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Farming Systems Data & On-Farm Trials of Beans (Phaseolus Vulgaris)

Mgeta and Kilosa Areas, Tanzania, 1985

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FARMING SYSTEMS DATA AND ON-FARM TRIALS OF BEANS (PHASEOLUS VULGARIS) MGETA AND KILOSA AREA, TANZANIA, 1985

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During the 1985 crop year, two varieties of Bean/Cowpea CRSP cultivars were tested on farmers' fields in Morogoro region; Kabanima, the variety for the high altitude-rainfall area, was tested on farms in Mgeta area; TMO 101, the variety for the low altitude area, was tested in the Kilosa area. In addition farming systems data were gathered from a sample of 59 farm families in Kilosa district. This report summarizes the results of these trials and farming systems data.

Sample Selection

Several months before planting time, members of the research group at Sokoine University of Agriculture, (SUA), Morogoro and Due visited the villages where it was anticipated the trials would be held to consult with village authorities and smallholder farmers (farming 25 acres or less) as to the reasons for the trials and their willingness to cooperate. In each area village personnel and farm families were enthusiastic. However, when the SUA research group returned to Kilosa just before planting time a representative from the Ministry of Agri-

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culture and Livestock Development (Kilimo) was in attendance the same day requesting each village farmer to plant a stipulated acreage of cotton, a low return crop which utilizes a great deal of labor. Village farmers were annoyed at the government's insistence on planting cotton; the SUA faculty members followed the Kilimo representative to the podium and farmers' resentment carried over to SUA personnel (who are also employed by the government). However, sufficient farmers volunteered to utilize the small quantity of seeds available. Researchers decided that, under the circumstances, it was better to take volunteers than to forgo on-farm testing.

SUA researchers gave each farmer instructions as to how the improved variety was to be planted in a manner identical to the traditional varieties normally used. Seeds were to be planted one to a hole (due to scarcity of seed), with holes 1 foot apart and rows 1 foot wide. For this experiment farmers were asked to plant the two varieties in monocrop (although they would normally interplant) to make yield comparisons easier. In other aspects farmers were asked to treat plots of improved and traditional varieties equally--the same amount of weeding, consumption, and so forth would be carried out on each plot. Plots were planted side by side to make comparisons easier.

This report first presents results of trials of Kabanima seed in Mgeta area. The results of the TMO 101 will be presented later.

MGETA AREA

Sufficient seed was available for testing in the fields of 12 farm families in Mgeta area where farming systems studies had been undertaken in the 1980 and 1981 crop years (Figure 1). These farming systems

studies provided excellent background data on the distribution of size of farms in the area, production of crops in the farming system, percentage of each major crop consumed and sold, net returns by crops, labor and purchased input use, and so forth (Due et. al, 1984 (1) and (2), Rashidi, 1981 and Mdoe, 1982). Thus the size of farm and other socio-economic characteristics of the 12 farmer families which volunteered for the Kabanima-traditional seed testing in 1985 can be compared with average farm families of the earlier studies.

In the earlier studies data on farm production was collected on a farmer memory basis during one interview. In 1985 farm families participating in the on-farm testing were interviewed either three or four times--one, two and three months after planting and at the end of harvest.

As noted earlier, farmers participating in the on-farm testing were volunteers. Earlier studies had defined farm families as families who were earning more than 50% of their income (crop and livestock sales plus non-crop income) from farming. When the 1985 data was analyzed, it was apparent that 5 of the 12 families did not meet these "farmer" criteria; these volunteers were village chairmen[1], a tavern operator, and a medical assistant. A dilemma presented itself as to whether to include or exclude these persons who consider themselves farmers but have substantial sources of non-farm income; thus a comparison of socio-economic charateristics of the 1985 farm and non-farm families with the 1981 farm families was made and presented in Table 1.

It is noted from Table 1 that the 1985 volunteers were younger, had more persons in the household engaged in agriculture and had more formal

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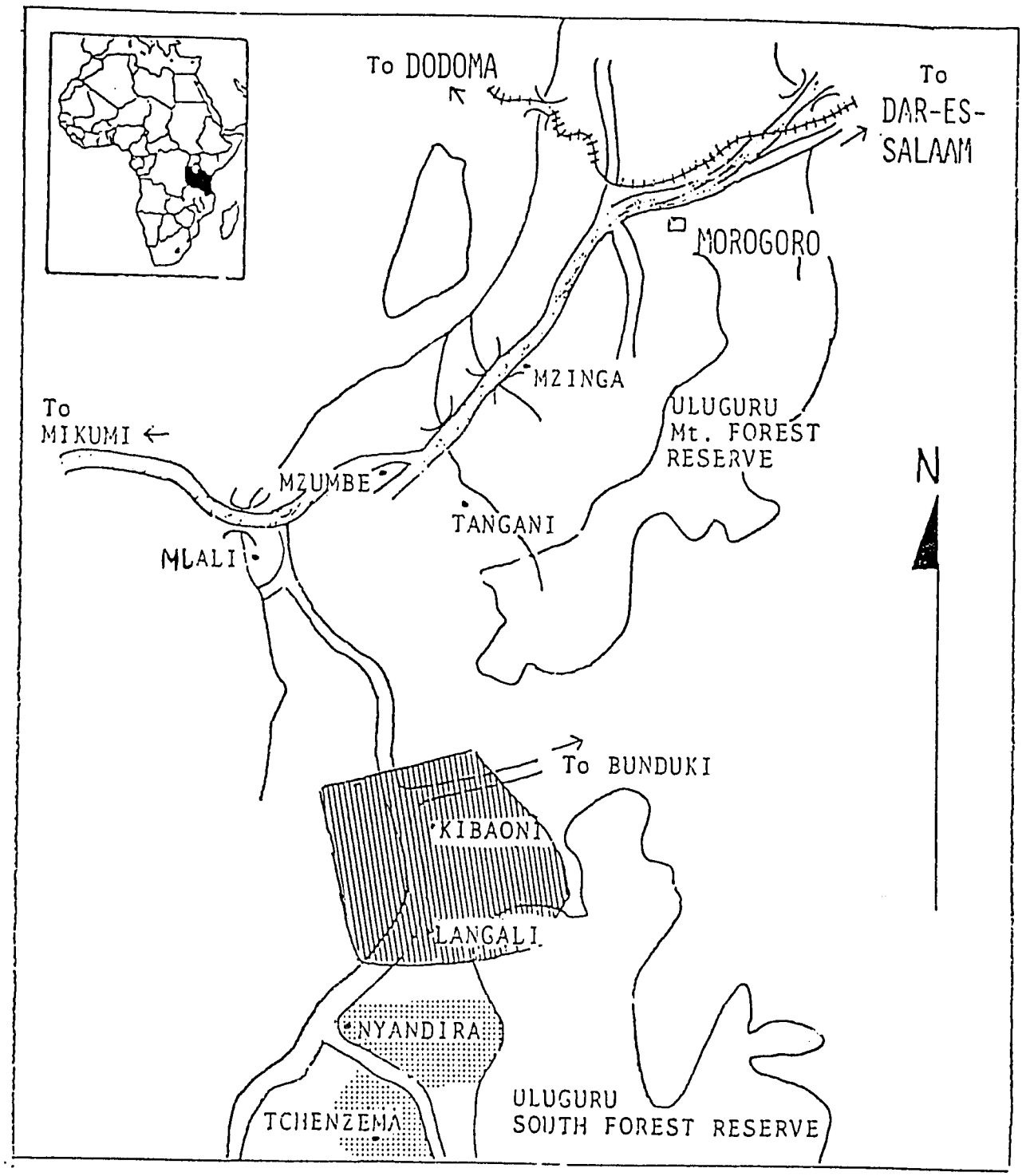
[1] Each village has a chair appointed and paid by the government.

Figure 1. MAP OF MOROGORO DISTRICT SHOWING LOCATION OF STUDY AREAS 1980/81 and 1981/82



Scale 1:250,000

KEY

- Sample area 1980/81
- Sample area 1981/82
- Regional headquarters
- Railway line
- Bitumized road
- Munyam road
- River

Table 1. A Comparison of Socio-Economic Characteristics of the Farm and Non-Farm Cooperating Families, 1985, and Farm Families Sampled in Mgeta Area, Tanzania, 1981.*

Characteristics	1985 Farm	1985 Non-Farm[1]	1981 Farm
Sample size	7	5	60
Means of:			
Age of family head	39.3	46.4	52.7
Age of spouse	27.0	33.2	40.7
Family size	7.4	8.4	7.1
Adult male equivalents[2]	2.0	1.8	1.3
Adult female equivalents[2]	2.0	2.2	1.3
Total adult equivalents[2]	4.0	4.0	2.6
Years schooling (head)	4.8	4.8	2.7
Years farming (head)	17.0	21.4	30.8
Number of shambas farmed	4.7	4.4	4.0
Acres in crops:[3]			
Maize	3.7	3.0	2.0
Beans	2.4	2.0	1.2
Sorghum	0	0	0.2
Banana	0.7	0.1	0**
Cabbage	0.3	0.9	0.5
Cassava	0**	0**	.8
Potatoes	0.2	0.6	0**
Cowpeas	0.6	0.8	0**
Other	1.0	1.5	0.8
Total	8.9	8.9	5.5

* Source: 1981, Due and al., 1984(2).
** Included with other crops due to small acreages.

1. Non-farm families obtained more than half their income from non-farm sources.

2. Person equivalents in full-time farming were calculated as follows: adult male and females 18 years and over are coded 1; males and females 12-17, 0.5; and male and females 8-11 years, 0.3. If persons were farming less than 12 months, the percentage of the year was used.

3. Intercropping was common in the villages; if a field was 1/2 maize and 1/2 beans and was 1 acre in size, it was calculated, in order to sum total acreage per crop, as 0.5 acres of beans and 0.5 acres of maize. Fields which were double cropped had the acreage per crop multiplied by the number of times to obtain total acreage per year.

education than in the 1981 sample. They also had larger amounts of cropped acreage (8.9 in 1985 compared with 5.5 in 1981). The 1985 farm sample was younger, on average, than the non-farm sample but had the same average level of education and acreages in crops. The authors agonized over inclusion or exclusion of the non-farm families. Since the purpose of the on-farm trials was the comparison of two varieties of beans, is it significant that non-farm families with greater cash resources for purchased inputs are included in the sample? Both farm and non-farm families in 1985 used purchased inputs on their beans, while very few purchased inputs were used in earlier studies. Non-farm families also had significantly higher sources of cash income than farm families in 1985. Therefore, it was decided to include the non-farm families when the data seemed appropriate (for example, when attitudes on variety differences were given) and exclude them when farming methods were being utilized which were not available to the farm population at large. Each table will denote whether or not the non-farm sample was included.

It is noted from Table 1 that the families in 1985 had almost twice as many acres in maize (the major food staple) and beans than the 1981 group. Thus they had, with their larger acreages, more maize and beans for sale. In the earlier study, all of the maize was for home consumption and 66% of the beans were sold; in 1985, 82% of the maize was consumed and 22% of beans were sold! Farm families in 1985 were also more hesitant to report sales due to a new government development tax which is being levied in each village.

Objectives in Farming

The families involved in the 1985 on-farm trials had the same

primary objectives in farming as other smallholder families sampled in earlier years; they wanted to grow enough food for the family first, and, if there was sufficient, generate some income.

Total Production, Consumption, and Sale

Given that the 1985 sample had 62% more acres in crops than the 1981 sample and that prices had changed over the period, it is interesting to compare average levels of production, consumption and sales of the two groups (Table 2).

Total value of production per family are six times higher in 1985 than in 1981--significantly more than the 61% increase in crop acres. However, when the production value is calculated in 1981 prices, total value of production would be only 93% higher. In both years crops were valued at their open market prices (the prices at which sales were made) rather than at official government prices which were much lower.

On average 66% of the total crop production (by value) was consumed and 34% sold in 1985; however only 38% of total crop production by weight was consumed. Principal cash earnings came from sales of cabbage, beans, maize, other fruits and vegetables (lettuce, cauliflower, onions, etc.), maize, and bananas. These data per family are shown in Table 2. Seventy-eight percent of beans were consumed and 22% sold.

Farm Capital Owned

The seven farm families which volunteered to try the new high yielding varieties of beans had twice as many tools on average as the sampled families in 1981. They had the same number of hoes, on average, but twice as many pangas, axes, knives, shovels, sickles, etc. In each sample, farm families had very little investment in farm tools; average

total tools owned was 5 valued at 170 Tsh. in 1981 and 10 valued at 433 Tsh. in 1985.

Table 2. Comparison of Average Production, Consumption and Sales of Major Crops of 1981 Farm Families Sampled with 1985 Farm Sample

	Mgeta 1981		Mgeta 1985	
Sample size	60		7	
	Kg.	Tsh.	Kg.	Tsh.*
Maize-production	652	2,608	934	15,572
-consumption	652	2,608	771	12,799
-sales	0	0	132	2,256
-waste	0	0	31	517
Beans-production	167	836	550	13,936
-consumption	56	280	406	10,291
-sales	111	556	122	3,078
-waste	0	0	22	567
Cabbage-production	1,321	1,271	1,729	4,323
-consumption	83	79	332	829
-sales	1,238	1,192	1,387	3,468
-waste	0	0	10	26
Cassava-production	209	209	19	457
-consumption	209	209	19	457
-sales	0	0	0	0
Banana-production	0	0	1,360	1,360
-consumption	0	0	423	423
-sales	0	0	937	937
Vegetables-production	81	364	1,056	2,095
-consumption	4	16	209	415
-sales	77	348	838	1,662
-waste	0	0	9	18
Other-production	181	500	228	1,167
-consumption	134	320	100	512
-sales	47	180	128	655
Total-production	2,611	5,788	5,876	38,910
-consumption	1,138	3,512	2,260	25,726
-sales	1,473	2,276	3,544	12,056
-waste	0	0	72	1,128

*Tsh. is Tanzanian shillings; the official exchange rate was 17 Tsh.= U. S. $1 in 1985.

Livestock Owned, Consumed and Sold

In the 1981 study 85% of the sampled farmers in the two villages owned livestock whereas in 1985 all 7 families owned livestock. On average the 1981 families owned 10 animals valued at 1,924 Tsh; in 1985 the average family owned 12 sheep, goats, poultry or hogs valued at 2,279 Tsh.

As noted in Table 3, very small numbers of livestock or poultry were reported consumed or sold. Sales amounted to only 144 Tsh. in 1981 but 614 Tsh. in 1985. It is acknowledged that memory bias may have adversely affected reporting of livestock consumed and sold.

Table 3. Average Number and Value of Livestock Owned, Consumed and Sold Per Farm Family, Mgeta, 1981 and 1985

	Owned				Consumed				Sold			
	1981		1985		1981		1985		1981		1985	
	No.	Tsh.	No.	Tsh.	No.	Tsh.	No.	Tsh.	No.	Tsh.	No.	Tsh.
Goats	2.1	1,035	1.8	892	0	0	0.7	325	0	0	0.4	183
Sheep	0.0	13	0.2	175	0	0	0.1	58	.1	6	0.2	117
Poultry	6.0	174	8.4	598	1.1	32.5	4.5	338	0	0	1.0	81
Pigs	0.8	670	0.7	567	0	0	0	0	.1	138	0.1	233
Other	0.9	34	0.6	47	0.1	3.5	0.3	27	0	0	0	0
Total	9.8	1,924	11.7	2,279	1.2	36.0	5.6	748	.2	144	1.7	614

Bean Yields of Traditional Versus New Variety

Kabanima out-yielded Kenia for each farmer who carried out the on-farm trials. On average Kabanima yields were three times higher than Kenia, the traditional variety (2.6 kg per plot of Kabanima compared with 0.7 kg per plot of traditional); however, only 4 of the 12 farmers

completed the on-farm tests. In addition, the variation in yields was high, as seen in Table 4.

It is also seen from Tables 1 and 2 that reported bean yields in 1985 by the 7 cooperating farmers were 65% higher than those of the 1981 sample; in 1981 farmers reported bean yields of only 139 kg per acre compared with 229 kg in 1985. The 1985 yield of 0.8 kg per 100 square meters translates in 70 kg per acre for the traditional variety; the 2.6 kg per 100 square meter translates into 229 kg per acre. However, as will be noted later, the 1985 sample used much more fertilizer on plots than the 1981 sample.

There does not appear to be a consensus of farmers' answers as to the effect on bean yields of intercropping beans with maize in 1985. For two farmers the yield remained unchanged, reporting yields of 80 and 240 kg. Three other farmers believed yields would increase if intercropped, with yields doubling for 1 of the respondents. For the remaining three respondents, yields were believed to decrease if intercropped. Generally, farmers believe that maize competed with beans for soil nutrients and has a shading effect on the beans resulting in yield declines.

Table 4. A Comparison of Yields (in Kgs. per 100 Square Meters) of Kabanima and Traditional Varieties on Farmers Fields, Mgeta, 1985

	Kabanima	Kenia
Farmer 1	4.8	0.8
2	1.2	0.4
3	3.4	1.1
4	1.2	0.8
Mean	2.6	0.8

Major Insects and Diseases Affecting Beans

When asked to rate the four most important insect pests affecting beans, respondents' replies are shown in Table 5.

