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Increasing Food Production through the Use of High Yielding Varieties: The Case of East Africa

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I. Feeding People Especially City Dwellers

According to the recently published World Bank publication called "the Sub-Saharan Africa — From Crisis to Sustainable Growth," the population growth is extremely rapid there. The average annual population growth rate between 1980 and 1987 has been estimated as 3.1% whereas the growth rate between 1987 and 2000 is predicted to be the same 3.1%. The task for the African agriculture to feed this population with such a high growth rate is enormous. The total population of the Sub-Saharan Africa excluding the Republic of South Africa and Namibia was around 451 million in 1987 whereas in 2025 it will be around 1,286 million.

Beside, the high rate of urban growth in this continent and its effect on food demand must be taken into account when we discuss the food problem in Africa, especially in Sub-Saharan Africa. This area has been considered as less urbanized area in comparison with other continents, but now most of the African countries have more than 20% of their population in urban areas. Some countries like Zambia has more than 50% urbanization rate. The average annual urban population growth rate for Sub-Saharan Africa has been 5.7% between 1973 to 1980 but has increased to 6.9% between 1980 to 1987.

If we focus our attention to the two countries in East Africa, Kenya and Tanzania, which we will closely examine in this paper, the picture is more alarming. The average annual population growth rate in 1980 – 87 for Kenya was 4.1% and for Tanzania 3.5%. Their total population reached 22 million for Kenya and 24 mil-

Table 1. Urbanization

	Urban Population						Percentage of Urban Population				Number of Cities of over 500,000 Persons	
	As a Percentage of Total Population			Average Annual Growth Rate (percent)			In Largest City		In Cities over 500,000 Persons			
	1965	1980	1987	1965–73	1973–80	1980–87	1960	1980	1960	1980	1960	1980
Sub-Saharan Africa												
Total	14w	22w	27w	5.5w	5.7w	6.9w	28w	36w	6.2w	41w	3t	28t
Excluding Nigeria	13w	21w	26w	5.7w	6.0w	5.9w	34w	43w	1w	36w	1t	19t
Low-income economies	13w	21w	26w	5.4w	5.5w	7.1w	27w	35w	7w	41w	3t	23t
Excluding Nigeria	12w	19w	23w	5.7w	5.9w	5.9w	33w	42w	2w	35w	1t	14t
1 Ethiopia	8	11	12	5.2	4.8	4.6	30	37	0	37	0	1
2 Chad	9	21	30	7.0	8.5	7.8	—	39	0	0	0	0
3 Zaire	26	34	38	4.7	4.5	4.6	14	28	14	38	1	2
4 Guinea-Bissau	16	24	29	3.8	8.1	4.4	—	—	—	—	—	—
5 Malawi	5	10	13	6.6	7.9	8.6	—	19	0	0	0	0
6 Mozambique	5	13	23	8.5	11.5	10.7	75	83	0	83	0	1
7 Tanzania	5	17	29	9.1	13.4	11.3	34	50	0	50	0	1
8 Burkina-Faso	5	7	8	3.9	4.4	5.3	—	41	0	0	0	0
9 Madagascar	12	19	23	5.2	5.7	6.4	44	36	0	36	0	1
10 Mali	13	17	19	4.6	3.8	3.4	32	24	0	0	0	0
11 Gambia, The	—	26	36	—	10.7	8.5	—	—	—	—	—	—
12 Burundi	2	5	7	4.7	11.8	9.2	—	—	0	0	0	0
13 Zambia	23	43	53	7.6	6.6	6.6	—	35	0	35	0	1
14 Niger	7	13	18	6.3	7.5	7.5	—	31	0	0	0	0
15 Uganda	7	9	10	8.4	3.8	5.0	38	52	0	52	0	1
16 São Tomé and Principe	18	30	40	6.0	5.1	7.3	—	—	—	—	—	—
17 Somalia	20	30	36	5.5	5.3	5.5	—	34	0	0	0	0
18 Togo	11	19	24	7.0	6.1	6.9	—	60	0	0	0	0
19 Rwanda	3	5	7	6.6	8.1	8.1	—	—	0	0	0	0

Table 1. (Continued)

