries with responsibilities in this area. Often the research organization has adequate facilities for the development of improved varieties, but lacks the means to obtain evaluations in the major corn growing areas in the country. This agronomist would be responsible for making arrangements with the Ministry of Agriculture for facilities to conduct the trials. He would be responsible for preparing the trials and summarizing the results. This would include the evaluation of the improved varieties and determining optimum cultural practices to obtain maximum economic yields from these improved varieties. Once these results become available he would be expected to present the information to the extension personnel, to assist in making the recommendations for the "package program" that would be used in the demonstration plots, and to assist the extension service in any way possible.

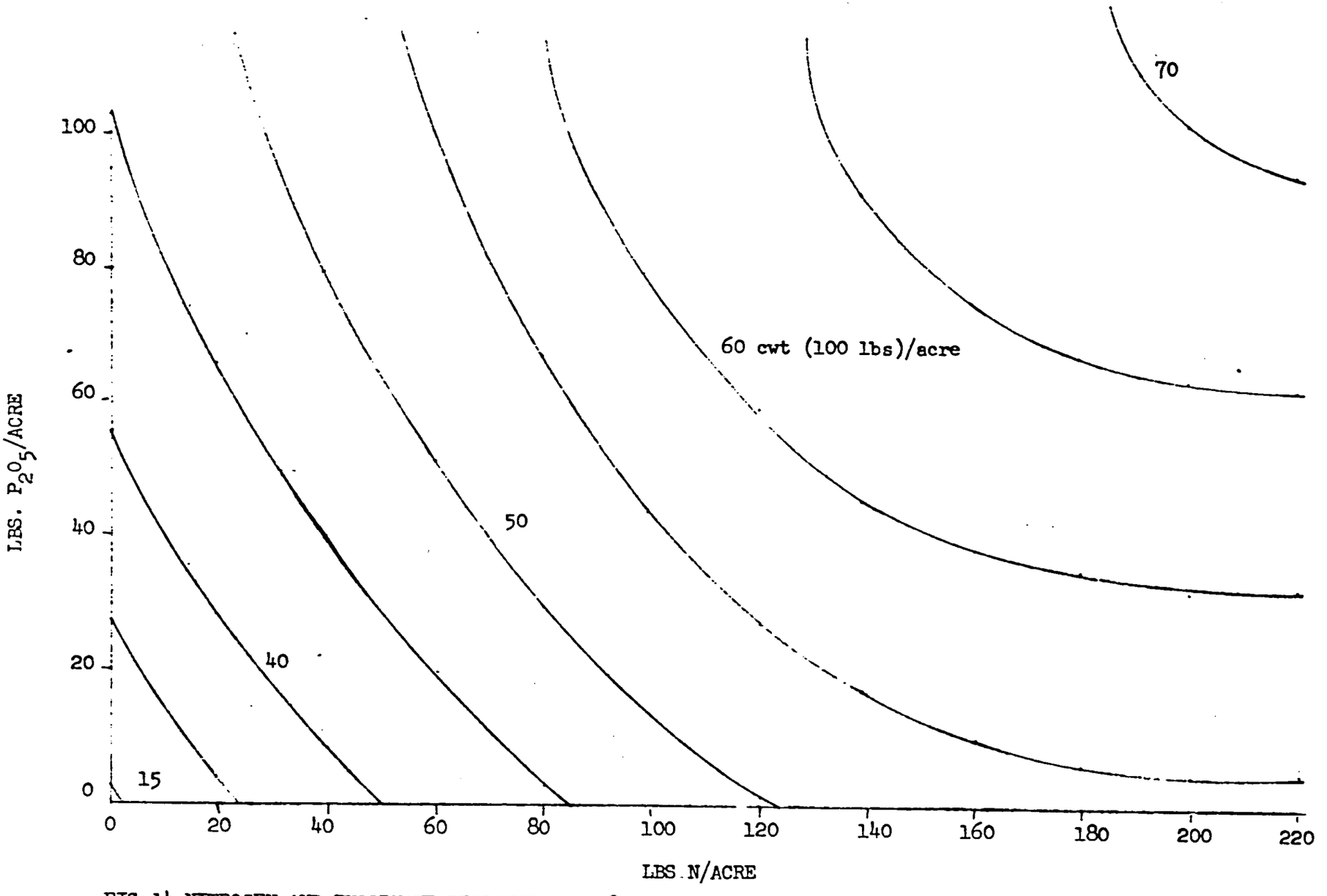

FIG. 14 NITROGEN AND PHOSPHATE RESPONSES ON 18 SANDY CLAY SOILS IN THE TRANS NZOIA, KITALE, KENYA, in 1968.