Aphids constituted the major problem to bean production and yields, posing a problem for 11 of the 12 surveyed farmers. This was followed by

Table 5. Major Insects Affecting Beans, Mgeta Sample, 1985

Problem:	Aphids	11
	White flies. . . .	6
	Birds & rats . . .	4
	Bollworms.	2
	Pod-borer.	2
	Beetles.	1

white flies and birds and rats. These pests generally attacked the bean plants as early as 10 days after planting to as late as 42 days after planting. The leaves were the parts most often attacked, followed by the main stem. The nature of the damage ranged from wilted leaves to stunted growth of the plant. These attacks by pests did not appear to vary by varieties of seed planted but rather by planting time for most of the surveyed farmers (11 of 12). Rats ate pods, birds ate seed at planting time or seedlings.

Responses to Questions Comparing Kabanima Beans with Traditional Varieties

Many questions were asked of the 12 families who volunteered to test the Kabanima variety side by side with the traditional variety to compare various characteristics; the answers follow the questionnaire which appears in the Appendix. This is a small sample and care must be taken in making generalizations from these data; in addition often only part of the sample replied to specific questions and only 7 of the 12 respondents were farmers. Some of the questions were designed under the assumption that the families would have enough seed that comparisons of taste, cooking quality, and other characteristics of Kabanima and traditional varieties could be made; this was not possible due to the shortage of Kabanima seed. In spite of the small sample size and other qualifications, some of these data were useful to the breeder and other researchers.

A. Responses to Questions on 1985 Questionnaire No. 2 (Tanzania - Mgeta area)

2a) Average height of beans 8 weeks after planting:
V_1 (Kabanima) 10.6 inches
V_2 (Trad) 9.6 inches
V_1 is bushy as is Kenia; V_2 is a vine;
V_1 is floppy; V_2 is also floppy

b) Is height important to the farmer? 4 answered yes, and 4 no. Those answering yes said they would get greater production if high.

c) Pod contact with the ground? V_1 (Kabanima) had less pod contact with the ground. Percent of plants with pod contact? V_1 (5% on average), V_2 slightly higher.

d) Of total beans planted, what % were bushy; answer 100%, only 1 farmer had the vine type.

3. What are the 3 to 4 most important insect pests on beans? 11 out of 12 replied "aphids", next most frequently mentioned were white flies (6), folage beetle (1), bollworms (2), pod borrer (2), birds and rats. Pests come 28 to 30 days after planting (5 responses) with 3 responses 10 to 21 days. (8 total responses)

d) What part of the bean is attacked? leaves and stems (7), green pods (4), whole plant (1).

e) Punctured leaf blades, pods bored, plants wilt, stunted growth.

f) Yes, damage is same for all varieties and the insects are worse with late planting.

Incidence of diseases: 3 leaf spot, 2 fungus, 2 rust, 1 mosiac.

NOTE: Families could not make comparisons of the HYV vs. the traditional Vs as there was so little seed for the HYVs. Therefore, the answers really relate to the traditional cvs consumed.

4. Consumption of green pods:

a) Of the 7 out of 12 who ate green pods, they consumed 2 times per week. These 7 families consumed green pods for 3.2 weeks on average.

b) Quantity eaten per time? 1.8 kg per time.

c) Variety preferred? They only had local varieties to consume: HYV was for seed.

d) Only 2 families reported sales of green pods with 75 and 100 kg each bringing 450 Tsh. each.

Reasons for growing preferred varieties--soft shelled pods which are preferred in the market.

NOTE: Families could not make comparisons of consumption characteristics of the HYV vs. the tradition Vs as there was so little seed for the HYVs. Therefore, the answers really relate to the traditional cvs consumed.

5. Consumption of green seed:
   a) All 12 families reported eating green seed; average was 3.3 times per week.
   b) Consumed for an average of 3.7 times a week (10 respondents).
   c) Consumed 1.7 kg. per time.
   d) Kenia as it is available, quick to cook.
   e) Only 1 farmer sold green seed; he sold 230 kg. for 910 Tsh.
   f) All were consumed after shelling and cooking.

6. Only two of the 12 families borrowed money from friends and relatives for fertilizer; all was repaid; amount borrowed was 200 and 210 Tsh., respectively.

B. Responses to Question on 1985 Questionnaire No. 3 (Mgeta Area, Tanzania)

2. Days to maturity: Kenia: 7 families said both Kenia and Kabanima took 90 days to maturity; 1 said 75 days for both and 1 said 60 for Kabanima.

   The question really concerned the range of maturity at 12 weeks whereas the answers related to days to maturity; thus the % of total beans planted which were at each stage 12 weeks after planting doesn't make sense as asked; i.e. if the plants take 90 days to mature, then all will be mature at 90 days.

3.

seed color:	not enough responses to judge differences.
size:	2 responses, 1 medium (Kab); 1 large (Kenia).
threshing:	both cvs were easy.
shattering:	3 reported no problem with Kenia; only two reported on Kabanima with medium shattering; others (1) reported Kenia a problem but 3 reported Kenia and Kebwebwe medium. There was not enough Kabanima to report really.
maturity concentration:	only 1 reported Kabanima which was good re this characteristic. Kenia also was good.
saved for seed?	8 families saved seed of 4 to 40 kg. Average was 20 kg.

4. Insect damage - no data reported.

5. Consumption of dried beans; again families did not have Kabanima to consume. Varieties preferred: 11 families reported; all preferred Kenia as it was easy to cook, had good taste and provided a thick soup. Color preferred - none.

   Soak before cooking? Only 1 family out of 11; soaked for 2 hours. Some soak better - no replied. Cook faster? 11 replied Kenia; cook 1 to 2 hours, average 1.5 hrs.

6. Dried beans consumed with:
   11 responded - all ugali.; 7 also replied second, bean soup, and others responded rice and bananas, potatoes, yams, rice and cassava, cassava and potatoes, bananas and cassava.

7. Other protein eaten? 11 replied meat, 2 dried fish and meat, 1 eggs and meat, 1 cowpeas and meat. How often per week? Once per week. 1 kg. per family average (Rocke doubts this frequency).

8. Why eat dried beans? 7 said because they were storable, 2 available.

9. Cooking acceptability factors: This question was not understood and answers are not codable.

10. Do all members of the family eat dried beans; 12 responded "yes".

11. How often per week? 11 responded 3 to 4 times per week for 4 to 53 weeks! Average was 29 weeks. % purchased? 2 said 5%, 1 said 25%; no response from others. Said only if poor harvest. Cooked per eating? 1 kg. Eaten at special times? 7 said yes, 4 said no. Explanations: supplement festivals (3), only when no other substitute for festivals (2), 2 said they were christians (no Ramadam), 1 replied for weddings. Beans cure illnesses: 11 said "no". Leftovers: eat or throw out (4), reboil (1), fertilizer (1); most are eaten later.

12. Storage for cons. 6 in sacks; 1 clay pot, 1 basket, 1 dusted with chemicals. Storage for sale? All replied "sacks". Storage for planting? 5 said sacks with insecticides; 3 said sacks, and 1 a tin or basket.

13. When storing for home consumption, do you add preventative measures? 1 ash, 5 DDT or melathiion; others no. (Wonder if these are really respondents answers?) How much? 1 kg. ask per 18 kg. beans; chemical 250 gms. per 2 sacks. How often? Once.

14. Varieties desired for storage for consumption? Kenia - 8 responses, Kibwebwe (2) - as only varieties available.

Reasons: Hard seed costs - Kibwebwe best; worst Kabanima (1), Kenia (4)
Color stability - Kenia best
Bruchids - Kibwebwe best; worse Kabanima (but no time to store) (1), Kenia (2)
Seed coat harden over time- No, Kibwebwe (4), Kenia (1) Yes, Kenia (2)
Moulding - no difference
Bruchids first appear? 2-3 months; damage seen fast (2), slow (4)
Seed completely destroyed? 6 months
How control bruchids? 3 DDT, 2 malathion, 2 ash, 1 store under fireplace.
How often treat seeds? once

15. Bean purchases? 4 yes, 4 no. All purchased Kenia @ 20 to 30 Tsh./kg.; ave. purchase only 18 kg. @ 490 Tsh. ave.

16. Other insects, pests? Response: aphids, birds, rats. Rats ate pods in field. % beans lost - no replies

17. Cooking problems after storage? (1) seed coat hardens; (1) need to clean well after chemical treatment, (5) no problems.

18. Harvesting? 9 reported uprooting whole plant; 3 picked some dry pods also.

19. Beans dried before shelling. 12 yes.

20. Method of shelling? 10 beat with sticks, 2 put small amounts in bag and pound no. 3 or 4.

21. How cleaned? 3 picked over by hand, 9 winnowing.

22. Where market your beans? 0 to NMC; 5 to market. 7 gave some away (2 to 20 kg.); 360 kgs. by 5 families marketed in local market brought 8,200 Tsh. (23/kg.) 298 kg. consumed by 8 families (37 kg. per family); 101 kg. given away by 7 families, and 313 kg. stored for seed later by 9 families (35 per family) and 165 kg. stored by only 4 families. Note these data <u>do not</u> correspond with consumption data given earlier!

23. Who does the marketing? 5 out of 8 said H&W, 2 said wife, 1 said husband.

24. Total yield of beans? 11 responses, total ;yield 1,556 kg. or 141 kg./family. Yield if monocropped? 145 kg./family average - about same as above. Reasons re intercropping - maize competes with beans for nutrients.

25. How is straw used? 2 do not use straw, 8 used as manure, 1 as livestock feed?

26. Characteristics of straw desired? upright (i.e. stands upright at harvest).

Who Selects Bean Seeds for Planting?

Responses as to who chose bean seeds for planting in 1981 and 1985 are given in Table 6. The wife alone made the majority of the decisions (57%) regarding bean seed choice for the more recent study, while in the 1981 study, bean seed choice was more likely to be that of husband and wife jointly (45%).

Table 6. A Comparison of Persons Choosing Bean Seeds for Planting by Sampled Families, 1981 and 1985, Mgeta, Tanzania

	1981		1985	
	No.	%	No.	%
Husband & wife. . .	27	45.0	2	29
Husband, wife & children.	8	13.3	0	0
Wife alone.	7	11.7	4	57
Husband alone . . .	3	5.0	0	0
Wife & children . .	11	18.3	0	0
Other (father). . .	0	0	1	14
No response	4	6.7	0	0

Off-farm Income and Gifts

The seven farm families volunteering to do farm trials in 1985 had more than four times as much off-farm (non-crop income) and gifts per family as farmers in 1981. Total off-farm income averaged 4.711 Tsh. in 1985 compared with 978 Tsh. in 1981. The largest source of this income (69%) was from selling beer, small quantities of fruits and vegetables, and so forth in 1985. Employment off the farm also generated over three

times as much income per family as in 1981 while gifts from friends and relatives were smaller in 1985 than in 1981 (Table 7).

Table 7. A Comparison of Average Off-Farm Income and Gifts per Sampled Farm Family, 1981 and 1985, Mgeta, Tanzania

Source	1981		1985	
	Tsh.	%	Tsh.	%
Employment & wages	436	44	1,400	30
Selling pombe (beer) or other items	134	14	3,261	69
Gifts	408	42	50	1
Total	978	100	4,711	100

Farm Operating Expenditures

Total farm operating expenditures were substantially different when comparing the data for the 1985 with that from 1981, as shown in Table 8.

Table 8. A Comparison of Average Farm Operating Costs and Depreciation per Sampled Family, 1981 and 1985, Mgeta, Tanzania

Purchased inputs	1981			1985		
	# Reporting	Mean Value Tsh	%	# Reporting	Mean Value Tsh	%
Hired Labor	22	46	11	3	2,327	44
Seed	43	84	20	1	1,545	29
Fertilizer	43	123	29	3	240	5
Chemicals	41	22	5	2	20	0
Transportation	23	49	12	1	1,040	19
Farm Rental	0	0	0	0	0	0
Depreciation	60	95	23	7	173	3
Total	60	419	100	7	5,345	100

Average total farm operating expenses per family in 1985 (5,345 Tsh.) was more than twelve times higher than in 1981 (419 Tsh.). This difference is due largely to contrasts in the use of hired labor, seed, and transportation. Hired labor constituted almost half (44%) of total farm costs in 1985 but only 11% in 1981, the figures being 2,327 Tsh. in 1985 and 46 Tsh. in 1981. Female hired labor amounted to 1,650 Tsh. per family while male hired labor was 677 Tsh. in 1985; female hired labor constituted the largest single share of total operating costs (31%) folowed by seed (29%), transportation (19%) and male hired labor (13%) in 1985. While the percentage of total costs allocated to seed were not significantly different between the two samples, the relevant monetary values were 1,545 Tsh. in 1985 and only 84 Tsh. in 1981. Expenditures for fertilizers and other farm chemicals were nearly double in terms of value in 1985 over 1981 (260 Tsh. compared to 145).

Credit

Two of the twelve surveyed families borrowed from friends and relatives in 1985 with the amounts being 200 and 210 Tsh., respectively. All of the money was used to purchase fertilizer and was repaid in full.

Total Cash Income

Total cash income per farm family was almost six times higher in 1985 than in 1981 (Table 9). The most significant difference was in the off-farm income reported in 1985 which accounted for 25% of the total. Crop and livestock sales were also much higher in 1985 than in 1981.

Family Living Expenditures

Average family expenditures per family for 1981 and 1985 are compared in Table 10. Although the total expenditures for the two years

Table 9. A Comparison of Average Total Cash Income (in Tsh) Per Sampled Farm Family, Mgeta, Tanzania, 1981 and 1985

Source	1981		1985	
	Tsh	%	Tsh	%
Crop sales	2,276	67	11,752	63
Livestock sales	141	4	2,279	12
Off-farm income	570	17	4,661	25
Gifts	408	12	50	0
Total	3,395	100	18,742	100

Table 10. A Comparison of Average Family Living Expenditures per Sampled Farm Family, Mgeta, Tanzania, 1981 and 1985

Category	1981		1985	
	Tsh.	%	Tsh.	%
Food	598	37	1,340	31
Maize grinding	48	3	573	14
Clothing & footware. . . .	712	44	1,107	26
Fuel, kerosine, batteries, etc.	162	10	640	15
Pots & pans, bedding . . .	24	1	0	0
Educational & medical. . .	55	3	200	5
Fees, fines & licenses . .	0	0	147	3
Transport (except crop marketing).	30	2	240	6
Other.	0	0	0	0
Total.	1,629	100	4,247	100

showed wide differences (1,629 Tsh. in 1981 compared with 4,247 Tsh in 1985), the distribution among categories show more similarity. Food, including maize grinding was highest category (45%) in 1985 compared with 40% in 1981. Clothing and footwear was the second largest category (44%) in 1981 but only 26% in 1985. Percentage allocations for such items as fuel and other energy sources, pots and pans, transport, education and medicine showed only slight differences between the two years. There was, however, some increase in the share of expenses for maize grinding reflecting in part the higher maize production in 1985 compared to 1981.

Net Cash Income

Farm families who volunteered for the 1985 trials had higher farm and off-farm incomes than sampled families in 1981, as shown in Table 11. Even with much higher average farm operating costs and family living expenditures, their cash balance at the end of the crop year was nearly seven times higher than the sampled families in 1981 (9,150 Tsh. in 1985 compared to 1,347 Tsh. in 1981).

Conclusions re On-Farm Trial Data

One must conclude from the on-farm trial data in Mgeta area in 1985 that the sample was small and that the farm families were farming larger acreages than the typical families in the area; therefore, incomes were much higher than average families. Farm operating expenditures were also much higher than average families showing much higher use of hired labor, purchased seed, fertilizer and transport than sampled 1981 families. Off-farm (non-crop) income was also significantly higher. All of these characteristics of the families who volunteered to test Kabanima and the

knowledge that only 4 of the 12 families chosen had reportable yields, raises serious questions as to the reliability of the data. Perhaps the

Table 11. Average Net Cash Income Per Sampled Farm Family, Mgeta, Tanzania, 1981 and 1985

	Tsh.	
	1981	1985
Crop sales	2,276	11,752
Livestock sales	141	2,279
Farm income	2,417	14,031
Less farm operating costs	419	5,345
Net farm income	1,998	8,686
Off-farm income & gifts	978	4,711
Total net cash income	2,976	13,397
Family living expenses	1,629	4,247
Balance	1,347	9,150

best conclusion is that it was a learning experience and that in the future families who undertake the on-farm testing will be genuine "farm" families typical of the Mgeta area.

03a01a08. 2

KILOSA AREA[2]

Again sufficient seed was available for testing in the fields of 12 farm families in Kilosa area where farming systems studies had been undertaken in the 1980 crop year. This 1980 farming systems study provided excellent background data on the distribution of size of farms in the area, production of crops in the farming system, percentage of each major crop consumed and sold, net returns by crop, labor and purchased input use, and so forth (Due and Anandajayasekeram, 1984, 1). Thus the size of farm and other socio-economic characteristics of the 12 farmer families which volunteered for the TMO 101-traditional seed testing in 1985 can be compared with average farm families of the earlier study. In addition in Kilosa a sample of 59 farm families was chosen to provide more adequate data on the farming systems and to use as a base for an economic evaluation of the new low altitude-rainfall variety TMO 101 (Figure 2).