	Urban Population						Percentage of Urban Population				Number of Cities of over 500,000 Persons	
	As a Percentage of Total Population			Average Annual Growth Rate (percent)			In Largest City		In Cities over 500,000 Persons			
	1965	1980	1987	1965–73	1973–80	1980–87	1960	1980	1960	1980	1960	1980
20 Sierra Leone	15	22	26	4.5	3.8	5.0	37	47	0	0	0	0
21 Benin	11	28	39	8.0	8.5	7.9	—	63	0	63	0	1
22 Central African Republic	27	38	45	4.2	4.5	4.7	40	36	0	0	0	0
23 Kenya	9	16	22	7.2	8.5	8.6	40	57	0	57	0	1
24 Sudan	13	20	21	6.7	4.4	4.2	30	31	0	31	0	1
25 Comoros	6	20	26	6.4	16.1	7.5	—	—	—	—	—	—
26 Lesotho	6	14	19	8.7	7.3	7.2	—	—	0	0	0	0
27 Nigeria	17	27	33	4.7	4.8	6.3	13	17	22	58	2	9
28 Ghana	26	31	32	3.9	2.4	4.1	25	35	0	48	0	2
29 Mauritania	10	27	38	9.0	9.2	7.9	—	39	0	0	0	0
30 Liberia	22	35	42	6.2	6.1	5.9	—	—	0	0	0	0
31 Equatorial Guinea	32	54	62	5.6	4.8	4.0	—	—	—	—	—	—
32 Guinea	12	19	24	5.1	5.3	5.7	37	80	0	80	0	1
Middle-income economies	20w	31w	37w	5.7w	6.3w	6.1w	39w	45w	0w	43w	0t	5t
33 Cape Verde	18	23	27	3.5	3.0	4.2	—	—	—	—	—	—
34 Senegal	33	35	37	2.8	3.2	3.8	53	65	0	65	0	1
35 Zimbabwe	14	22	26	6.7	5.5	6.3	40	50	0	50	0	1
36 Swaziland	7	14	30	5.1	13.3	13.9	—	—	—	—	—	—
37 Cóte d'Ivoire	23	37	44	7.6	7.3	6.9	27	34	0	34	0	1
38 Congo, People's Republic	35	53	41	5.1	6.0	4.6	77	56	0	0	0	0
39 Cameroon	16	35	46	6.8	8.6	7.4	26	21	0	21	0	1
40 Botswana	4	19	21	18.4	10.3	8.1	—	—	—	—	—	—
41 Mauritius	37	43	42	3.6	1.7	0.8	—	—	—	—	—	—
42 Gabon	21	36	43	4.5	6.8	6.7	—	—	—	—	—	—

Table 1. (Continued)

	Urban Population						Percentage of Urban Population				Number of Cities of over 500,000 Persons	
	As a Percentage of Total Population			Average Annual Growth Rate (percent)			In Largest City		In Cities over 500,000 Persons			
	1965	1980	1987	1965–73	1973–80	1980–87	1960	1980	1960	1980	1960	1980
43 Seychelles	—	—	56	—	—	—	—	—	—	—	—	—
44 Angola	13	21	26	5.6	7.0	5.8	44	64	0	64	0	1
45 Djibouti	—	—	79	—	—	—	—	—	—	—	—	—
Six most populous economies	14w	22w	28w	5.2w	5.4w	7.5w	22w	30w	11w	48w	3t	15t
Sahelian economies	13w	19w	23w	4.4w	5.3w	5.4w	41w	40w	0w	12w	0t	1t
Oil exporters	17w	28w	34w	5.0w	5.4w	9.1w	17w	21w	18w	54w	2t	11t
All low-income economies												
Total	17w	21w	30w	3.3w	3.9w	8.8w	11w	13w	30w	43w	59t	165t
Excluding China and India	14w	20w	24w	4.8w	4.8w	5.6w	24w	29w	17w	43w	10t	51t
South Asia	18w	22w	25w	3.8w	4.0w	4.1w	11w	11w	25w	40w	15t	49t
Excluding India	15w	19w	21w	4.5w	4.1w	4.3w	22w	25w	22w	41w	4t	13t

Source: World Bank, *Sub-Saharan Africa: From Crisis to Sustainable Growth,* Washington D.C., 1989, Appendix Table 35.
Note: Summary measures for urban population as a percentage of total population are weighted by each country's share in the aggregate population. Summary measures for the other indicators are weighted by each country's share in the urban population. Summary measures do not include estimates for missing country data. w for weighted average; t for total.