TABLE 9. FERTILIZER RESPONSES ON 10 CLAY SOILS, ON OR NEAR MT. ELGON

a) N costs/70 ($.098) per lb. and corn sells for 25/-per bag ($38.60/ton or $.98/bu)

Money available for nitrogen per acre.		Recommended N		Predicted yield increase		Increase in gross return per acre.		Increased profit per acre.		% Profit from nitrogen usage
Shs	Dollars	Lbs/acre	Kg/ha	Bags/acre	Tons/ha	Shs	Dollars	Shs	Dollars	
50/ - ($7.00)		71	80	11	2.47	275	$38.50	225	$31.50	450
100/ -($14.00)		142	159	17	3.81	425	$59.50	325	$45.50	325
Economic optimum 134 ($18.77)		191	214	20	4.48	500	$70.00	366	$51.24	273
b) Nitrogen costs/80 ($.112) per lb.										
50/ - ($7.14)		63	71	10	2.24	250	$35.00	200	$28.00	400
100/- ($14.29)		125	140	16	3.58	400	$56.00	300	$42.00	300
Economic optimum 131 ($18.35)		187	210	20	4.48	500	$70.00	369	$51.66	282
c) Nitrogen costs/90 ($.126) per lb.										
50/ - ($7.14)		56	63	9	2.02	225	$31.50	175	$24.50	350
100/- ($14.29)		111	124	15	3.36	375	$52.50	275	$38.50	275
Economic optimum 127 ($17.79)		182	204	19	4.26	475	$66.50	248	$48.72	274

$1.00 = 7/14 Shs; 1 ton/ha = 4.464 bags/acre; 1 kg/ha = .893 lbs/acre

N.B. There were no significant phosphate responses on these soils and therefore it is recommended that phosphate be applied at rates adequate to replace the phosphate removed in the crop. Suggested rates are 20 lbs/acre P_2O_5 where the expected yield is below 20 bags/acre, and up to 40 lbs P_2O_5 per acre at higher yield levels. Phosphate costs are not included in the following table; the phosphate cost is regarded as an "overhead" cost here.