Sample Selection

It was originally intended that a random sample be drawn, but after the negative reaction to the government official and in the interest of keeping faith with the villagers, volunteers were solicited from the group. It was believed that volunteers would be more receptive and cooperative than farmers who had been appointed or randomly selected.

Information was available from a random sample of families from the same villages in 1980 and these data were compared with the current year's sample. An analysis of variance was conducted between total acreages of farm households in 1980 and 1985. The results in Table 03a02a08.2

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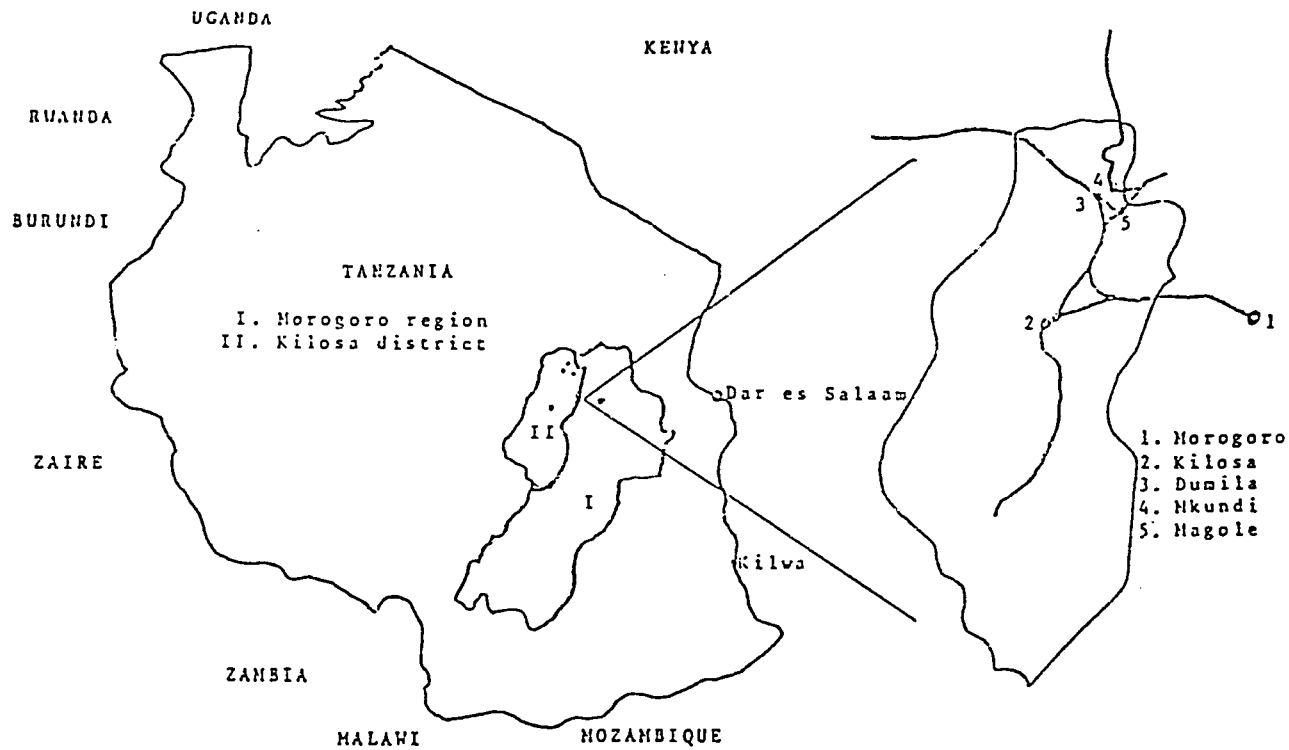
[2]Most of this section comes directly from Rocke (1986).

Figure 2. Map Showing Location of Kilosa District and Dumila, Mkundi, and Magole Villages Morogoro Region, Tanzania



12 show that the differences between the average acreages planted in the two years were not significant at the 5% level, indicating that the samples were taken from the same population.

Table 12. Analysis of Variance of Mean Farm Size Among Sampled Farm Households in Dumila, Mkundi, and Magole in 1980* and 1985

	Year	Sample Size	Mean Acreages	Computed F Ratio	Table F 5% Level
Dumila	1980	19	8.6	.062	3.00
	1985	19	8.9	.062	3.00
Mkundi	1980	20	7.0	.807	3.00
	1985	20	6.0	.807	3.00
Magole	1980	19	9.9	.573	3.00
	1985	20	8.3	.573	3.00

*Source: 1980 data, Kashuliza, A (1982) and Due and Anandajayasekeram (1984.1).

The distribution of farm sizes by village in 1980 and 1985 is shown in Tables 13 & 14. Unfortunately, the classification of farms was different in the two years; however, distribution by size is similar.

The 1980 study found that land was available for expanded production for 80% of the families in Dumila and 90% of the families in Mkundi villages but for only 55% of the families in Magole (Kashuliza, 1982, Table 5).

Test Plot Procedures

Each of the 12 farmers received 268 grams of the HYV TMO 101 seed and was instructed to plant this seed in their fields. The farmers were asked to plant the same number of HYV and local seeds in equal-sized, adjacent plots, thereby reducing the problem of environmental biases. Instructions were given to these farmers, the village chairmen, and the

Table 13. Distribution of Sample Farms by Size, Kilosa District, 1980*

Acres	Dumila No.	Dumila %	Mkundi No.	Mkundi %	Magole No.	Magole %	Kilosa No.	Kilosa %
up to 4.9	1	5	3	15	4	20	8	13
5 to 9.9	16	80	17	85	11	55	44	73
10 to 14.8	3	15	0	0	1	5	4	7
Over 15	0	10	0	0	4	20	4	7
Total	20	100	20	100	20	100	60	100
Mean	7.7		6.3		9.4		7.8	

*Kashuliza, A. (1982) and Due et al. (1984.1).

Table 14. Distribution of Farm Size by Village, Sampled Farm Households, Kilosa, District, 1985

Farm Size (acres)	Dumila No.	Dumila %	Mkundi No.	Mkundi %	Magole No.	Magole %	Kilosa No.	Kilosa %
Up to 3.0	2	11	5	25	4	20	11	19
3.2-6.0	5	26	7	35	6	30	18	30
6.1-9.0	5	26	3	15	4	20	12	20
9.1-12.0	3	16	5	25	1	5	9	15
Over 12.1	4	21	0	0	5	25	9	16
Total	19	100	20	100	20	100	59	100
Mean	8.8		6.1		8.2		7.8	

extension agents (when applicable) for planting and care of the test plots.

Each time enumerators visited the villages, they followed normal protocol by reporting to the village chairman to inform him of their

presence and register their names with him. They also tried to involve the extension agents during the village visits, because they were responsible for disseminating new agricultural information to other farmers. At the beginning of the surveys the extension agents were disinterested, but by the end of the survey period they had become very cooperative.

Since enumerators' time in the villages was limited, the farmers agreed to meet at a central meeting point. In Dumila and Mkundi meetings were by the chairman's house, and in Magole at the chairman's office. Although interviewing farmers in the field is optimal, for this survey it was impractical in most cases due to time constraints and the scattered nature of the fields. However, the team did make visits to the farmers' fields to observe farming practices and crops whenever possible. When farmers failed to come to meeting points, they were interviewed in their field or house. Each time the team worked in a village the experimental test plots were seen and monitored to record progress.

The farmers were instructed to plant one seed per hole at one foot intervals between seeds and rows. Normally farmers plant two or three seeds per hill, but they were requested to plant only one per hole so that germination rates could be observed. By using the customary spacing of one foot between rows and plants, test plots measured approximately 0.028 hectares in each case. Farmers were also asked to plant their preferred local variety in equal-sized test plots adjacent to the HYV plots, with the same number of seeds and identical spacing of rows and columns. In this manner plots could be observed side by side.

The farmers were not requested to monocrop the test plots, but in each case only the test beans occupied the plots. Care, such as weeding and fertilizing, was to be identical for each farmer across plots of HYV and traditional varieties. In every case, farmers weeded once and did not apply any pesticides on beans. This is standard procedure in the study area. It was emphasized that consistent agricultural practices were critical for proper assessment of the test plots.

After discussing the method of planting and care of the crops, written instructions and diagrams were left with the participating farmers and village chairmen. If the farmers became confused or forgot instructions, they could return to the village chairman for help. The unreliability of transport and rainfall, and academic commitments prevented the team from being physically present when the plots were planted.

Progress

Returning a month later to observe the status of the HYV beans, it was found that three farmers did not plant the seeds; two explained that this season's low rainfall would not support the crop, while the other offered no excuse. At this time the extension agent was located and offered his cooperation with the on-farm trials. He said that he would give the packets to two other participating farmers that had land which would support late bean planting, but he never delivered the seeds.

Since neither a pathologist nor entomologist was available to go into the field, diseased bean leaf and insect samples were collected from each test plot and taken to the University for proper identification. Time and personnel did not allow for precise measurement of disease and

insect occurrence; therefore, only an estimate or generalized observation was used to compare the different varieties planted.

The farmers joined the team each time the experimental plots were visited, but rarely were both husband and wife present. This was a joint learning experience for both the farmer and researchers. They were very eager to harvest the beans so they could compare the actual harvest.

By personal observations, all plots exhibited only mild occurrences of bean common mosaic virus and angular leaf spot; TMO 101 was found to be slightly more susceptible to these diseases than the local varieties. In general the farmers did not know the diseases, nor did they fully understand the effect they had on the bean plant. Studies presented at the 1984 and 1985 Bean CRSP workshop in Tanzania stated that yield reduction due to angular leaf spot and bean common mosaic virus may be as high as 52% (Swai and Keswani, p. 71; Buchukundi and Keswani, 1985).

The insect damage to each set of plots appeared uniform. Many different insects were found in plots; aphids, beanflys, foliar beetles, leafhoppers, and caterpillars were the primary pests. The farmers could easily identify or describe the insect and its destructive capabilities. Studies by A. K. Karel, an entomologist at Sokoine University, reported yield losses up to 31% due to foliar beetles (Karel, 1984, p. 38).

Clearly it is important to breed varieties that display a degree of resistance to insects and diseases. At this time fungicides, pesticides, and fertilizers were either unavailable or unaffordable in Tanzania. Due to time and personnel constraints, no measurements were taken to determine yield losses due to disease and insects.

Evaluations

When the rains continued to fail in some areas, some local varieties yielded very little (Table 15). However, TMO 101 displayed its drought adaptability by producing greater yields than traditional local varieties. Tesha mentioned this characteristic in his paper presented at the 1985 Bean CRSP workshop at Sokoine University (Tesha, 1985). The farmers specifically mentioned this favorable characteristic when asked to evaluate TMO 101.

Other evaluations of this HYV included its uprightness and compact stand. The upright stand keeps the pods off the ground and reduces the chance for fungal growth, with can reduce yields. Compactness is a favorable characteristic which makes harvesting faster and threshing easier. At harvest the whole plants are uprooted, carried in a sack to the house, and spread on the ground to dry in the sun. In rare cases after uprooting plants are spread on clean ground alongside the field to dry in the sun. The bean pods are then beaten with sticks to remove the seeds, and the cleaned seed is again dried in the sun before storage.

The yield comparisons can be found in Table 15. Five different local cultivars were planted in the three village test plots. Eight of the 12 farmers actually reaped a harvest from their test plots. Each farmer's harvest was measured in kibabas, the locally accepted unit of measurement which is approximately 0.8 Kg. The number of kibabas was then converted to Kgs. for standardization and computation purposes. The seeds were then purchased from the farmer at twice the local market price. This rewarded the farmers and provided an incentive to cooperate

Table 15. Comparison of Traditional and TMO 101 Yields in Kilograms from Test Plots of 100 Square Meters by Village, 1985

		Varieties		
		TMO 101	Local*	Local*
Dumila Farmer	1	1.0	0.5	-
	2	stolen	stolen	-
	3	-	-	-
	4	-	-	-
Mkundi Farmer	5	7.0	7.0	-
	6	5.0	3.5	1.5
	7	1.0	0.5	-
	8	0.5	0	0
Magole Farmer	9	3.0	0.5	-
	10	1.0	0.5	-
	11	1.0	0	0
	12	-	-	-
Mean		2.40		1.45
Standard Deviation		2.38		2.47
Mean (omitting #5)		1.78		0.75

*Local varieties include Karoboi Red and Blue, Lobi, Fisi, and Red.
-Did not plant

with the researchers in future years. All farmers kept some seed to plant for the next growing season. It was stressed that these seeds should be planted again in the same manner, and observation, inputs, and yields noted.

Yield variation within TMO 101 is noticable, ranging from 0.5 Kgs. to 7.0 Kgs. The standard deviation was 2.38 for the HYV, while the standard deviation was 2.47 for the local cultivars. More agronomic information is needed to determine the causes of this variation. Regrettably, this type of information was not gathered before harvest, and vehicle malfunction prevented the researchers from returning to gather the information later. The farmer who harvested 7.0 Kgs. of TMO 101 planted in a valley where water retention was high.

The average yield of TMO 101 was 524 Kg./Ha. (212 Kg. per acre) from the on-farm trials. The average (3 year) yield at the experimental plots at Sokoine University was 1,026 Kg./Ha. (415 Kg. per acre) (Palapala and Keswani, p. 14), but this yield was obtained with use of fertilizer and pesticides. The on-farm trials did not use these inputs. The local variety yielded 311 Kg./Ha. (126 Kg. per acre) from the on-farm trials. Therefore, the HYV out-yielded the local varieties by 68%. When the unusually high yield was excluded from the mean, the average yield for TMO 101 was reduced to 387 Kg./Ha. (157 Kg. acre) and local varieties fell to 164 Kg./Ha. (66 Kg./acre); this translates to a 135% increase in performance of TMO 101 over the traditional cultivars. Every farmer preferred the HYV over the local variety. One participating farmer tasted the HYV and found it palatable; he commented that there was no discernable difference in cooking times. Since the color of the HYV is the locally preferred color (red/brown), rejection due to taste and color should be minimal.

Soils

The soils of this region range from black to red clay, and include sandy loam types. Since the structure of the clay soils is easily compactable, water absorption and retention is a problem. Pores of clay soils are very small and fill quickly. Thus, the capacity to absorb rain water is very limited; there is either runoff or standing water. The runoff destroys the top soil by washing it away, and the standing water promotes disease and fungus growth. If there is a drought this type of soil contracts and becomes very hard, placing extra stress on the plant. Sandy loam soils are quicker to absorb water, but water also evaporates

faster. The addition of organic matter to the soils would greatly increase their water and nutrient absorbtion and retention capacity (Rodale Press, pp. 36-39).

Rainfall

The rains in Kilosa district begin in November and continue until May. Within this time, there are two rainy seasons. The short rains, which fall between October and early February, averaged 431 millimeters from 1958 to 1985 at Llonga Research Station[3]. The long rains, which usually begin by mid-February and continue until May, average 608 mm. during the same period. The rains are unpredictable, with the short rains less reliable than the long rains. There is usually a short drought of two to three weeks between seasons. After the rain subsides in May, there is usually little rain again until October (see Figure 3).

The short rains are essential to loosen the soil for land preparation by manual labor; in some areas planting is done during this period. The majority of cultivation takes place during the long rains. The variability of the rains is a major constraint to stable yields. Over the past 27 years at the Ilonga Research Station, the short rains were above average 14 times, while the subsequent long rains were below average during eight of those 14 years. During the 13 years when the short rains were below normal, the long rains followed with eight below average rainfalls and five average rainfalls. Thus the unpredictability of rainfall makes choosing a planting time difficult (Lev, p. 1).

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[3]Ilonga, the location of one Tanzanian research station, is located approximately 40 kilometers from the study area.