Table 2. Position of Maize in the Cereal Production of Kenya and Tanzania, 1965, 1980, 1987 (1000t)

	Kenya			Tanzania		
	1965	1980	1987	1965	1980	1987
Maize	1,301	1,620	2,170	751	1,726	2,337
Millet	130	90	50	117	380	297
Sorghum	163	200	130	149	563	663
Rice	14	40	40	73	363	571
Wheat	172	216	195	33	91	72
Total Cereal	1,794	2,233	2,612	1,123	3,126	3,945
Percentage of Maize (%)	72.5	72.5	83.1	66.9	55.2	59.2
Cereal per capita (kg)	192.6	142.3	118.7	110.3	173.2	164.4

Source: World Bank, *Sub-Saharan Africa — From Crisis to Sustainable Growth,* Appendix Tables.

lion for Tanzania in 1987. The average annual urban population growth rate for Kenya for the same period was 8.6% and for Tanzania 11.3%. They have started the urbanization process from a rather low level, but their urbanization rates reached 22% for Kenya and 29% for Tanzania in 1987, according to the World Bank's estimates. (World Bank, 1989, See Table 1)

In its recent history, agriculture in Sub-Saharan Africa, especially its food production has performed rather well. Relying largely on the traditional tools of hoe and cutlass, and the farming method of bush fallow and shifting cultivation, they have achieved food self-sufficiency despite the rapid introduction of cash crops for exports such as cotton, groundnuts, cocoa or coffee by the African small-scale farmers. The increase of food production was mainly made possible by opening up of new land, but also by introduction of new types of food crops with higher yield than the traditional crops. The good example of such new food crops are cassava and maize which have been rapidly replacing the traditional crops like yam and millet. In East Africa, together with Southern Africa, maize has become the single most important staple crop. Maize can be grown in the area of lower rainfall than the area where yam or banana can thrive, or without irrigation or in swamp which is necessary for rice growing. Maize flour can be cooked just like millet flour and is considered more palatable. The spread of maize flour as a staple diet is also said to be influenced by the existence of plantation estates where the migrant workers were fed with meals made of maize flour such as *ugali* and acquired a taste for it.

The rapid urbanization tended to promote the shift of taste from traditional staple food to the new ones, especially to wheat and rice. This shift was accelerated by the imports at the subsidized prices or by foreign aid. However, maize is in a rather unique position as it is considered as one of the prefered cereals together with wheat and rice among the urban dwellers, but its production comes over-

whelmingly from domestic sources, although in the year of famine its imports have supplemented the domestic sources. This is quite different from wheat or rice which supply is tended to be dependent on imports in most of the countries of Sub-Saharan Africa. The above picture reflects very well the situation of Kenya and Tanzania in recent years. The importance of maize production in these two countries can be seen in Table 2. In both countries, the traditional types of agriculture has been under a strain caused by the worsening of man/land ratio, which necessitated the small farmers to adopt more land-intensive type of agriculture. At the same time, the governments of both these countries have come to emphasize the introduction of high yielding maize varieties as a possible solution to feed the growing population, especially in the cities.

II. Adoption of Improved Maize Seeds by Small-Scale Farmers

1. Kenya

In Kenya, agriculture is still the mainstay of its economy although it has developed quite a sizeable manufacturing sector which contributed 19% of GDP in 1987. Agriculture still contributes 31% of GDP in the same year, and close to 80% of the population derive their livelihood from agriculture. Maize is the primary staple food grown by smallholders.*