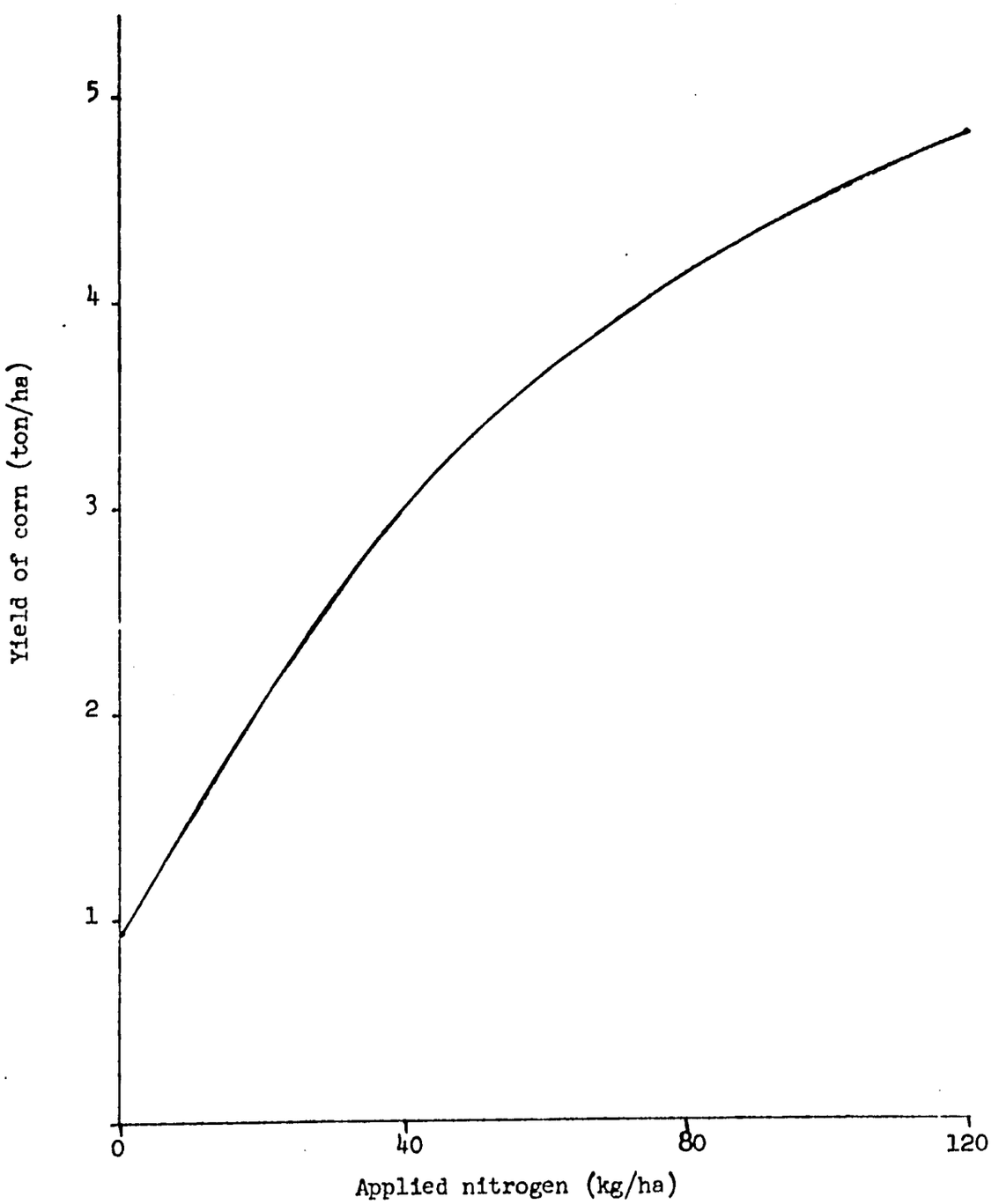

Figure 15. Response to N from 76 fertilizer trials in Central Mexico when the response was not limited by drought during 1962-1965.

Extracted from the 1967-68 CIMMYT Report.

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THE KENYA SEED COMPANY--A KEY FACTOR IN THE SUCCESSFUL MAIZE IMPROVEMENT PROGRAM IN KENYA

Success in the production and distribution of hybrid corn seed has not been obtained except by the private enterprise sector. Kenya was most fortunate in having a local commercial company willing to undertake the production of hybrid seed when the first Kenya hybrids were released in 1962. This company had been organized by a group of large-scale European farmers in the Trans Nzoia area near Kitale. In order to make available to themselves seed of the new grass varieties being developed by the Grassland Research Station at Kitale (subsequently expanded and renamed the National Agricultural Research Station). A Danish farmer with previous seed production experience was one of the main stock holders and enthusiastic promotors in this company. Although seed is provided throughout East Africa now and even exported to other countries having similar ecological conditions including Australia, the grass seed market was fairly limited. As these farmers looked for additional sources of revenue they discovered there was a good market in the export of sunflower seeds primarily to the U.S. for the bird seed trade. To exploit this situation, the Kenya seed company purchased cleaning and grading equipment, and contracted the production of the sunflower seed to interested farmers. Despite this expansion, the company went through several years of financial difficulties; but in the early 1960's the Kenya Farmer's Association provided some needed capital in exchange for a percentage of the stocks and advertised for a professional manager. They were able to hire the services of extremely energetic and efficient Dutchman, Mr. W. Verburt.