Figure 3.
Longterm Rainfall at Ilonga Research Station, 1960-1980

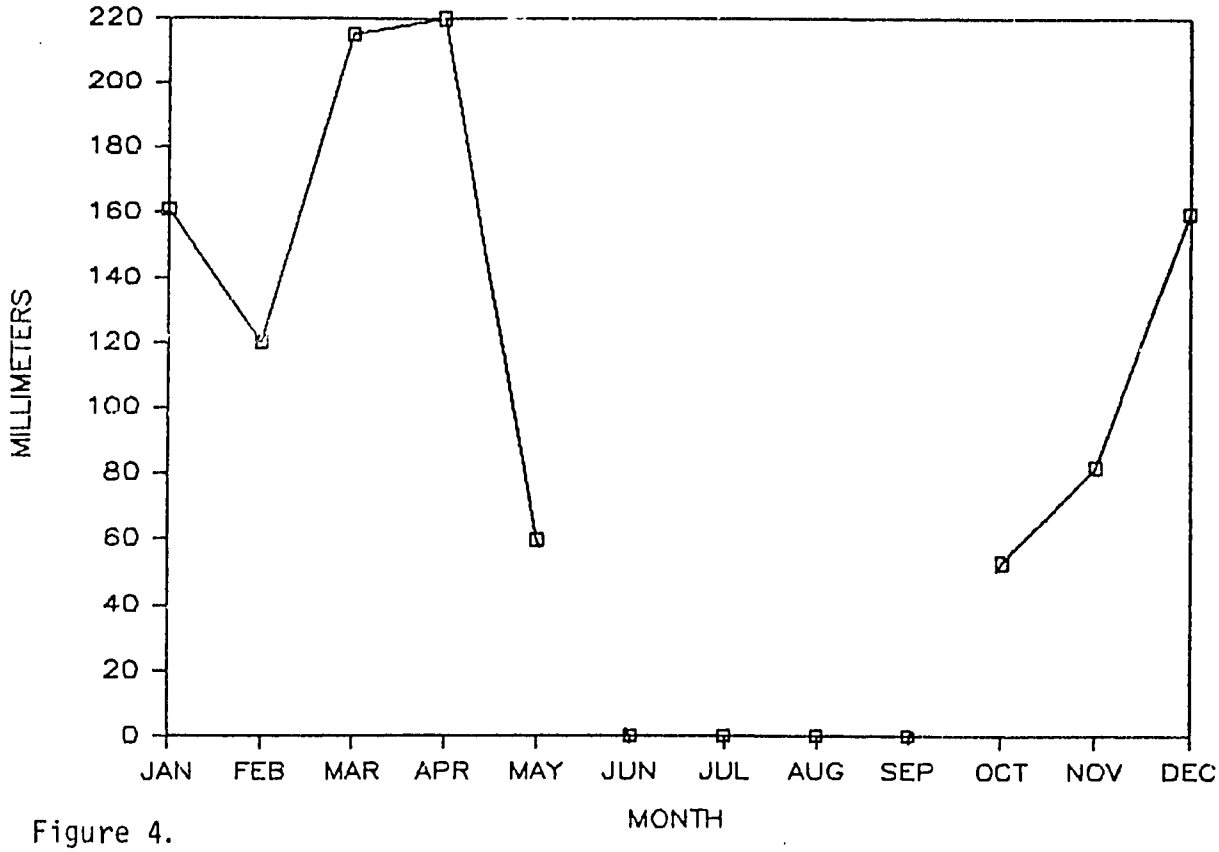
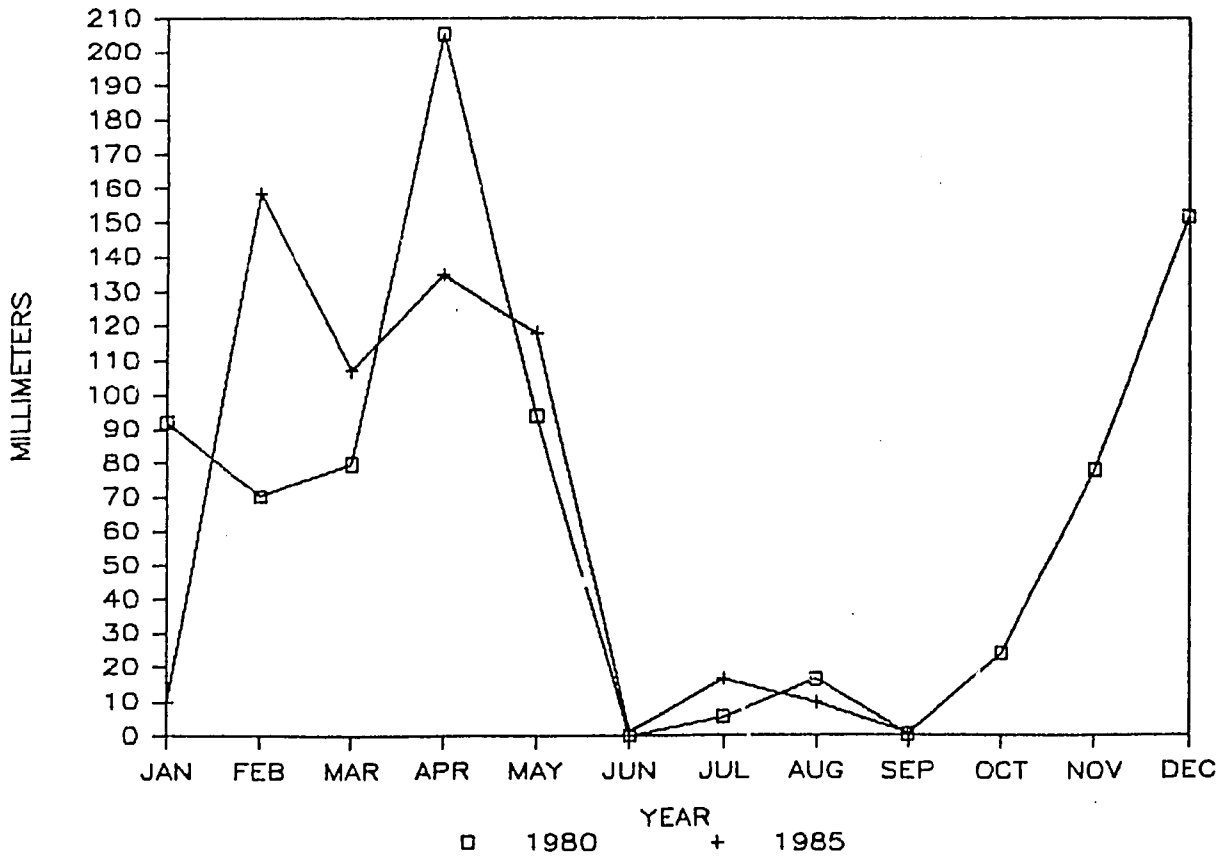


Figure 4.
Rainfall by Month for Selected Years at Morogoro



Source: Sokoine University Meteorological Station

The unpredictability of rain increases the need for drought resistant crops. Farmers reported that the rains were sporadic and poor during the 1985 growing season. This is reflected in poorer than average yields (Table 16). Rainfall data at Sokoine University from 1980 and 1985 are shown in Figure 4. Unfortunately, no rainfall data were available for areas of the study villages, but the general rainfall pattern for 1985 was lower than 1980. The University's rainfall closely approximates the study area; the 1980 yields are compared with 1985 data (Table 16) to show variations.

Table 16. Comparative Average Yields of Selected Crops in Kilograms per Acre in Kilosa District for 1980 and 1985 and Percent Change from 1980 - 1985

	Maize	Sorghum	Beans	Rice	Cotton
Dumila					
1985	385	176	104	249	126
1980	463	243	224	301	222
% change	-17	-28	-54	-17	-43
Mkundi					
1985	223	254	110	278	169
1980	408	296	172	240	300
% change	-45	-14	-36	+16	-44
Magole					
1985	263	171	185	210	N/A
1980	421	390	290	376	N/A
% change	-37	-56	-36	-44	-

Farm Households

The mean socio-economic data for the Kilosa farm households sampled in 1985 are shown in Table 17. The average age of the husbands was 47 and of the spouses 37 years. The number of children, of which there were more females than males, averaged 3.6 per household.

Table 17. Average Socio-Economic Data per Sampled Farm Household by Village, Kilosa District, 1985

Means of:	Dumila	Mkundi	Magole
Age of Husband	49	45	48
Age of Wife	35	37	38
% of Husbands with Multiple Wives	32%	5%	20%
No. of Children, Male	2.1	1.2	1.9
No. of Children, Female	2.2	2.0	1.6
Family Total	6.6	5.2	6.7
Adult Male equiv.*	2.1	1.5	1.7
Adult Female equiv.	2.3	1.6	1.6
Total Adult equiv.	4.4	3.1	3.3
Years Education, Male	2.8	3.6	4.5
Years Education, Female	2.5	2.9	3.7
# of Years Farming	26.2	25.5	24.3
# of Shambas	4.5	3.6	2.6
Distance to Shambas (fields) (Km)	1.2	0.6	2.9

* Person equivalents for full time farming is calculated by male or female over 18 years = 1.0; male or female 12-17 years = 0.5; male or female 8-11 years = 0.3 (Due et al., 1985, p. 22).

Households generally consisted of additional adults other than the husband and wife, giving a total average family size of 6.2 persons per household. This resulted in total adult equivalents farming of 3.6 per household. In general, the male members of the household had better formal education than their female counterparts, receiving 3.6 years compared to 3.0 for the females.

Respondents had been farming an average of 25 years, cultivating 15 different crops with 23 intercrop combinations on 3.6 shambas (fields) per household located at an average distance of 1.6 km from their homes. The average size of shamba was 0.91 ha. (2.3 acres) per farm family for an average farm size of 7.8 acres (Table 18). Of total farm acreage,

approximately 50% was devoted to maize production, with 58 of the 59 farmers cultivating that crop; beans were cultivated by over half of the farmers (61%) but occupied only 4% of the farm acreage. Sorghum and rice were cultivated by 51% and 29% of the farmers respectively, with acreage in these crops representing 15 and 10% of cropped acreage. Other crops cultivated included bananas, sugar cane, cotton, tubers, coconuts and vegetables.

Table 18. Average Acres Planted, Percentage of Land Devoted to Each Crop, and Number of Farm Households Planting Each Crop, Sampled Families in Study Villages, 1985

	Dumila			Mkundi			Magole		
Crop	Average Acres	%	No.	Average Acres	%	No.	Average Acres	%	No.
Maize	4.5	53	19	2.4	39	19	5.0	61	20
Bean	.5	6	14	.3	5	14	.2	2	8
Banana	.7	8	4	.2	3	1	.2	2	2
Sugar	.7	8	6	.2	3	3	.2	3	3
Cotton	.2	2	8	.3	5	8	0	0	0
Tubers*	.5	6	7	.3	5	3	.3	3	5
Sorghum	.4	4	5	2.0	33	18	.7	9	7
Rice	1.0	11	10	.1	2	3	1.3	16	4
Other**	.2	2	2	.3	5	3	.3	4	4
Total Acres	8.8	100	19	6.1	100	20	8.2	100	20

*Cassava and potatoes

**Tomatoes, green grams, cowpeas, coconut, sesame, and yams

No. is the number of farm households planting a particular crop.

Cropping Patterns

Cropping pattern and calendars varied by farm household depending on soil types, labor commitments, and rainfall patterns (see Table 19). However land preparation practices were fairly similar beginning with hand hoeing (and in some cases hired tractors) just prior to the rains or shortly thereafter for maize, rice and sorghum and just before planting for beans and cotton. Crops were generally weeded twice during the crop year, at six and twelve weeks after planting. With the exception of some maize plots, all harvesting was conducted during the dry season. January, February and March were the busiest months for the area although this varied by cropping pattern. Hired labor was generally used for land preparation and weeding. Female members of the farm households contributed approximately 50% of total participating primarily in land preparation, weeding and har- vesting although some were involved in planting (Tables 20, 21, and 22).

Objectives in Farming

Farm households throughout Kilosa regarded food production as the major objective in farming, with 97% electing this objective as primary and the secondary objective was generating enough cash to buy family living articles or build a house.

Food Preferences

Food preferences for the region are listed in Table 23 which shows maize followed by sorghum as the most preferred crops. Other crops favored included cassava, cassava leaves and tubers such as sweet potatoes.

Table 19. Cropping Calendar by Crop in Dumila, Magole, and Mkundi, 1985

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize	LP	LP	LP						LP	LP	LP	LP
	P	P	P	P								P
	W1	W1	W1	W1								W1
			W2	W2	W2							
			H	H	H	H						
Beans			LP	LP	LP							
			P	P	P							
				W1	W1	W1						
					W2	W2	W2					
							H	H				
Rice	LP								LP	LP	LP	LP
	P	P	P									
	W1	W1	W1	W1	W1	W1						
					H	H	H					
Sorghum	LP	LP							LP	LP	LP	LP
	P	P	P									
	W1	W1	W1	W1	W1							
			W2	W2	W2	W2	W2					
					H	H	H	H	H			
Cotton	LP	LP	LP	LP								
		P	P	P								
			W1	W1	W1							
						W2	W2					
							H	H	H	H		

LP - Land Preparation
P - Planting
W1 - First Weeding
W2 - Second Weeding
H - Harvest

When farm households were asked to outline the minimum acreages needed for subsistence consumption in a 'normal' year, the results tally closely with the actual cropped areas and consumption as shown in Table 24. The differences are remarkably similar for maize with a difference of only 0.11 acres. Less beans were planted than that reportedly needed for family consumption, the difference being 0.97 acres, the reason often being currently unsuitable planting conditions.

Table 20. Average Labor Days Allocated to Crops per Farm Household by Gender and Percent Female, Dumila, 1985

	Maize	Beans	Sorghum	Rice	Cotton	Total
Land Prep.						
Male	33	3	18	17	10	81
Female	21	3	17	23	9	81
(%F)	(47)	(50)	(49)	(57)	(47)	(50)
Planting						
Male	10	2	1	23	5	41
Female	8	3	1	18	4	34
(%F)	(44)	(60)	(50)	(43)	(44)	(45)
Weeding						
Male	26	3	6	25	10	70
Female	21	3	5	22	9	60
(%F)	(45)	(50)	(45)	(47)	(47)	(46)
Harvesting						
Male	14	2	7	11	4	38
Female	12	3	6	12	5	38
(%F)	(43)	(40)	(46)	(52)	(55)	(50)
	---	---	---	---	---	---
Total	145	22	61	151	86	443
% Female	(43)	(55)	(48)	(50)	(48)	(48)

Table 21. Average Labor Days Allocated to Crops per Farm Household by Gender and Percent Female, Mkundi, 1985

	Maize	Beans	Sorghum	Rice	Cotton	Total
Land Prep.						
Male	26	5	27	4	6	58
Female	22	5	18	8	6	59
(%F)	(46)	(50)	(40)	(67)	(50)	(46)
Planting						
Male	4	2	3	2	2	13
Female	5	2	3	2	2	14
(%F)	(56)	(50)	(50)	(50)	(50)	(52)
Weeding						
Male	24	7	25	5	10	71
Female	18	7	22	5	6	58
(%F)	(43)	(50)	(47)	(50)	(38)	(45)
Harvesting						
Male	11	4	18	3	6	42
Female	18	3	12	3	11	47
(%F)	(62)	(43)	(40)	(50)	(65)	(53)
	---	---	---	---	---	---
Total	63	17	55	18	25	178
% Female	(49)	(48)	(42)	(56)	(51)	(48)

Table 22. Average Labor Days Allocated to Crops per Farm Household by Gender and Percent Female, Magole, 1985

	Maize	Beans	Sorghum	Rice	Cotton	Total
Land Prep.						
Male	31	5	16	23	-0-	75
Female	23	7	12	25	-0-	67
(%F)	(43)	(58)	(43)	(52)	(0)	(47)
Planting						
Male	6	2	4	6	-0-	18
Female	5	3	5	7	-0-	20
(%F)	(45)	(60)	(56)	(54)	(0)	(53)
Weeding						
Male	19	6	15	11	-0-	51
Female	18	6	17	15	-0-	56
(%F)	(49)	(50)	(53)	(58)	(0)	52
Harvesting						
Male	11	5	10	12	-0-	38
Female	14	5	15	15	-0-	49
(%F)	(56)	(50)	(60)	(55)	(0)	(56)
	---	---	---	---	---	---
Total	60	21	49	62	0	192
% Female	(47)	(53)	(52)	(54)	(-)	(51)

Table 23. Listed Frequencies of Food Preferred by Farm Households by Village

	Dumila	Mkundi	Magole
Maize	19	20	18
Sorghum	14	15	11
Rice	13	5	8
Beans	1	6	8
Cassava	2	6	3
Potato	1	1	3

Table 24. Comparison of Estimated Average Acres per Farm Household Needed for Food Consumption and Actual Acreages Planted for Consumption by Village, 1985

	Dumila		Mkundi		Magole	
	*est.	act.**	est.	act.	est.	act.
Maize	2.79	2.49	1.90	2.10	2.49	2.49
Beans	.59	.30	.49	.20	.49	.10
Other	.49	.99	.99	1.19	.40	.40
Total	3.87	3.78	3.38	3.49	3.38	2.99
% increase to cover bad year	3		-3		13	

*est. = estimated: act. = actual
**Actual acres produced for food consumption was calculated by dividing reported food (by crop) consumed by average yield per hectare (by crop).

Production, Consumption and Sale

Total volume and value of production, consumption and sale of crops, with value computed using open market prices, are given in Table 25. The mean of total crops produced per sampled family in Kilosa area amounted to 1,555 kg. of which maize represented the largest share (65%). Maize was also the most important crop in terms of the value of crop production accounting for 52% of the total average value of 14,112 Tsh. Of the remaining crops, the next most important in terms of crop value were rice (13), sorghum (10%), and beans (8%), in that order.