The research and development of the new maize varieties was mainly undertaken in Kitale Research Station, and at the year of Kenya independence, i.e. 1963, USAID entered the scene and developed hybrid seed, "H600" series, which produced high yield and proved appropriate to the high potential areas of Kenya. In 1964 when the commercial production of this variety was started, it was assumed that the African small farmers would continue to use the local open pollinated varieties. Contrary to this assumption, they demanded and purchased the hybrid maize eagerly. It became so popular that small farmer hybrid maize production soon surpassed larger farmer output (See Table 3). Shortage of high potential land under the population pressure no doubt contributed to such state of affairs. In the drier lowland area the development of early maturing maize was undertaken at Katumani Research Station near Machakos, and soon followed by the development of medium maturity variety at Embu. Katumani's new seeds are open pollinated composite type whereas the seeds from Embu are hybrids. The adoption of the Katumani composite seeds seems to be much slower, however, in comparison with the hybrids in the higher potential areas of Kenya.

The increase of crop yield per land area depends on many factors, of course, and the use of HYV is only one of these. In order to demonstrate that good husbandry other than new seeds could increase yield substantially, A.Y. Allen showed the following experimental results as in Table 4. The results indicates that physical inputs (seed, nitrogen, phosphate) alone produced a 66% increase over the original average, while the good husbandry (early planting, weeding, proper spacing)

Table 3. Area of Improved Maize Grown in Kenya 1963 to 1979 in hectares

Year	Large Scale Farms	Small Scale Farms	Total
1963	158	4	162
1964	11,615	708	12,323
1965	22,137	8,110	30,247
1966	25,860	15,269	41,129
1967	55,501	46,642	102,143
1968	36,501	51,331	87,832
1969	39,500	64,291	103,791
1970	47,110	97,372	144,482
1971	63,785	149,864	213,649
1972	73,944	206,904	280,848
1973	53,370	264,699	318,069
1974	39,214	292,358	331,572
1975	50,697	352,053	402,750
1976	50,903	377,092	427,995
1977	59,357	429,602	488,959
1978	29,016	407,860	436,876
1979	20,146	347,550	367,696

Source: U.S. AID, *Kitale Maize: The Limits of Success,* AID, 1980, Appendix C.
In this table one can see the expansion of small farmer improved maize production far exceeded large farmer production after 1968.

produced a 148% increase. All six practices taken at a high level produced a 307% increase [J. Gerhart, 1975, p. 6].

At any rate, the detailed study conducted by John Gerhart in 1973 who surveyed 360 small-scale farmers in Western Kenya found that the use of hybrid maize in Kenya increased rapidly. In the period of only ten years between 1964 to 1973, the use of hybrid maize has increased from an initial 400 acres (162 ha) to at least 800 thousand acres (324 thousand ha), which means perhaps half the total production in Kenya. In the high and medium potential areas west of the Rift Valley, about two-thirds of small-scale African farmers had adopted hybrid seed by 1973. Gerhart concluded that the agro-climatic zone was found to be by far the most important variable in explaining adoption among the farmer as a whole. Location of the farm in the higher altitude and rainfall zones rather than lower altitude and less rainfall zones increased the likelihood of adoption of the new maize varieties. Size of farm, however, was significantly related to the earliness of the adoption, larger farms adopted the hybrid earlier. This may be due to their greater capacity to take risks, and/or because of the preferential treatment that large scale farmers receive from the extension services and the credit provision. However the farm size was not significantly related the adoption in 1973, which shows that the early adoption by the larger farmers facilitated the subsequent adodption by smaller farmers [Gerhart, 1973, pp. 47–448]. This took place before the Kenya government started the Integrated Agricultural Development Project (IADP) which aimed at providing the input packages in combination with the Smallholder Production Services and Credit Project (SPSCP) in the 1970s.

Table 4. Effects of Husbandry and Input Use on Maize Yields

Factor	Treatment	Yields lbs/Acre	Added Return Shs/Acre	Added Cost Shs/Acre
Time of planting	Start of rains	5200	270	Very little
	4 weeks later	3040		
Plants per acre	16,000	4580	115	8
	8,000	3700		
Type of seed	Hybrid	4360	175	12
	Local	3380		
Amount of weeding	3 times, early	4640	130	20
	Once, late	3600		
Phosphate/acre	50 lb.	4160	10	32
	None	4080		
Nitrogen/acre	70 lb.	4380	65	72
	None	3860		

Source: A.Y. Allan, "District Husbandry Trials in Western Kenya, 1966 and 1977," Quoted in M.N. Harrison, "Maize Improvement in East Africa" in C.L.A. Leakey, *Crop Improvement in East Africa,* 1970, p. 45.