When the Kenya government was informed that the hybrid seed had proven to be a superior product and was ready for commercial development, advertisements were put out to various commercial companies to find an interested organization. The Kenya Seed Company requested permission to produce the seed immediately and was given a five year monopoly by the Kenya government as an incentive to invest money in this area. No other companies were interested. Because of the sunflower section, it was very easy to move into hybrid seed cleaning and grading by merely obtaining new screens for the present plant. There were the usual difficulties the first year including late arrival of the

screens, weavil infestation of the hybrid seed in the fields, and not adequate fumigation subsequently, etc; but all in all the Kenya Seed Company did a very efficient job from the beginning. With the subsequent expansion in the demand for hybrid seed, the sunflower plant was completely inadequate for the volume that had to be handled. Hence, a new efficient set of machinery specifically designed for maize was obtained. A new warehouse for storing the processed seed was also built. (Kitale is very fortunate in having a relatively cool climate so that there is no problem in maintaining germination for a period of time under normal storage conditions; whereas more tropical areas would have had problems in this respect). The manager was also sent to the U.S. to visit seed companies here and look into their methods of operation so that the efficiency of the maize section could be increased even further. Since corn plays such an important role in the national economy, the Kenya Ministry of Agriculture felt it desirable to obtain a small share in this company. They requested and have been granted by the Kenya Seed Company, a 20% share in the company at no expense to the Kenya government. This entitles them to supply a member to the board of directors as well.

Since this is a semi-private company that depends on a reasonable profit, the hybrid seed has been sold to the farmers accordingly, and the Kenya government has not found it necessary to provide a subsidy. This was certainly a wise decision and has contributed to the success of the maize improvement because the farmers, especially uneducated ones, feel that something that they have to pay extra for must be a superior product. (If the cost is low they feel the quality is also correspondingly poor). The price is carefully controlled all the way through channels, from the price paid to the growers down to wholesale prices and even retail prices in individual small shops. This price is set as a joint policy between the Kenya government and the Kenya Seed Company at a level sufficient to provide a fair profit to the Kenya Seed Company as well as to the middlemen but yet does not permit exploitation of the people. This is a uniform price throughout Kenya. If any distributors or retailers are found to be selling seed above the established price, they are no longer permitted to obtain supplies of seed. This has proved to be a very effective means of controlling the price. Although the large-scale farmers (nearly half are now Kenyan) require graded seed for machine planting, the demand from small-scale farmers using hand planting equals or exceeds the demand

for machine planting. Hence, only the cracked and very small seeds are discarded. The medium flats and medium rounds are graded out for machine planting, and the remainder of the seed is mixed for sale to the small-scale farmer. This factor plus the general efficiency of the Kenya Seed Company has permitted them to sell hybrid corn seed at one of the lowest prices throughout the world, i.e. $228.30 per ton ($5.80/bu).

There has been very close relationships between the Maize Research staff, of the National Agriculture Research Station, and the Kenya Seed Company personnel. Initially the inbred line bulking and production of single crosses was done by the Maize Research Section. But with the very rapid expansion, this soon became impossible and the Kenya Seed Company hired one of the assistant plant breeders from the Research Section to supervise this operation by the Kenya Seed Company itself. Now the Maize Research Section merely maintains Breeders' seed of each inbred line and sells this to the Kenya Seed Company whenever additional bulking is required. With the gradual shift from traditional inbred lines and three-way and double-cross hybrids to the variety-cross hybrids, inbred line maintainance and single cross production is becoming an increasingly less important aspect. In the variety crosses, the improved parental varieties are sold to the Kenya Seed Company after each cycle of improvement. These stocks are bulked up and used to replace the previous material. This maintains very nigh level of seed stocks because the hybrids grown by commercial farmers are never more than 2 or 3 generations away from the improved strains developed by the plant breeders.

The Kenya Seed Company uses its very best farmers to bulk up and handle the breeding stocks. The contracts are at guaranteed prices for the inbred lines and single crosses produced from inbred lines with their more uncertain production potential. The commercial seed is also handled through contracts with the large-scale farmers near Kitale. Initially all the seed producers were European, but as these farms have been moving into Kenyan ownership, the new farmers have been encouraged to produce the hybrid seed as well. A committee of Research and Kenya Seed Company staff screen the applications from the large-scale farmers and select the more competent farmers as there is always an excess of applications over the amount of seed required. The price incentive and this selection is one of the most effective means of providing

high quality seed. The Kenya Seed Company pays these farmers 80 shillings a bag or $123.53 per ton ($3.14/bu.) for this seed compared to the commercial price of 25 shillings a bag or $38.60 per ton. A farmer who fails to meet the government certification standards the previous year through neglect or efficiency is not allowed to produce hybrid seed the following year. A new grower is permitted to produce 10 acres the first year and if he does a satisfactory job, he is permitted to produce additional acres in subsequent years until now some of the farmers are producing as much as 100 acres. In 1968 there were 29 European growers and 17 Kenyan growers for a total of 466 hectares of seed.