On average, over 50% of the total volume of production was consumed (53%) in all three villages but that consumption varied by crop ranging from 0% for cotton and sunflower to 58% for maize and potatoes and 61% for beans. Sales represented 42% of total production by weight with the

Table 25. Average Crop Production, Consumption, Sales, and Seed/Waste per Farm Household by Village in 1985

	Dumila		Mkundi		Magole	
	Kg.	Tsh.	Kg.	Tsh.	Kg.	Tsh.
Maize						
Production	1,288	10,387	436	2,725	1,319	8,771
Consumption	692	5,577	416	2,600	663	4,409
Sales	489	3,946	8	50	586	3,896
Seed/Waste	107	864	12	75	70	466
Sorghum						
Production	63	441	462	3,127	120	780
Consumption	10	70	258	1,745	43	281
Sales	50	350	197	1,335	73	473
Seed/Waste	3	21	7	47	4	26
Cotton						
Production	26	169	51	333	0	0
Consumption	0	0	0	0	0	0
Sales	26	169	51	333	0	0
Seed/Waste	0	0	0	0	0	0
Rice						
Production	283	3,793	31	487	84	1,345
Consumption	145	1,943	20	314	36	576
Sales	131	1,757	10	157	47	753
Seed/Waste	7	93	1	16	1	16
Beans						
Production	65	1,579	22	616	37	1,013
Consumption	45	1,093	16	449	14	384
Sales	17	413	4	111	20	547
Seed/Waste	3	73	2	56	3	82
Sunflower						
Production	9	62	6	44	131	903
Consumption	0	0	0	0	0	0
Sales	9	62	6	44	130	896
Seed/Waste	0	0	0	0	1	7
Sugar						
Sales	-	810	-	566	-	492
Banana						
Sales	-	505	-	42	-	433
Cassava						
Production	35	112	40	200	2	6
Consumption	22	70	19	95	2	6
Sales	13	42	21	105	0	0
Seed/Waste	-	0	-	0	0	0

Table 25. Average Crop Production, Consumption Sales, and Seed/Waste per Farm Household by Village in 1985 cont.

	Dumila		Mkundi		Magole	
	Kg.	Tsh.	Kg.	Tsh.	Kg.	Tsh.
Potato						
Production	35	353	9	137	42	634
Consumption	12	120	4	61	16	241
Sales	22	223	5	76	24	363
Seed/Waste	1	10	-	-	2	30
Other*						
Production	29	435	16	252	24	785
Consumption	15	225	8	125	11	360
Sales	14	210	8	127	13	425
Total						
Production	1,833	18,646	1,073	8,529	1,759	15,162
Consumption	941	9,098	741	5,389	785	6,257
Sales	711	8,487	310	2,946	893	8,278
Seed/Waste	121	1,061	22	194	81	627

*Other signifies cowpeas, tomatoes, sesame, and green gram.

remaining 5% either wasted or used for seed. Variation by village also is shown in Table 25.

Farm Capital Owned

Farm households generally did not own significant amounts of farm equipment as show in Table 26. On average, each household owned 3.4 hoes valued at 66 Tsh., 1.5 pangas with a value of 38 Tsh., and 1.1 axes at a value of 4.3 Tsh. Other tools owned included hammers and shovels with value of 13 and 17 Tsh., respectively.

Livestock Owned, Consumed and Sold

As shown in Table 27, the sampled farm households reported owning very little livestock with no family owning any cattle. The largest single type of livestock owned was poultry with each family owning an average of 6 head. Goats and pigeons were reared in the area but these were not abundant. Small amounts of poultry were consumed by the families, (4 per family) and about 2 were sold for a total sales value of 85 Tsh., representing the only livestock sales for the area.

Table 26. Average Number, Cost, and Life* of Farming Implements Owned per Farm Household in the Study Areas in 1985

		Dumila	Mkundi	Magole
Axe:	Number	1.1	1.0	1.1
	Cost in Tsh.	42.2	36.0	49.6
	Life in Years	10.0	9.0	7.4
Shovel:	Number	0.2	0.2	0.2
	Cost in Tsh.	8.2	11.7	31.0
	Life in Years	2.3	2.0	6.0
Hoe:	Number	4.0	3.0	3.2
	Cost in Tsh.	57.0	64.0	76.0
	Life in Years	5.0	3.0	3.9
Hammer:	Number	0.5	0.4	0.3
	Cost in Tsh.	13.9	15.0	9.2
	Life in Years	5.0	3.0	6.9
**Panga:	Number	1.7	1.3	1.4
	Cost in Tsh.	42.0	31.1	40.0
	Life in Years	6.0	4.0	5.6

* Life refers to the number of years an implement is functional.
** Panga, also known as a machete or bush knife.

Table 27. Average Number of Livestock Owned, Consumed, and Sold per Farm Household (In Tsh.) 1985

		Dumila	Mkundi	Magole
Cattle				
	Owned	0	0	0
	Consumed	0	0	0
	Sold	0	0	0
Goat				
	Owned	0.2	0	0
	Consumed	0	0	0
	Sold	0	0	0
Pigeon				
	Owned	0	1	0
	Consumed	0	0.2	0
	Sold	0	0	0
Poultry				
	Owned	4.6	5.8	4.7
	Consumed	2.5	5.8	3.7
	Sold	1.3	1.5	1.6
Total Sales(Tsh.)		82.0	92.0	80.0

Constraints to Agricultural Production

The five major-constraints affecting farmers' attempts to expand agricultural production are insect damage, drought, labor shortages, poor storage facilities and input unavailability (Table 28). Insect damage was a major problem to 51 of the 69 farmers surveyed (85%), with drought ranked second, being a problem for 73% of the respondents. The severity of the problems posed by insects is not surprising, given the relative lack of knowledge of farmers with regards to use and benefit of insecticides, and the unavailability and high costs of these chemicals. Storage problems originate from the storage methods used. Crops were generally stored in tins, clay pots, gunny sacks or large home-made bark containers (Kilindo), resulting in mold development and insect infestation.

Table 28. Listed Frequencies of Major Constraints to Production by Village

Constraints	Dumila	Mkundi	Magole
Insects	20	17	14
Drought	17	16	11
Labor Shortage	4	6	13
Input Availability	9	6	7
Storage	7	6	5

Farm Operating Costs

Average farm operating cost per farm family are tabulated in Table 29. Hired labor and machinery represented the two most significant expense items, accounting for 46 and 40% of total farm operating costs.

Male hired labor was substantially higher than female hired labor, both in number of days hired and total expenditure, but the wage rates for the two groups were approximately equal. Expenditure on seed was substantial (211 Tsh.) but little was spent on chemicals (12 Tsh.) or on tools (61 Tsh.) reflecting the low levels of farm capital. Although machinery hire was minimal on some farms, the high cost of that item on others resulted in a substantial average cost of 830 Tsh., representing 40% of total farm expenses.

Table 29. Average Farm Operating Costs (in Tsh.) of Sampled Farm Households by Village, 1985

	Dumila		Mkundi		Magole	
	amt.	value	amt.	value	amt.	value
Hired male labor, days	32	1,042	16	428	29	854
Hired female labor	7	234	6	178	5	138
Seed, kg.	8	280	4	118	10	235
Fertilizer, kg.	0	0	0	0	0	0
Chemicals, kg.	0.1	4	0.4	26	0.2	5
Machinery hire	-	595	0	0	-	1,896
Tool purchase	0.7	51	0.8	52	0.8	80
Total (Tsh.)		2,206		802		3,208

Off-Farm Income and Gifts

A number of farm families received income from non-farm sources including employment and gifts. Income was earned from 21 different types of employment activities including wage labor, carpentry, tax collection, marketing and shopkeeping (Table 30). Overall, off-farm income of 3,371 Tsh. per family was earned of which 3,136 Tsh. (93%) was

Table 30. Average Off-Farm Income and Gifts Earned per Farm Household by Village, 1985

	Dumila	Mkundi	Magole
Employment			
Husband	1,158	2,712	3,336
Wife	0	0	54
Selling Goods			
Husband	1,386	71	720
Wife	21	0	400
Gifts			
Husband	0	0	25
Wife	0	0	230
Total			
Husband	2,544	2,783	4,081
Wife	21	0	684
Husband & Wife	2,565	2,783	4,765

contributed by the husband. Wives earned most of their income from selling such goods as beer and firewood, while off-farm emloyment was the major source of income for the husbands. Gifts were not a significant source of off-farm income, amounting to only 85 Tsh. of which 77 Tsh. (91%) was received by the wives.

Family Living Expenditures

Average family living expenditures per farm family are shown in Table 31. Expenditures for food represented the single largest item, accounting for 39% of total expenses when bean purchases are included and 48% when maize grinding is added. Clothing was the next largest representing 25% of total family living expenses. Smaller amounts were spent on fuel, education, medicine, transportation and taxes for a total average family expenditure of 9,220 Tsh. per family.

Table 31. Average Family Living Expenditures (in Tsh.) per Farm Household and Percent of Expenditure by Category by Village in 1985

	Dumila		Mkundi		Magole	
	Tsh.	%	Tsh.	%	Tsh.	%
Food	2,876	30	3,637	41	2,603	28
Beans	611	7	442	5	711	8
Maize Grinding	892	9	1,064	12	553	6
Clothing	2,399	25	1,875	22	2,622	28
Fuel*	984	10	827	9	646	7
Household**	375	4	185	2	597	7
Medical, Educ.	580	6	340	4	728	8
Fees (taxes)	513	5	176		118	1
Transportation	391	4	274		639	7
Other	0	0	0	0	0	0
	9,621	100	8,817	100	9,237	100

* Fuel includes kerosene, batteries, charcoal, and firewood.
** Household includes furniture, tiles, tin for roofs, linens, lamps, etc.

Total Cash Income

Cash income per farm household from both farm and non-farm sources averaged 10,028 Tsh. as seen in Table 32. Of this total, crop sales accounted for 65% of total cash income and off-farm income for 34% with less than 1% from livestock sales.

Net Cash Income

The average net cash income and expenses per farm household are given in Table 32. The most striking feature is the average deficit of 1,264 Tsh. for the region as a whole, representing a large amount of negative savings in this drought year. It may be that respondents

underreport income but are most ready to reveal expenses. Family living expenses accounted for a significant part of the deficit, absorbing 92% of the total average farm income.

Table 32. Average Cash Income and Expenses (in Tsh.) per Farm Household by Village, 1985

	Dumila	Mkundi	Magole
Total Crop Sales	8,487	2,946	8,278
Total Off-Farm Income	2,565	2,783	4,765
Livestock Sales	82	92	80
Total Income	11,134	5,821	13,123
Less Family Living Expen.	-9,621	-8,817	-9,217
Less Farm Operating Costs.	-2,206	- 802	-3,208
Balance	- 693	-3,798	+ 678

Further Data Analysis[4]

Small scale farming is full of uncertainties complicated further by the introduction of new technology including new crop varieties. Many factors, including weather, disease and pests, economic conditions and government policies interact to affect the decision-making process and feed back into the adoption of new technologies. Therefore, if the new technologies recommended by the Bean/Cowpea CRSP are to be adopted, their benefits to the farming systems must be first established. This is especially relevant to the new TMO 101 variety now being tested. Farm activities derived from the survey were used to analyze farmers' decision-making processes including the adoption of new technologies and crop allocation decisions under various production options.

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[4] In this section, following Rocke (1986), hectarages rather than acreages were used throughout.

The survey analysis formed the basis for designing a linear programming model aimed at maximizing farmers' gross margin of production. This is done subject to various production constraints obtained from the survey data; specifically the model maximizes farmers' gross margins, defined as total value of production less expenses for seed. The included constraints are available family labor, land, nutritional intake, and risk considerations. These factors are introduced to determine the impact of price and yield variability on farming decisions. Such a formulation would provide for the determination of the economic impact of crop allocation decisions, including the high yielding bean varieties (HYV) on farm incomes. The inclusion of risk into the programming model is found to reduce the level and standard deviations of net revenue. Given the limited environmental conditions available for the cultivation of rice, acreage of land available for rice production was parameterized up to a maximum of 10% of total land currently allocated to the modelled crops.

The model is based on the assumption that small farmers aim to avoid financial ruin by adopting a production strategy that at least provides subsistence.

The Linear Programming Model

The objective of the linear programming model is to determine the optimal crop mix, consisting of five crops including TMO 101, that produce the greatest net returns subject to land, labor, nutritional and risk constraints. The included crops of maize, beans, sorghum, rice and cotton were selected on the basis of their importance in the farm-level survey. Following the recommendations of Boussard and Petit (1967), such

production risk is incorporated into the decision making process by including minimum income, total permissible loss and focus of loss as dependent variables.

Holding the other variables constant while varying minimum income obtained from crop sales allows the model to generate a number of solutions sensitive to these changes in minimum income. Thus the minimum income is incrementally varied from 0 to a maximum at the point at which the solution became infeasible. Total permissible loss acceptable to the farmer is an endogenous variable determined by subtracting the desired minimum income from total expected gross margin. This total permissible loss is divided by the number of included crops and this fraction assigned to each crop as a measure of its riskiness. By varying crop activities the effect of diversity and risk on total gross margins can be analyzed.

The focus of loss is a probability distribution that monitors the riskiness of a particular variable. Assuming receipts from crop sales are normally distributed, the standard deviation of each cropped hectarage can be used to model the variability of crop prices and yields.

The linear programming model is written as follows:

$$\text{MAX} : \sum_{i=1}^{6} C_i X_i - OL$$

Subject to:

$$1) \quad \sum_{i=1}^{6} F_{mi} X_i \leq b_m \qquad (m = \text{months January}, \ldots, \text{December})$$

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2) $\sum_{i=1} X_i \leq b_{13}$

3) $\sum_{i=1}^{6} N_i X_i \geq b_{14}$

4) $\sum_{i=1}^{6} U_i X_i \geq b_{15}$

5) $\sum_{i=1}^{6} C_i X_i - \text{loss} = b_{16}$

6) $P_i X_i - (1/K)(\text{loss}) \leq 0$

where: i - crops; maize, local beans, sorghum, rice, cotton, and HYV beans
C - gross margin of crop i per hectare
X - hectares of crop i

1) m - months, January through December
F - average days farm household worked with crop i per hectare
b_m - number of days available for work per month

2) b_{13} - average hectares of land available

3) N_i - quantity (Kg.) of calories crop i produces per hectare
b_{14} - current quantity (Kg.) of calories farm household consumed from crop i

4) U_i - quantity (gm.) of utilizable protein crop i produces per hectare
b_{15} - current quantity (gm.) of utilizable protein farm household consumed from crop i

5) Loss - total permissable loss
b_{16} - minimum permitted income

6) P_i - focal loss, variations of riskiness in crop i
K - crop activities

The Objective Function

$$\text{Max} \quad \sum_{i=1}^{6} C_i X_i - OL$$

The objective function is to maximize the gross margin from crop production defined as total value of production less seed expenses by selecting a mix of cropping activities. Only the market value of seed is included as expenditure given the low value of capital inputs and the fact that few other purchased inputs were used except expenses incurred for hired labor and equipment. Land and family labor costs were not included in the model; each factor was included as a possible constraint. Hired labor and machinery costs would enter the model only if family labor became a constraint, which did not occur. The prices of all crops with the exception of cotton, were based on market prices reported in the survey. Since no prices were as yet available for the HYV, the market price for local beans was used. For cotton the official government price was used since the government is the sole purchaser of that crop. The average yields obtained from the farm survey were used as the expected yields in the model. Tables 34 and 35 list seed costs and average crop prices.

Table 35 lists the average price per Kg. in Tanzanian Shillings for each commodity. These prices were obtained from the survey administered in each village.

Table 33. Coefficients of Linear Programming Model for Dumila

	X_1	X_2	X_3	X_4	X_5	X_6	OL		RHS
Z =		7558	5441	1896	9427	1741	4248		
Jan		15.3	.5	14.8	13.5	30.6	.5		110.75
Feb		11.1	.5	1.4	3.4	55.8	.5		97.5
Mar		13.5	1.4	35.0	27.6	54.8	1.4		110.75
Apr		8.9	35.3	7.4	25.9	18.5	35.3		106.3
May		6.1	11.1	8.1	20.0	60.2	11.1		110.75
Jun		5.4	9.8	0	10.1	0	9.8		106.3
Jul		6.4	10.8	5.1	0	18.5	10.8		110.75
Aug		.5	4.2	9.1	0	18.0	4.2		110.75
Sep		3.7	0	0	2.7	0	0		106.3
Oct		3.9	0	0	19.7	0	0		110.75
Nov		4.4	0	16.0	34.8	0	0		106.3
Dec		12.5	3.2	.5	53.3	0	3.2		110.75
Land		1	1	1	1	1	1		2.71
Cal		9299	2363	4107	6133	0	4818		8733
UP		118	114	64	76	0	232		123
Mini		7558	5441	1896	9427	1741	10492	-1	= Mini
FLC		6417						-1/K	0
FLC			5446					-1/K	≤ 0
FLC				1116				-1/K	≤ 0
FLC					4697			-1/K	≤ 0
FLC						3361		-1/K	≤ 0
FLC							9672	-1/K	≤ 0

X_1 - Hectares of maize
X_2 - Hectares of local beans
X_3 - Hectares of sorghum
X_4 - Hectares of rice
X_5 - Hectares of cotton
X_6 - Hectares of HYV beans

Mini - Minimum Income in Tanzanian Shillings per hectare
RHS - Right Hand Side

Labor - Days per hectare by month by family
Land - Land available
Cal - Calorie constraint in available calories/ha.
UP - Utilizable Protein in available gms/ha.
FLC - Focus Loss Constraint in Tanzanian Shillings
L - Total permissable loss
1/K - Diversity Fraction

Table 34. Average Seed Costs in Tanzanian Shillings to Plant One Hectare of Selected Crops by Village, 1985

	Dumila	Mkundi	Magole
Maize	190	148	158
Local beans	600	686	676
Rice	662	775	790
Sorghum	131	125	121
Cotton	289	289	N/A
HYV beans	600	686	676

Table 35. Average Price Received in Tanzanian Shillings Per Kilogram of Each Crop Sold by Farm Households by Village, 1985

	Dumila	Mkundi	Magole
Maize	8.07	6.25	6.65
Beans	24.3	27.8	27.4
Rice	13.4	15.7	16.0
Sorghum	7.0	6.7	6.7
Cotton	6.5	6.5	N/A

The gross margin per crop is then computed by multiplying the crop price by the expected yield of each crop and subtracting the cost of seeds. These gross margins are then summed across all crops to get total gross margins.