2. Tanzania

In Tanzania, where the population density per land suitable for cultivation is not so high as in Kenya, except for a few very conjested area like the lower slope of Mt. Kilimanjaro, the government tried to introduce hybrid maize on communal fields created under the so-called Operation Ujamaa Village. These villages were created during the period of the Second Five Year Plan 1969 – 74, by shifting the small-scale farmers who had been living scattered in the wide area to the newly created village sites. Introduction of modern technology and better husbandry was one of the main reason for creating the Ujamaa villages, and for this purpose the government insisted that villagers open up communal farms. The government thought that the introduction of hybrid maize and other inputs as well as such social infrastructures as schools, clinics, and water supply, would be easier, if the rural population was concentrated into villages.

Thus the Tanzania Rural Development Bank (TRDB) was established in 1971 to provide these villages credit in the form of inputs rather than cash. It supplied production inputs such as new variety seeds, fertilizers, insecticides, and farm implements in connection with other parastatals such as Tanzania Seed Company, Tanzania Fertilizer Corporation, etc.

Development of HYV of maize in Tanzania has been mainly done at the Ukiliguru and the Ilonga Agricultural Research Stations and later at Uyole too, and the new varieties have been commercialized through Tanzania Seed Compa-

Table 5. Distribution of Improved Maize Variety Seed

(ton)

Year	Hybrid	Open pollinated	Total
1972–73	420	1	421
1973–74	666	109	775
1974–75	1366	1050	2416
1975–76	1484	1638	3122
1976–77	916	2128	3044
1977–78	409	1061	1470
1978–79	2485	1615	4100
1979–80	3022	107	3129
1980–81	2129	1516	3645
1981–82	1525	851	2376
1982–83	1909	1465	3374
1983–84	2537	1114	3651

Source: Tanzania Seed Company Ltd., Quoted from A.J. Moshi, et al., "Maize Research in Tanzania," *To Feed Ourselves,* A Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 1985, p. 117.

ny Ltd. This company apparently obtained much of their seeds from the Kenya Seed Company which has remained as a private enterprise with high rate of efficiency. Kenya Seed Company exported to Tanzania at least 1000 tons of hybrid and composite maize seeds in 1978/79 [USAID, 1980, p. 8]. Table 5 shows the sales of improved maize seeds by the Tanzania Seed Company between 1972 to 1983.

In the 1980s, most Ujamaa communal farms' production broke down, but by then many small farmers had learned how to grow hybrid maize and had seen the potential impact of the new technology. Those individual farmers in the highlands which are the high rainfall areas, took up the recommended package promoted by TRDB. The package consisted of the fertilizers of 50 kg of triple super phosphate (TSP) and 100 kg of calcium nitrate (CAN), together with 10 kg of hybrid seed. This should be used on one acre. Also an insecticide, i.e. DDT or endosulphan, was included, and the total standard package cost was 320 shillings in the 1979/80 season [T. Rasmussen, 1987, p. 10]. This was equivalent to the value of 3.5 bags (1 bag = 90 kg) at the producer price of 1 sh. per kg, while with good rains and proper husbandry, it might produce 12.7 bags which could fetch 1146 shillings [T. Rasmussen, 1982, p. 57], at the official producer price in 1979/80 season. P. Bo and T.T. Rusmussen conducted research in 1979/80 to determine the average yield of maize per acre in the actual small farmer situation, with or without the use of the package among 120 sample households in six villages in Iringa Region. The average yield for the total sample was found to be 503 kg per acre, which means 5.6 bags and the equivalent of 503 shillings (See Table 6). In only one of these villages, Ninga, the difference of yields between users of these inputs and non-users were compared (See Table 7). It was found that although the users of the input had a higher average yields, they also had a considerably

Table 6. Yields, Input Costs and Net Return per Acre in Six Villages in Iringa Region, Tanzania, 1979–1980