The Kenyan government has a certification program with standards equal to or above those of the International Crop Improvement Association. Any seed that fails to meet these standards must be sold in commercial channels and cannot be sold for seed under any circumstances. Seed from the male rows must be harvested early and sold in commercial channels as well. In addition to this, the Kenya Seed Company has their own staff of advisors to help new growers do a better job in all aspects from the cultural practices to the rouging, detasseling, harvesting, and shelling. Because of the efforts of the Kenya Seed Company and the West German Extension Team working with the large-scale Kenyan farmers, the percentage of failures has been held to about five percent annually.

The seed for the small scale farmers was packed in 20 lb. cloth bags which is sufficient for 1 acre. They placed instruction sheets giving the recommended cultural practices in each bag (English on one side and Swahili on the other side).

The seed is distributed through the Kenya Farmer's Association (KFA) and Dalgety, Inc. KFA is a large cooperative association formed originally by the European farmers though it now has a large Kenyan membership as well. Dalgety, Inc. is a commercial company handling fertilizer, insecticides, small items of farm machinery and parts, and various farm chemicals. The Kenya Seed Company has also established outlets in Tanzania through the Tanzania Farmer's Association and in Ethiopia with Ethiopian Building Supplies and Technical Company. The KFA maintains branch outlets in the large towns. Dalgety wholesales the

seed to the small Asian and Kenya shopkeepers that have stores scattered throughout the rural areas. These were once exclusively Asian but these are gradually moving to Kenyan ownership through restricted trading licenses and loans to Kenyan's for small businesses.

The Kenya Seed Company monitors the situation closely; and if there are bottle necks and other problems, it helps in solving these problems. It also has a retail outlet in Kitale at which it sells to anyone willing to pick up the seed, but no retail deliveries are made.

In the early days of the industry, no one could predict the rate at which the sales could expand. The Kenya Seed Company was more optimistic than government personnel and always produced more seed than government research and extension personnel felt might be sold. Unexpected rapid exceptance of the package program by the small farmers in 1966 coupled with a severe drought in the hybrid seed producing areas in 1965 resulted in a large shortage. All export sales were curtailed and orders were reduced by 25-50% to enable equal distribution of the seed to those desiring hybrids. With this shortage, production in 1966 was tripled (see tables 1 and 2). Better cultural practices by the hybrid seed producers and favorable environmental conditions resulted in a very large crop, with a resulting large carryover which imposed a severe financial strain on the Kenya Seed Company. Since that time sales have stabilized so that it has been possible to more accurately estimate demands.

The severe drop in the sale to large-scale farmers in 1968 was due to the drop in price of commercial maize from $58.10 to $38.60 per ton. In the small scale farming areas demand continued but at a much reduced rate. This reduction rate was partly due to the lower price but was also a reflection of distribution and credit problems. The government had extended credit to farmers with 15 or more acres, but because of inadequate staff and other problems, there were long delays in processing these applications. Hence, funds for seed and fertilizer were not available in time for early planting as required. The other problem was the inadequacy of the stock of the small retail merchants due to their own credit difficulties. There had been some problems as far as the KFA and Dalgety were concerned in obtaining payment for seed supplied to these merchants on credit in 1967. Hence, in 1968 all wholesale sale of seed to the local merchants was for cash. Hence, many of these merchants were unable to

obtain large stocks of these seeds and since there was very little purchased by the small-scale farmers prior to planting time, the limited stocks were soon exhausted following the onset of the rains. By the time the additional stock had been obtained it was too late to benefit from the early planting part of the package deal and the farmers tended to plant their own seed rather than waiting for the hybrid seed to arrive. The Kenya Seed Company sales manager, Mr. Hazelden, made a thorough investigation of these problems and proposed means of alleviating them. This included more regional stocking centers by KFA and Dalgety so that the local merchants do not have to go so far to replenish their supplies.