The Constraints

i) Labor

$$\sum_{i=1}^{6} F_{mi} \leq b_m$$

Actual family labor used by cropping activity is calculated monthly from the survey data on a per hectare basis. The days available per month are obtained by subtracting a total of six days per month for such activities as marketing, religious ceremonies and illness. The remaining days for each respective month are multiplied by the average adult labor equivalents per household computed from the farm survey.

ii) Land

$$\sum_{i=1}^{6} X_i \leq b_{13}$$

The average hectarages of land cultivated in the five modelled crops is used for each village as the average farm size. Land available for rice production was constrained to be less than 10% of total currently cultivated land due to the limited land suitable for rice production.

iii) Nutritional Constraints

$$\sum_{1=1}^{6} N_i X_i \geq b_{14} \qquad \text{CALORIES}$$

$$\sum_{i=1}^{6} U_i X_i \geq b_{15} \qquad \text{UTILIZABLE PROTEIN}$$

The production and consumption of food is a major concern of farm households and is tied directly to nutritional considerations. Although all nutrients are important for health the unavailability of data on all

nutrients resulted in only calories and utilizable protein being included in the model. Daily calorie consumption of the four crops is computed as follows:

$$\sum_{i=1}^{4} \frac{1}{D_y} (R_i X_i T_i)$$

Where D_y = the number of days per year (365)
R_i = the yield per hectare of crop i (in Kg)
X_i = hectares of crop i produced
T_i = caloric content per kilogram of crop i

The value of this equation must meet or exceed the current (1985) daily calorie consumption which is computed as:

$$\sum_{i=1}^{4} \frac{1}{D_y} (B_i T_i)$$

where B_i is current consumption of crop i per farm household (in Kg). Other variables were defined as previously.

The utilizable protein constraint was constructed in a similar manner with utilizable protein substituted for calories. In both cases cotton is not included since it is not a food.

The nutritional content of the crops are detailed in Table 36 for calories and utilizable protein.

Table 36. Calorie and Utilizable Protein Available per Kilogram by Crop

	Maize	Sorghum	Rice	Beans
Food Energy (Kcal)	3570	3450	3640	3360
Utilizable Protein (Grams)	45.6	54.1	45.1	162.7

Source: Latham, Appendix I

Each farm household is comprised of consumer units that have different weights according to age and sex (see Table 37). The

computation of the value per consumer unit was based upon the nutrient requirements at a medium level of activity for individuals. The adult female was used as the base against which a nutritional index was developed.

Table 37. Nutritional Index

	Adult		Adolescent		Child			
	Male	Female	Male	Female	7-9	4-6	1-3	< 1
Calories	1.34	1.00	1.35	1.14	1.16	0.97	0.72	0.44
UP*	1.29	1.00	1.25	1.21	1.04	0.83	0.67	0.58

UP* = Utilizable Protein Source: Latham, (1979)

Table 38 shows the weighted consumer units by village. The consumer units were multiplied by the daily recommended calories or utilizable protein level to get the minimum required amount of calories or utilizable protein consumed per day.

Table 38. Weighted Average Consumer Units per Household by Village

	Dumila	Mkundi	Magole
Calories	7.3	6.3	6.3
Utilizable Protein	7.1	6.0	6.4

Table 39 compares the actual amount of calories and utilizable protein consumed per average farm household per day for the four study crops to the minimum recommended daily requirements in 1985.

The four crops converted into calories and UP produced between 38% and 42% of the total minimum recommended levels of utilizable protein and between 46% and 52% of the minimum recommended levels of calories:

Table 39. Actual, Recommended, and Percent Recommended of Calories and and Utilizable Protein per Farm Household by Village in 1985

	Actual		Recommended		% of Recommended	
	*Kcal	**UP	Kcal	UP	Kcal	UP
Dumila	8,733	123	16,753	291	52	42
Mkundi	6,637	100	14,458	246	46	40
Magole	7,456	100	14,458	262	51	38

* Minimum Kcal. = 2,295 per adult
** Minimum UP (Utilizable Protein) = 41.9 per adult

however, it can be assumed that farm households consumed other food stuffs, such as vegetables, fruits, meats, and herbs. These constraints dictate to the LP to allocate the appropriate crops that will assure the farm household of at least the current 1985 nutrient consumption level.

(iv) Minimum Income

$$\sum_{i=1}^{6} C_i X_i - \text{loss} = b_{16}$$

The fourth constraint introduced the concept of risk. Boussard and Petit's concept of "negligible possibility of ruin" is used in this model. It is assumed that farmers want to maximize their "normal" (or mean) value of income subject to the constraint that the focus of loss of one crop is at least equal to a fraction of the permissable loss. Focus of loss is defined as the level of loss which the farmer or decision maker would be "surprised to reach in any eventuality". Total permissable loss is determined by taking total gross margin (obtained from an optimal crop mix) minus a stated minimum income (Boussard and Petit, p. 873). In other words, farmers want to maximize net income within the constraint that the possibility is very small in any given

year that the income is below a fixed minimum. The fixed minimum income is varied incrementally upward from 0 (less risk averse) to a maximum. This maximum identified the most income that can be assured, given the constraints to production. Total permissable loss is endogenous, i.e., defined by the solution. It will vary according to the minimum income that the farmer is willing to accept.

(v) Security

$$P_i X_i - (1/K)(\text{loss}) < 0$$

This constraint assures the farmer of security by stating that the focal loss of one crop cannot exceed the fraction 1/K of the total permissible loss. Receipts of each crop (price times yield) were found to be normally distributed. The focus loss, P_i, is computed as follows:

$$P_i = z\alpha \ \sigma_i / X_i ,$$

where α is equal to .1 (Boussard et al., p. 876). Thus the focal loss is a probability distribution, with $\alpha = 0.1$ and $\alpha = 1.282$. The P_i is a measure of riskiness. Both expected price and yield of each crop were used to measure risk. The probability distribution supports a statistical base of confidence in the data (gross receipts per hectare). In this case, on the average, the gross receipts will fall within the distribution 90% of the time. The standard deviations of receipts per hectare are shown in Table 40. The standard deviations of the local beans are reflected from actual field data by village. The standard deviations of the HYV beans are taken from the test plots. Since the test plots were small in number and size in each village, the total results of TMO 101 were treated as a single unit, hence the same yields and standard deviations of gross receipts are used in the three villages.

With K defined as crop activities, the fraction 1/K is used to diversify the cropping pattern so that the loss of one crop is only a fraction of the total permissable loss. K was varied from 5, encompassing an equal weight for each crop, to 3, where diversity was placed in at least three crops. K was not any lower than 3 because the average farm household planted at least 3 crops. K was varied to observe the interactions among crop mixes and the effect on minimum income.

Table 40. Standard Deviations of Gross Receipts per Hectare of Crops by Village, 1985

	Dumila	Mkundi	Magole
Maize	5004	1778	2203
Local Beans	4248	4646	4754
Sorghum	871	3023	4653
Rice	3665	5480	2670
Cotton	913	419	N/A
HYV Beans	7631	7631	7631

In summary, the linear programming model is designed to optimize the gross margin from the sale of five major crops, subject to the availability of family labor and land, the provision of minimum calorie and utilizable protein requirements equal to the 1985 crop year and risk minimization. The risk constraint, adopted from Boussard and Petit, uses minimum income, variations in gross crop sales and number of cropping activities as the principal measures of risk. Both minimum income and the number of cropping activities were systematically varied in increments to analyze changes in gross margins at different levels of risk.

The results of this modelling will be discussed in the subsequent section specifically in terms of the economic impact of crop decisions on incomes, risk and gross margins.

Results of the Linear Programming Model

The results of the LP solutions must be examined carefully before considering any conclusions. This section analyzes the results of the LP model, given the constraints outlined earlier. Again, the average farmer was represented with separate coefficients and parameters that typified the particular village. Results from only one village, Dumila, will be shown as results from other villages are similar (Rocke, 1986).

The high yielding variety bean, TMO 101, was added, then removed from the model to determine the HYV's impact upon the farming systems. Also, since there are special environmental conditions for producing rice, hectares of land available for rice production are parameterized up to a maximum of 10% of total land currently allotted to the five study crops.

The tables 41 through 43 are organized to reflect LP solutions when levels of risk and number of crops grown are varied. In each table solutions are designated as follows:

row A) projected pattern of current crops without the HYV.
row B) solutions generated when the HYV is added to the model,
row C) solutions when the HYV has a yield variation as "stable" as the local variety, and
row D) Present crop patterns of the average farmer.

Projected current crop patterns in row (A) are used as a base to compare the introduction of the HYV and other constraints into the farming system. By varying risk indicators (crop diversification and minimum cash income), changes in crop mixes and expected gross margins

can be observed. When the HYV is introduced into the LP model in row (B), one can compare the changes in crop mix and expected gross margins with the current projected crop mix. If the HYV is an acceptable crop, it will be incorporated into the solution and have an economic impat on the expected returns.

Since the standard deviation of the yield of TMO 101 was much larger than the local cultivars planted in the sample of 60 farmers' fields, the standard deviation was lowered to equal that of the local bean cultivars in row (C) of the tables. Therefore, (C) was used to estimate the crop mixes and expected gross margins that would result if breeders could make the yield of TMO 101 as stable as that of the local bean cultivars. The productivity of each solution is measured in terms of expected gross margins. Ultimately the farm household must decide if the trade-off for a minimum cash income, crop diversification, and percent increase over projected current production when the HYV introduced is worth taking the risk to gain more income. The final column of the tables shows the percent change in expected gross margins over row A (local beans and other crops) when the HYV is introduced (row B) and when the yields of the HYV are stabilized (row C) to that of the local beans.

Row D shows the average family's present cropping pattern without the constraints incorporated into the LP model.

The following section will discuss the results of the LP in two parts: first, the LP solution for Dumila will be examined, then a comparison of the solutions from each village will be highlighted noting the similarities and differences. The final section will present the conclusions and recommendations.

Dumila

Earlier the coefficients and variables of the LP model that are unique to Dumila were given in Table 33. They HYV bean variable was added to the set of equations to determine the potential impact the new variety would have upon an average farmer's farming system. A minimum income and the diversity factor (1/K) were varied to observe stages of risk. It is hypothesized that as farm households were willing to accept a lower minimum income (more risk), the expected gross margin from crop production will increase. The farmer is compensated for taking additional risk by receiving higher gross margins (Berry, P., p. 7). As farm households reduce their desire to diversify crops (thereby increasing the probability that any one crop they are producing may fail), the total gross margin increases. This implies that when crops are diversified for security reasons, some crops of lower value are grown, resulting in a reduction of potential gross margin. Crops are also diversified for food variety.

In the Dumila LP, if the farm households elected to diversify the crops so that the loss of one crop did not exceed one-fifth of the total permissable loss, the maximum guaranteed cash income would be 2,177 Tsh. (Table 41, row 1A). Sorghum, cotton, rice, beans, and maize are grown in descending order of hectares produced. This scenario represents the most risk averse farmer producing traditional variety beans. As the farmer is less willing to need a minimum cash income, the farmer is considered less risk averse (row 4A). Since cotton has the lowest gross margin per hectare of the study crops, it is dropped from production at this point.

Table 41. Optimal Solutions at Various Minimum Income Levels with K = 5, Income Expressed in TSh., and Crop Mix in Hectares in Dumila

	Minimum Income TSh.	Perm. Loss TSh.	Maize Ha.	Local Beans Ha.	Sorghum Ha.	Rice Ha.	Cotton Ha.	HYV Beans Ha.	Gross Margin TSh.	Change %
1A	2177*	7770	.24	.28	1.39	.33	.46	-	9947	-
1B	3631*	7341	.23	.27	1.31	.31	0	.15	10971	10
1C	4678*	7151	.22	.26	1.28	.29	.38	.26	11829	19
2A	2000	8310	.26	.30	1.48	.35	.30	-	10310	-
2B	2000	11966	.37	.44	1.25	.40	0	.28	13965	35
2C	2000	16398	.51	.60	.59	.40	0	.60	18398	78
3A	1000	10376	.32	.38	1.60	.40	0	-	11375	-
3B	1000	13898	.43	.51	1.08	.40	0	.28	14897	31
3C	1000	19045	.59	.70	.32	.40	0	.70	20045	43
4A	-0-	11818	.36	.43	1.50	.40	0	-	11818	-
4B	-0-	15829	.49	.58	.91	.40	0	.32	15829	34
4C	-0-	21710	.65	.80	.03	.40	0	.80	21709	54
D	-0-		1.86	.20	.16	.40	.08	0	15723	

A- Projected patterns of current crops
B- Projected crop pattern with HYV
C- Projected crop pattern when HYV standard deviation of yield equals local cultivar's
D- Present hectares and gross margin for an average farmer
*- Largest Minimum Income
Perm.- Total permissible loss

Rice production, requiring special land characteristics, was limited to 0.40 hectares of the total land available for the study crops. (This was the average hectares of rice produced by farm households in Dumila.) The farmer, by forfeiting a maximum guaranteed income of 2,177 TSh. in row 1A can increase his gross margin from 9,947 Tsh. to 11,818 Tsh, or by 19% (in row 4A).

When the HYV bean is introduced into the farming system in row 1B, the farm household will only plant 0.15 hectares of this HYV at a minimum cash income of 3,631 TSh. As the farmer becomes less risk averse, the farm household will plant more HYV beans as in row 4B. By forfeiting a

minimum income, gross margins increase from 10,971 TSh. to 15,829 TSh., or by 44%. Only 0.32 hectares of HYV beans are planted when the model cannot guarantee any minimum income from crop production. Farmers will not automatically switch all their beans into HYV until the HYV is established and has a consistent high yield. Presently the standard deviations of the HYV bean yield per hectare are larger than the traditional cultivars.

When the HYV yield is as consistent as the local variety, both the minimum income and total expected gross margins increase (row 1C). Since the farmer is highly diversifying the crops (more risk averse), the two bean varieties are planted in equal-sized plots. The expected gross margins could increase from 19% to 54% over row 1 projections, depending on the level of minimum cash income. In Table 41 minimum cash income required is increased from 0 (row 4) to 1,000 TSh. (row 3), to 2,000 TSh. (row 2), and the highest possible (row 1).

In actual 1985 farm production patterns, maize, not sorghum, occupied the most hectares planted (row D). The LP model selected sorghum as the principal crop because of the low standard deviations in yields. Even though sorghum yields are more stable than maize, food preference for maize heavily outweighs the advantage of stability. Farm households compensate the instability of maize yields by planting "excessive" (1.86) hectares of maize. They therefore assume that this hectarage would be sufficient to cover catastrophic conditions and that any surplus could be easily sold.

Table 42 shows the cropping patterns with the same minimum incomes as in Table 41, but the farm household diversifies the crop mixes so that

the loss of one crop is only 25% or less of the total permissable loss. With the existing five crops, 3,731 TSh. is the largest minimum income that can be achieved (row 1A). Sorghum, cotton, rice, beans, and maize (ranked in descending order) are produced. This is the most risk averse action the farm household could undertake given the assumptions. As the minimum income approaches zero (row 4A), cotton is not produced, hectares devoted to sorghum are reduced, and hectares of maize and beans are increased. The average gross margin per hectare of maize and beans is at least three times higher than for sorghum and cotton (Table 41) without including family labor; however, the standard deviations of the yields per hectare of sorghum and cotton are much lower than for maize and beans. Therefore, as farm households reduce their security constraints, crops with the higher gross margins enter the solution. As explained earlier, rice is constrained to produce a maximum of 0.40 hectares. Since rice has a high gross margin per hectare and low deviations in yields per hectare, rice produces its maximum permitted hectarage.

When the HYV bean was introduced into the model (row 1B), minimum income rose from 3,731 TSh. to 5,066 TSh.; as the farm household became less risk averse, their total gross margins increased from 12,184 TSh. to 19,892 TSh.(row 5B). More HYV hectares were brought into production at this time as the farmers increased their risk taking. The HYV did not surpass the traditional variety in hectares at the highest risk level (willing to accept no minimum income). When the HYV has its yield stabilized (row 5C), gross margin increased further from 19,892 TSh. to 23,880 TSh. Thus farmers must be convinced that the HYV yield is stable and reliable before they make a total commitment to the improved variety.