Villages	Masisiwe	Lulanzi	Tagamenda	Igagala	Ngalanga	Ninga	Total Sample
Percentage of farmers receiving loans (%)	0	100	75	80	0	55	52
Percentage of farmers using hybrid seed (%)	0	80	0	90	65	55	50
Average yield kgs/acre	410	605	242	1146	275	470	503
Average seasonal input costs per acre shs.	41	111	35	216	58	114	90
Average other input costs per acre[2] shs.	21	81	27	39	0	5	30
Percentage of farmers using TSP (%)	25	95	10	95	60	60	58
Percentage of farmers using CAN (%)	5	0	50	95	30	70	42
Percentage of farmers using insecticide (%)	80	90	45	95	75	65	75
Average total input costs per acre shs.	62	192	62	254	59	119	120
Average net return per acre[3] shs.	348	413	180	892	217	351	383

Source: Compiled from P. Bo and T. Rasmussen, *Peasant Economy and Rural Credit, CDR, 1982.*
Note: (1) Including local seeds; (2) Hired labour etc.; (3) At official producer price.

Table 7. Comparison between Users and Non-Users of Seasonal Inputs in Ninga Village, Iringa Region, Tanzania, 1979–80

	Non-Users	Users
Number of households	9	11
Average yield (kgs/acre)	352	499
Standard deviation	156.7	223.6
Average seasonal input cost per acre shs	16	142
Average net return per acre shs	336	357

Source: Same as Table 6, p. 60.

higher input costs. The average net return per acre was therefore not much higher. It was probably this kind of narrowness of profit difference which deterred the adoption of the improved variety seeds. This kind of cost-benefit calculations have probably been done even by the small scale farmers in Tanzania intuitively, and the result would be the slow adoption rate of the high yielding maize varieties.

III. Constraints in the Use of High Yielding Varieties at the Farm Level

The slowness of adoption of the high yielding varieties by the small scale farmers is often attributed to the conservativeness of their attitude, but very often it is because of the existence of a number of constraints facing the farmers. These constraints include, (a) information, (b) availability of seasonal inputs, (c) cost, and (d) farm management aspects. I would like to look into these major constraints based on the available farm level studies undertaken in Kenya and Tanzania.

1. Information

Even among the peasants, there exist certain amount of willingness to experiment new things. However, because they are just barely subsisting, risk factor has a high premium among them. For small farmers, if an information is available through other farmers that the new variety was beneficial to them, the adoption is made much easier. This is the reason why the larger farmers who can stand to take risks tend to adopt the new variety first often through the recommendation of the extension service, but smaller peasants soon follow when the results are confirmed and the news of success are conveyed from such early adopters to them. J. Gerhart found in his western Kenya study that 44.7% of small scale farmers heard about hybrid maize first from their friends or neighbours, whereas 35.4% heard first from the extension agents (See Table 8). Later, P.M. Shipton found that farmers in western Kenya who adopted hybrids early "tended to be richer, more heavily involved in cashcropping, and more highly schooled than those who did not" [Shipton, p. 177]. However, later the small peasants accepted hybrid, especially in the higher potential area where rainfall is more stable. This history of adopting hybrid maize in Kenya pointed to the importance of transmission of information especially *from neighbor to neighbor.*

2. Availability of Seasonal Inputs

Here, the availability denotes not only that of high yielding seeds, but also of other inputs like fertilizers, insecticides, credit, etc.

In western Kenya, one of the factors that promoted the widespread adoption of hybrid maize was the efficiency of the Kenya Seed Co. and its enthusiasm in engaging many seed distribution outlets, such as the Kenya Farmers Association (KFA), cooperatives, and many private shopkeepers, especially in higher altitude

Table 8. "From Whom Did You First Hear about Hybrid Maize?"
(All answers in percentages)

Source	Zones in Order of Decreasing Agricultural Potential				Weighted Average
	Zone 1	Zone 2	Zone 3	Zone 4	
Extension agent	30.5	33.3	43.2	40.2	35.4
Dealer/stockist	15.8	6.7	4.5	4.1	9.9
Friend/neighbor	42.1	50.0	44.3	18.0	44.7
Employer	3.2	0	1.1	2.7	1.7
Agricultural show/field day	0	0	1.1	4.1	0.4
Newspaper	2.1	1.1	0	5.5	1.2
Can't recall, other	6.3	8.9	5.7	11.1	6.7
	100.0	100.0	100.0	100.0 (sic)*	100.0