If the high yielding variety, TMO 101, would have had the same variations as the local variety, expected gross margins would increase from 42% above projected current production at the highest minimum income level (row 1C) to 80% above expected gross margins at no minimum income (row 5C). Thus farmers could increase their expected gross margins by 10,594 TSh., or by 80%, if they were willing to accept the uncertainty of receiving no cash income from crop production.

Table 42. Optimal Solutions at Various Minimum Income Levels with K = 4, Income Expressed in TSh., and Crop Mixes in Hectares in Dumila

Minimum Income TSh.	Perm. Loss TSh.	Maize Ha.	Local Beans Ha.	Sorghum Ha.	Rice Ha.	Cotton Ha.	HYV Beans Ha.	Gross Margin TSh.	Change %
1A 3731*	6217	.24	.28	1.39	.33	.46	-	9947	-
1B 5066*	7118	.28	.32	1.56	.38	0	.17	12184	22
1C 6504*	7608	.30	.35	1.30	.40	0	.35	14112	42
2A 3000	8423	.33	.38	1.59	.40	0	-	11422	-
2B 3000	12610	.49	.58	.94	.40	0	.30	15610	37
2C 3000	19505	.76	.65	0	.40	0	.89	22505	97
3A 2000	10043	.39	.46	1.45	.40	0	-	12043	-
3B 2000	15037	.58	.69	.67	.40	0	.36	17037	42
3C 2000	20963	.81	.52	0	.40	0	.96	22963	91
4A 1000	11665	.45	.53	1.32	.40	0	-	12665	-
4B 1000	17465	.68	.80	.41	.40	0	.41	18465	46
4C 1000	22421	.87	.40	0	.40	0	1.03	23421	85
5A -0-	13287	.51	.61	1.18	.40	0	-	13287	-
5B -0-	19892	.77	.91	.14	.40	0	.47	19892	50
5C -0-	23880	.93	.28	0	.40	0	1.09	23880	80

A- Projected patterns of current crops
B- Projected crop pattern with HYV
C- Projected crop pattern when HYV standard deviation of yield equals local cultivar's.
*- Largest Minimum Income
Perm.- Total permissible loss

Table 43 shows the results when crop activity changes to represent a diversity of one-third or less of the permissable loss. The optimal

solution guarantees a minimum income of not less than 5,346 TSh. (row 1A). Cotton is no longer produced and rice uses all hectarage available for production. Sorghum occupies 1.65 hectares with maize, beans, and rice being allotted 0.29, 0.34, and 0.40 hectares, respectively. When the farm household desires a minimum income level of zero (row 5A), sorghum is produced on 0.45 hectares, with maize, beans, and rice grown on 0.85, 1.00, and 0.40 hectares of land, respectively. Therefore, total gross margin increases from 11,111 TSh. at the largest minimum income to 16,587 TSh. at the zero level. The difference in gross margins between the most and least risk averse farmer would be 49%.

Table 43. Optimal Solutions at Various Minimum Income Levels with K = 3, Income Expressed in TSh., and Crop Mix in Hectares in Dumila

Minimum Income TSh.	Perm. Loss TSh.	Maize Ha.	Local Beans Ha.	Sorghum Ha.	Rice Ha.	Cotton Ha.	HYV Beans Ha.	Gross Margin TSh.	Change %
1A 5346*	5765	.30	.35	1.66	.40	0	-	11111	-
1B 6904*	5768	.30	.35	1.48	.40	0	.18	12671	14
1C 8551*	13371	.68	.81	0	.40	0	.81	21921	97
2A 5000	6465	.33	.39	1.58	.40	0	-	11465	-
2B 5000	14276	.73	.86	.26	.40	0	.45	19276	68
2C 5000	19339	1.00	0	0	.40	0	1.17	24339	112
3A 3000	10513	.53	.63	1.13	.40	0	-	13513	-
3B 3000	18264	.94	.79	0	.40	0	.57	21263	57
3C 3000	22207	.96	0	0	.40	0	1.34	25207	86
4A 1000	14561	.75	.88	.68	.40	0	-	15561	-
4B 1000	20995	1.08	.57	0	.40	0	.66	21995	41
4C 1000	25640	.81	0	0	.40	0	1.49	25639	65
5A -0-	16585	.85	1.00	.45	.40	0	-	16585	-
5B -0-	22360	1.15	.45	0	.40	0	.70	22360	35
5C -0-	25856	.74	0	0	.40	0	1.56	25856	56

A- Projected patterns of current crops
B- Projected crop pattern with HYV
C- Projected crop pattern when HYV standard deviation of yield equals local cultivar's
*- Largest Minimum Income
Perm.- Total permissible loss

When TMO 101 is made available to farm households, the HYV becomes the dominant bean variety when the farmers become less risk averse (row 5C). Also, sorghum leaves the solution when farm households become less risk averse, making maize the dominant crop, with the HYV bean, local bean cultivar, and rice the crops grown. The HYV can increase expected gross margins from 14% to 35%, depending on the minimum income required at this risk level.

If the variation of yields of TMO 101 could equal those of the local bean cultivar, expected gross margins could increase over 100% than without the HYV (row 2C). Only the most risk averse farm households would plant the local bean cultivar. The HYV would become the primary crop grown with maize and rice accounting for the other crops. HYV beans could then be sold to purchase maize flour or other food. This study does not attempt to determine the demand for beans, but from personal observation, food is relatively scarce in these villages. It is assumed that these farmers could sell their surplus beans to others in the surrounding area or sell it in nearby cities of Morogoro or Dodoma. One will recall that all villages are located near a tarmac road.

Since surveyed farm households did not produce fewer than three crops on the farm, the diversity fraction 1/K, was not varied further. By studying the results of Dumila farmers, the following observations were noted:

1) As the farm household diversifies its risk into different crops, total gross margin is decreased. At zero minimum income required, with K = 3, total gross margin is 16,585 TSh.; however, when crop activities change to K = 5, gross margin decreased to 11,818 TSh.

2) The maximum minimum income rises as farm households reduce the cropping activity. As K becomes larger (more diversity), minimum

income decreases. As farm households become less diverse, minimum income increases.

3) As the required minimum income declines, total gross margins increase. There is a trade-off for risk taking; the benefits are higher for one willing to take more risk. (Risk is lowered when a minimum cash income is assured.)

4) Since the standard deviations of expected net incomes of the HYV bean are larger than the local cultivar, farmers perceive the HYV as being more risky. Therefore, as farmers become less risk averse, they are willing of plant more hectares in HYV beans.

5) The HYV beans increased the guaranteed minimum income between 29% to 40% when crop diversity was placed in five crops.

6) Total gross margins increased when HYV beans were introduced into the system. The range of increases varies from 10% to 68%, depending upon the risk level.

7) Presently TMO 101 has a much larger yield variation per hectare than the local bean cultivar. If the HYV has its yield variation (in terms of standard deviation about the mean) equal to that of the local bean cultivar, then the HYV would increase expected gross margins and a minimum income above current levels would be achieved.

8) Gross margin increases from 15,723 TSh. of the present cropping pattern (row D) to 25,856 TSh. in row 5C of Table 43.

This LP model did not reproduce the current cropping patterns of Dumila (row D Table 41). Sorghum was the primary crop in the LP model, while in actuality maize was the primary crop. As discussed earlier, food preferences and experience may outweigh the reality of planting a more stable yielding crop. Since the yield varies greatly in maize, the farmers in Dumila plant excessive hectares of maize to insure enough food for consumption. Another explanation for not parallelling actual hectares planted, may be mis-specified coefficients, especially of labor requirements. Since all data were based on memory recall, there might have been an error in reporting.

Nutritional constraints equivalent to the 1985 crop year were met in all solutions. Enough calories and utilizable protein to at least

satisfy the 1985 level of consumption, a year of below average rainfall and yields, for the study crops were obtained by farm households. No hired labor or machinery was necessary in any solution, given data obtained.

Summary of LP Model Analyses

When using Boussard and Petit's model to estimate risk and uncertainty, it was assumed that:

1) Farmers maximize their gross margins under the constraint that the possibility of having a total cash income below a fixed amount in any given year would be very small (10% of the time) and

2) Focus of loss on one crop is equal to a fraction (1/5, 1/4, or 1/3) of the maximum loss permitted.

By varying a fixed minimum income and "K" (crop activities), various risk levels were revealed with solutions of optimum crop mixes and total gross margins for each village. In the tables showing solutions, fixed minimum incomes were varied when "K" was held constant. After current crop activities were projected at a specific minimum income, the HYV bean variable was added to ascertain its impact on the farming systems at each risk level. In every case, total gross margins increased. A fixed minimum income for the most risk averse farm household was greater when the HYV bean was an option in the crop activities than when it did not appear.

The table data show the introduction of TMO 101 and "stable" HYV against the current crop solutions at different levels of "K" and minimum cash income (risk) with the resultant expected gross margins. It can be seen that the HYV made the farm household more secure by adding additional revenue and raising the minimum income farm households could receive. In Magole and at selected risk levels in Dumila and Mkundi, the

HYV would be preferred over the local bean varieties currently grown. Yields of local beans in Magole were more variable in yield than in the other villages, even though the beans were of the same types. When the variation in yield of the HYV was equal to that of the local bean cultivar, the HYV became the preferred variety.

"K" is varied to show a farmer's decision to plant a variety of crops to spread the risk of any one crop failing. It can be seen that as farm households are willing to decrease these crop activities, total gross margin increases. Concentrating on fewer crops, more hectares of crops with high gross margins will enter the solution. When farm households elect to diversify crops (more risk averse), they sacrifice crops that can potentially generate more income. In essence, they trade-off the possibility of purchasing the commodity on the market against growing the crop themselves. The next section summarizes the results of the Kilosa study and presents the final conclusions.

CONCLUSIONS AND RECOMMENDATIONS FROM KILOSA STUDY

This section will outline the results of the Kilosa study and identify implications regarding policy decisions, technology adoptions, and areas of further research. Some limitations of the study will be recognized and suggestions to alleviate these constraints will also be presented. One must remember that this is a study concerning one specific HYV in one small area in Tanzania. Therefore, further testing of the characteristics and yield of this variety, TMO 101, should be undertaken before recommendation for general government release.

On-Farm Trial Results

Eight of the twelve farmers who were given the HYV seeds harvested their test plots. Citing poor rainfall, three farmers did not plant the test beans, another farmer reported that the HYV beans from the test plots were stolen. With no commercial inputs, and omitting one unusually high yield from the test plots, on average TMO 101 outyielded the traditional bean cultivars on the test plots by 136% (387 kg/ha vs. 164 kg/ha) in a year of below average rainfall. When TMO 101 is compared with the average bean yield of the sampled 60 farmers, TMO 101 outyielded the traditional cultivars by 60%. The standard deviations of the yield between the cultivars on the test plots were similar.

No crop scientist from Sokoine University of Agriculture was available to collect insect and disease specimens from the test plots. The following characteristics were observed by the author:

1) TMO 101 was "upright and compact" while the traditional cultivar was "floppy." All farmers liked this characteristic of TMO 101.

2) Both test varieties had an equal incidence of disease and insect infestation.

3) The HYV test plot matured evenly while the traditional cultivars matured at varying rates.

4) TMO 101 displayed drought resistant characteristics. During the dry period, some test plots with traditional cultivars dried up and did not produce a harvest, while all plots of TMO 101 did produce a yield.

Since the color of TMO 101 is the locally preferred color (red/brown), rejection by consumers due to color should be minimal. Only one family tasted the HYV, and found it to be palatable. The harvest was purchased from farm families for twice the market price to reward the farmers and to encourage further participation in future on-farm trials.

Yield results of TMO 101 were used in the linear programming model to assess the economic impact this variety may have on an average farm family in each of the three villages.

Linear Programming Results

Based on 1985 data, the high yielding variety, TMO 101, always made a positive economic contribution to farm households in each village. The advantages TMO 101 can offer farm households are summarized as follows:

1) A greater minimum cash income can be realized at every level of risk. For the most risk averse farmers, this means more security without increasing risk.

2) When the HYV is planted, expected gross margins consistently exceeded current levels, given yield, cost, and price assumptions made earlier.

3) If the farmer is willing to decrease the number of crop activities, farm households could expect a greater gross margin, given assumptions used. As the fraction "1/K" is increased, the farm household can expect higher gross margins, with current yields and prices. For example, in Dumila and Mkundi, cotton hectarage was reduced and became less important as farm households placed greater emphasis on fewer crops. By having the farmer increase the fraction of total permissable loss for one crop, more flexibility is given to the farm household to plant greater revenue producing crops.

4) If yield variation of TMO 101 is assumed equal to that of the local bean cultivars, both minimum income and expected gross margins would be greater than the current gross margins.

5) In the most advantageous case, TMO 101 can increase gross margin per Dumila family of 6,637 TSh. over average current levels. When TMO 101 yields are assumed to be stabilized as much as the traditional cultivar yields, gross margins can increase 10,133 TSh. over current Dumila farmer practices. Hectares allocated to each crop also changes as seen in Table 43.

Even though the farming system survey revealed that hired labor and tractor rental were utilized by the average farm household, the solutions of the LP did not find it necessary to hire additional assistance. It was assumed that family labor would be utilized first before hired labor and tractor rental. When monthly maize and bean labor requirements were

doubled, the solutions still did not require hired labor or tractors. It is speculated that temporary peaks in labor for land preparation and weeding may account for the necessity to hire labor, even when sufficient family labor is available per month.

Since low yields in most crops were reported during the dry 1985 crop season, the recommended minimum nutritional needs of calories and utilizable protein could not be obtained in the solutions. However, the LP solutions provided sufficient calories and utilizable protein for the average farm family above the actual 1985 farm produced consumption level of maize, beans, sorghum, and rice. In a normal rainfall year of 1980, recommended minimum levels of calories and utilizable protein were available from farm production (Gillard-Byers, 1984).

HYV Adoption

Since additional total value of production would be generated in these villages by adopting the HYV, family consumption could increase, more goods and services could be purchased by farm households, or family deficits could be eliminated or reduced. In 1985, sampled families in Magole and Mkundi were operating a family budget deficit after reported expenditures were met. The HYV would provide a higher minimum income for the more risk adverse farm household and at the same time offer additional expected gross margins. Any surplus income could be utilized to purchase inputs such as fertilizer and pesticide, or to buy additional food, clothing, and so forth. In many towns inputs were unavailable; however, efforts are currently being made to distribute locally produced fertilizers throughout the country.

The HYV TMO 101 always had received the recommended amounts of fertilizer and pesticides at the research station, but the 1985 on-farm trials were the first zero purchased input trials. Average yields of TMO 101 on the university research plots were 1,026 Kg./Ha. compared to 524 Kg./Ha. on the farmers' fields. It is very difficult to estimate when fertilizer and other such inputs will be available and affordable for Tanzanian farmers. For this reason, the research stations need to stress the importance of zero-input trials. In this particular case, TMO 101 outyielded the local bean varieties without any commercial inputs. Also, the standard deviations or variations in yield between TMO 101 and the local cultivars on the test plots were similar.

Experimental plots in the farmers fields are important to the adoption process of a new technology or variety. The farm households are able to visually assess the performance of the HYV. The interaction between researchers and farmers also enables the two parties to communicate with each other concerning the HYV; this is one of the principles of the farming systems research approach. By interacting with research personnel, the farmers realize someone is trying to assist them. This may have a positive psychological affect on the attitude of the farmers. It is, therefore, recommended that the experimental plots not fail due to negligence of either party . Research personnel must be approachable to farmers, try to honor commitments, and work directly with the farmers on the appropriate occasions. The farmers chosen for the plots must understand the purpose of the experiments, be respected members of the community, and have a desire to cooperate with researchers.

The farm household's experimental plot should be accessible to other community members. When the new technology is made available by researchers and is utilized by farmers, new concepts and input use can spread quickly through a community. It is, therefore, critical that farmers chosen work with researchers. Much time and money is involved in on-farm trials and it is crucial that the experiments are conducted correctly. As long as the experimental plots are designed and operated in a uniform method, one can be selective of the choice of participants in the trials without biasing the experiment.

HYV Distribution

The on-farm trial analysis is only one of a series of steps that are necessary when a high-yielding variety seed is considered for distribution in a developing nation. When analyzing the distribution process, infrastructure and marketing are two important factors that must be recognized concurrently with research of new varieties. If production can be increased, can the efficiency of marketing channels also be improved? The proper channels must be identified, and appropriate modifications made, if necessary, before the product is disseminated. If the farmers cannot buy seed or distribute the excess production, then the marketing and input channels need to be re-organized. Since Tanzania has a large rural population, it is imperative the government efficiently organize its marketing boards and infrastructure so that the parastatals and private merchants can provide inputs and market the increased production from HYV use.

One must realize that when a HYV is made available to farmers, the price of that crop will fall once the market (demand) is saturated. Once

the price changes, the solutions of the LP model will also change. This study recognizes only the initial acceptance or rejection of TMO 101. Additional studies are needed to determine the demand for beans. The demand estimate may be low unless more nutrition education is provided. When beans are combined with cereal crops (such as the staple maize) a high quality protein results. For those persons who cannot afford meat, an increase in bean consumption will increase the protein intake. If this can be explained to families, their demand for beans should increase.

Limitations of Study

The limitations of the study must be recognized when analyzing the results.

1) The sample size of the test variety bean, TMO 101, was small. Four farmers from each of the three villages were invited to participate in the on-farm trials; only eight harvested the test plots. Also one will recall that agronomic and disease data were not collected. It is important that all available information is collected so that all factors can be recorded and analyzed.

2) The on-farm trials were conducted in a relatively dry year. Although it is important to monitor crops during periods of stress, it is also important to analyze data over a period of time. Time series data can give a more accurate assessment of the true agricultural conditions.

3) Boussard and Petit's focus of loss is one way to incorporate risk into a farming system model. As discussed earlier, other methods are available to model a farmer's risk aversion.

4) The farm families' labor costs were not included in the model. The opportunity to obtain an off-farm income that required a full time commitment (5½ days per week, annually) was slim. Part time employment such as firewood and charcoal making, carpentry, beer brewing, and other such activities could be completed during the slack labor periods. Land costs also were not included in the model.

5) Prices for each crop were at the average market rate for 1985 and yields were average yields reported by the sample of 59 farm families. Prices/yields will change next growing season, and

therefore may affect the optimal crop mix. No attempt was made to forecast the future prices/yields of each commodity, thereby these solutions are applicable only to the 1985 growing season. The structual model, however, may be used when yearly price/yield data are available.

6) The nutrition levels (calories and utilizable protein) were set at 1985 consumption levels of the crops consumed by the average family in the study from their own production; this production supplied approximately 50% of the daily nutritional requirements (Table 39). The low yields and risk aversion factors prevented a solution at the 100% nutrition level. As noted earlier, farm households consume more than maize, beans, sorghum, and rice, therefore, the 1985 consumption of these crops was used as a guide.

7) The LP solutions did not require hired labor or machinery while the survey data revealed that the average family hired some labor and tractors. This contradiction may be explained by incorrect labor coefficients, such as an under reported estimate of family labor per month. Multiple visits were used to record labor days during the growing season to minimize errors in farmer memory recall. Another explanation may be that hired labor may have been utilized during peak labor periods, such as immediately following the first rains (that loosen the soil for land preparation), or during peak rainy periods in the growing season when weeds were growing rapidly.

Cotton

This study revealed that cotton is not a high return crop in farming systems of the three villages. One will recall that farmers were told to grow a minimum number of hectares of cotton by government officials. In Magole, cotton was not grown. In Dumila and Mkundi, the LP solutions consistently did not include cotton. When given the option to plant cotton, only the most risk averse farmer would plant the crop. If the government cannot provide a higher price for the commodity, or provide inputs to increase yields, then the government should re-examine its policy of promoting cotton in this area. Perhaps promoting another cash crop would be advantageous to farmers in this area.

Government Policy Implications

As mentioned earlier, the government's insistence on farmers planting cotton in the study area needs to be re-examined. Neither the farmers nor the results of this research support the government's recommendation that each farm household grow a minimum hectarage of cotton.

The release of a high yielding variety bean will be forthcoming. The initial results of the HYV bean development program demonstrates that varieties being produced on research stations will be accepted into the farming systems. The government must now investigate ways to facilitate the distribution of HYV seeds so that the maximum number of farmers can benefit from higher yields. The higher yields necessitate a greater demand for labor at harvest, thus an appropriate technology design of a bean thresher might be supported. Currently, agricultural engineers at Sokoine University and Washington State University are developing such an implement.

This study may be used in conjunction with other Tanzanian farming systems data to formulate a general Tanzanian agricultural policy. It must be stressed that this study represents only one year's data collection in one low rainfall-altitude area. However, when these data are combined with other studies of agricultural policies in Tanzania, a new policy may be formulated.

TMO 101 Recommendation

This study addressed only a part of the total decision-making process that is necessary before the University and other concerned parties make a final decision on releasing a new variety such as TMO 101.

As discussed earlier, TMO 101 did exhibit unfavorable disease characteristics similar to those of the local cultivars; nevertheless, the yield was superior. When land, labor, nutrition, and risk were taken into consideration, the variables essential to production decision making, the HYV again made a positive impact on gross margins of an average farm family of Dumila, Mkundi, and Magole. It can, therefore, be recommended that TMO 101 has the potential to increase the level of well being to rural Tanzanian farm households in similar agro-ecological zones.

Researchers at Sokoine University, Washington State University, and officials from the Government should meet soon to determine if TMO 101 should be recommended for distribution. The trade-off of releasing a high yielding seed that needs further refinement (disease traits,as in the case of TMO 101) needs to be weighed against the alternative of waiting to develop the "more perfect" seed. This study has shown that TMO 101 should be accepted by the farmers. The current bean yield is low, thus this HYV should be welcomed by farm familes in this and similar ecological areas. If the "perfect" bean seed is still a long time off, then perhaps at the intermediate stage a new variety (such as TMO 101) should be released. A central question is "can the farmers afford to wait for the "perfect" seed?"

SUMMARY OF ON-FARM TRIALS, MGETA AND KILOSA AREAS

These on-farm trials were undertaken during a period when the Tanzanian economy was severly depressed; farm prices were low, foreign exchange was severely constrained, petroleum was rationed and in short

supply and wage goods were often unavailable in the shops (Tanzania Ministry of Agriculture 1982 and 1983, Due et al., 1985).

Unfortunately when on-farm trials of two potential high yielding varieties of beans were being tested during the 1985 crop year in Mgeta and Kilosa areas of Tanzania, sufficient seed was available for only 12 farmers in each area. Each farmer was asked to planht HYV and traditional seed side by side, to treat them identically as far as cropping practices were concerned, and then to compare yields at harvest. Each plot of each seed was approximately 100 square meters. Of the 12 farmers who volunteered for the program in Mgeta (the high altitude-rainfall area), only seven were farmers earning the majority of their income from farming and, on the seven farmers volunteering, only four reported a harvest. In Kilosa, the low-altitude-rainfall area where TMO 101 seed was being tested, eight farmers had harvests of TMO 101 and traditional varieties. Comparison of yields of the high yielding and traditional varieties are shown in Table 44.

It is noted from Table 44 that the high yielding Kabanima outyielded the traditional variety (Kenia) in Mgeta by 225% and the HYC TMO 101 outyielded the traditional varieties by 68% in Kilosa if all eight farmers are included or by 133% if the farmer with the excessively high yields (farmer No. 2) is omitted. The 1985 yield of 0.8 k.g per 100 square meters translates into 70 kg. per acre for the traditional variety; the 2.6 kg. per 100 square meters translates into 229 kg. per acre for Kabanima. In Kilosa the 1.8 kg. per 100 square meters translates into 157 kg. per acre for TMO 101 and .75 kg. into 66 kg. per

Table 44. Comparison of Yields of High Yielding and Traditional Varieties of Beans (in Kg.) Per 100 Square Metre Plot, Mgeta and Kilosa, 1985

	Mgeta		Kilosa	
	Kabanima	Traditional	TMO 101	Traditional
Farmer 1	4.8	0.8	1.0	0.5
2	1.2	0.4	7.0	7.0
3	3.4	1.1	5.0	3.5 1.5
4	1.2	0.8	1.0	0.5
5			3.0	0.5
6			1.0	0.5
7			1.0	0
8			0.5	0
Mean	2.6	0.8	2.4	1.45
Mean (omitting #2)			1.8	.75

acre for the traditional varieties. The average (3 year) yields of TMO 101 at the experimental plots at Sokoine University was 415 kg. per acre but this yield was obtained by using fertilizer and pesticides. In both areas this was a dry year and yields were much lower than usual; also fertilizer and pesticides were unavailable to most farmers in both areas.

Farmers in both areas liked the new high yielding varieties but the sample of farmers testing each was too small to enable much generalization of findings. Since the researchers were anxious to repurchase as much of the high yielding seed as possible for further seed generation, it was not possible to allow farmers to keep seed for taste and cooking testing.

Kabanima, the variety tested in Mgeta area, was developed by the Research station in Iringa and has been tested for consumer acceptance there. There was not enough surplus seed of TMO 101 to allow adequate consumer taste and cooking-quality testing in 1985. Farmers who grew TMO 101 liked the compactness of the plant and its upright stand; the upright stand keeps the pods off the ground and reduces the chance of fungal growth, which can reduce yields. Compactness is a favorable characteristic which makes harvesting faster and thressing easier. TMO 101 appeared not to be more disease and insect resistant than the local varieties; unfortunately no crop scientists from Sokoine University of Agriculture was available to collect insect and disease specimens from the test plots on farmers fields. TMO 101 matured evenly while the traditional cultivars matured at more varied rates. TMO 101 displayed drought resistant characteristics during 1985, which was an unusually dry year in the area. The color of TMO 101 is the locally preferred color (red/brown). The few families testing TMO 101 found it to be palatable with cooking time comparable to traditional varieties.

In Kilosa, the additional data from a sample of 59 farmers enabled formulation of a linear programming model to ascertain the benefit of TMO 101 to farmers in this area if the differences in yields of the 1985 cropping season were sustained and if yields of TMO 101 could be stabilized to reduce variability, similar to the traditional varieties. It was found that average farm family gross margin (value of production minus seed costs) could be increased materially using TMO 101 over the traditional varieties, given the assumptions utilized. It is hoped that in 1986 on-farm trials of these two varieties will continue.

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Farming Systems Questionnaire - Beans, Morogoro Region

Department of Crop Science and Rural Economy

University of Dar es Salaam, Morogoro - 1984/85

==========

*Schedule for first visit, 3-4 weeks after crop planting

Village _____ District _____ Region _____

Farmer's name _____ Enumerator _____ Number _____

1. Farm household:

   List the number of persons in the household and the percentage of the last year they participated.

Persons	Age	Months in Household	Formal Education
Farmer _____	____	_____	_____
Other wives _____	____	_____	_____
Children _____	____	_____	_____
_____	____	_____	_____
_____	____	_____	_____
_____	____	_____	_____
_____	____	_____	_____
_____	____	_____	_____
Others _____	____	_____	_____

2. What is the farmer's marital status? Married _____ No. of wives _____
   Widowed _____ Divorced _____ Never married _____

3. How many years have you been farming? _____

4. What foods are preferred by your family? List preference.

	Husband	Wife
a)	_____	_____
b)	_____	_____
c)	_____	_____

5. What are your objectives in farming in order of priority?
   1) _____
   2) _____
   3) _____

6. Indicate which of these you have (and number if relevant):

House with thatch roof _____ Metal roof _____

Concrete floor _____ Radio _____ Bicycle _____

Beds _____ Lantern _____

7. In the rectangles below, show the crops grown in each shamba, the proportion of different mixtures, varieties (of beans) and acreage, date of planting of each mixture. Plot No. 1 is the first planted. Star crops which are intercropped. Differentiate between beans for sale as green beans.

1

Crop	%	Variety

Acreage _____

Date of planting _____

2

Crop	%	Variety

Acreage _____

Date of planting _____

3

Crop	%	Variety

Acreage _____

Date of planting _____

4

Crop	%	Variety

Acreage _____

Date of planting _____

5

Crop	%	Variety

Acreage _____

Date of planting _____

6

Crop	%	Variety

Acreage _____

Date of planting _____

8. If there are shambas planted with more than one crop per year, indicate shamba number and second crops as above. Star crops which are intercropped.

Shamba No.

Crop	%	Variety

Acreage _____

Date of planting _____

Shamba No.

Crop	%	Variety

Acreage _____

Date of planting _____

Shamba No.

Crop	%	Variety

Acreage _____

of planting _____

Shamba No.

Crop	%	Variety

Acreage _____

Date of planting _____

Shamba No.

Crop	%	Variety

Acreage _____

Date of planting _____

Shamba No.

Crop	%	Variety

Acreage _____

Date of planting _____

9. What is the distance of each shamba from the house in km?
   1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____

10. Is your farm (circle one): 1. level, 2. rolling or undulating, 3. steep slope.

11. In deciding on the crops planted on each shamba, who are involved in the decisions?
    Husband and wife _____ Husband only _____ Wife only _____
    Others (specify) _____

12. Which are the busiest months of the year on the farm (state months)?
    _____

13. Which varieties of beans are preferred for:
    a) consumption: 1) _____ 2) _____ 3) _____
       Explain _____
    b) Sale 1) _____ 2) _____ 3) _____
       Explain _____
    c) Yield 1) _____ 2) _____ 3) _____
       Explain _____
    d) Early planting 1) _____ 2) _____ 3) _____
       Explain _____
    e) Late planting 1) _____ 2) _____ 3) _____
       Explain _____

14. a) Who chooses the planting seeds? Husband _____ Wife _____
Husband and Wife _____ Other _____

b) On what basis are seeds chosen? Explain _____

_____

c) Which varieities are chosen? _____

d) How much of each variety per acre? Variety 1 _____
Variety 2 _____

e) When are the seeds chosen? At planting? _____
At harvest? _____
Other _____

Explain _____

f) How much of each variety was purchased? Variety 1 _____
Variety 2 _____

g) What did the seed cost if purchased? V1/kg _____ V2/kg _____

h) Where was seed purchased? _____

15. Bean planting:

a) How do you plant the beans? In rows _____ Spacing (rows)_____ Spacing seeds _____
on ridges _____ spacing of ridges _____ spacing of seeds _____
in hills _____ spacing of hills _____ other _____ spacing _____

b) How many seeds per hole (circle one): 1) 1
2) 2-3
3) about 4
4) other

c) Do you soak the seeds before planting? 1) yes 2) no How long _____

d) What % of seeds germinate? _____

e) If interplanted with maize, are the beans and maize planted
1) at the same time
2) beans after the maize _____ days
3) maize after beans _____ days

f) Do you thin the beans if intercropped? 1) yes 2) no Explain _____

g) Do you thin the beans if monocropped? 1) yes 2) no Explain _____

_____

16. a) Do you eat bean leaves? 1) yes 2) no

b) How often per week _____ Quantity each meal _____

c) Which varieties are most preferred? Variety 1 _____ Variety 2 _____
Explain _____

d) Is smoothness (lack of hairiness) in beans important? 1) yes 2) no

Explain _____

e) Is leaf thickness important? 1) yes 2) no

Explain _____

17. Which varieties produce: Tender pods _____

Course pods _____

Smooth pods _____

Hairy pods _____

18. When picking leaves for consumption, do you? (Circle all which are relevant).

1) pick from all plants _____

2) pick from selected plants _____

3) pick from selected areas _____

4) pick one leaflet from each leaf _____

5) pick all leaflets from each leaf _____

6) pick all leaflets on a branch _____

7) pick _____ leaves from each plant _____

8) How frequently do you pick _____ week for _____ weeks

Quantity per picking per meal _____

19. a) For every cup of seed planted, how many do you expect to get back? _____kg

b) What acreage of each do you plant first for family consumption? (to insure adequate consumption)

maize _____ acres

beans _____ acres Explain _____

other _____ acres _____

c) How much of the acreage is increased to cover a potential bad year? _____%

_____

20. What is the height of the bean plants:

10 days after planting _____

20 days after planting _____

21. Labour profile:

Complete the labour profile for each crop by sex for the period to date.

Be careful to convert children's labor as shown.

Be careful to segregate labor by sex.

List labor inputs this past year for each major crop. Enter the number of days worked by males and females each month. Convert child labor as follows: ages 8-11- .3, 12-17- .5 If intercropped, group the crops intercropped.

Operation		Jan.	Feb.	Mar.	April	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Total
Land Preparation:														
Maize	M													
	F													
Beans	M													
	F													
Sorghum	M													
	F													
Rice	M													
	F													
Cotton	M													
	F													
Vegetable	M													
	F													
	M													
	F													
	M													
	F													
Planting														
Maize	M													
	F													
Beans	M													
	F													
Sorghum	M													
	F													
Rice	M													
	F													
Cotton	M													
	F													
Vegetable	M													
	F													
	M													
	F													

Operation		Jan.	Feb.	Mar.	April	May	Jun	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Weeding:														
Maize	M													
	F													
Beans	M													
	F													
Sorghum	M													
	F													
Rice	M													
	F													
Cotton	M													
	F													
Vegetable	M													
	F													
	M													
	F													
Fertilizing & Spraying														
Maize	M													
	F													
Beans	M													
	F													
Sorghum	M													
	F													
Rice	M													
	F													
Cotton	M													
	F													
Vegetable	M													
	F													
Other	M													
	F													
	M													
	F													

Operation		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Harvesting														
Maize	M													
	F													
Beans	M													
	F													
Sorghum	M													
	F													
Rice	M													
	F													
Cotton	M													
	F													
Vegetable	M													
	F													
Other	M													
	F													
	M													
	F													
	M													
	F													
Marketing														
Maize	M													
	F													
Beans	M													
	F													
Sorghum	M													
	F													
Rice	M													
	F													
Cotton	M													
	F													
Vegetable	M													
	F													
Other	M													
	F													
	M													
	F													