Source: *The Diffusion of Hybrid Maize in Western Kenya,* p.9. J. Gerhart (*Note that Zone 4 totals 85.7%. The error appears to be in the line "Friend/neighbor.")

areas. On the other hand, it is said that "the lower demand for hybrids in the lower altitudes was partly responsible for the relative scarcity of stockists there but effect was probably circular" [Shipton, p. 169]. In Tanzania, crop seed distribution system is not as efficient as in Kenya. It is said that many more peasant farmers would use hybrid if the seeds are available. Of other inputs, the question of availability of fertilizer could be the most important. After villagization, smallholders in Tanzania have been cultivating their own farms much more intensively than before, and the soil fertility would decline rapidly if fertilizers are not applied. The availability of fertilizers means that not only enough quantity must be delivered but also delivered at the right time. Phosphate fertilizers are important at the time of seed planting for base dressing, and nitrogen fertilizers for top dressing at later stage. Supply of these two types of fertilizers were found to be more or less erratic, and farmers were said to be applying whatever was available rather than what was appropriate. H. Bantje's study of smallholder agriculture in Mbozi District of Tanzania shows that "fertilizer rather than land is the limiting factor" for production. Also he pointed out that "the rate of fertilizer application was more dictated by availability than by the ability to pay for it" [Bantje, p. 52].

Tanzania has a fertilizer factory in Tanga, but this factory has been in trouble since its establishment. The factory's supply of fertilizer has been most erratic, and at times the factory has shut its production completedly [A. Coulson, *Tanzania: A Political Economy*, p. 281]. It is partly the failure of this factory that the supply of fertilizers has been so unreliable.

The availability of seasonal credit is another important factor for enabling the small scale farmers to obtain necessary production inputs. The initial drive to make small farmers adopt hybrid maize seeds was made by the Tanzanian government through the process of villagization. By making villages as the recipients of the institutional loans for seasonal inputs, hybrid maize was introduced to their com-

munal farms first. However the institutional credit was hard to obtain because the application for the loan was rather cumbersome, and because the fund was quickly exhausted as there was so much default. Some of the reasons for the default is that the loan was given in the form of fertilizers and pesticides, only to have been delivered after the right timing had passed.

Credit may not be absolutely necessary. In Kenya, it was reported that smallholder credit scheme did not contribute much to the spread of hybrid maize there. "Institutional credit played no big role in the quick spread of hybrids in the first decade." The Special Rural Development Project (SRDP) which tried to spread hybrids in the Project area did not have any substantial effect on the spread of hybrids in western Kenya [Shipton, p. 176]. It seems the hybrids caught on without the help of credit schemes there.

3. Costs

As the Table 7 shows, if the costs of inputs which must accompany with the introduction of the improved seeds are high, it does not give enough net income increase and therefore incentives to the adopting farmers. Cost here means not only the calculated difference between net incomes in a normal climatic situation, but also their ability to stand against drought and other natural hazards such as plant deseases. In East Africa, it is often said that drought is experienced as often as once in seven years in the drier areas. Shipton's study in the western Kenya reveals that the small scale farmers in the lower altitude area have much lower adoption rate of new varieties than those in the higher altitude area where climate is more stable. In fact, in the lower altitude area 6 – 24% of the farmers who once adopted the hybrid went back to the local seed later [Shipton, p. 185]. It is sometimes said that the local seeds are better suited than hybrids to the short rain season, in the climatic zone where the rainfall regime is bimodal. At any rate, many small scale farmers do not switch completely to the hybrids but tend to use both hybrid and local seeds for the sake of security. Hybrids are also said to have more problems in storage because their kernels are softer, and are more valnerable to the maize weevil.

As the costs of seasonal inputs for high yielding varieties are substantial, many farmers do not use the technically optimal level of inputs, but use much less because of their resource constraints. They tend either to use one or two items of the recommended package only [Bo and Rasmussen, p. 59], or spread the inputs thinly over large field [Bantje, pp. 50 – 52].

In view of the erratic and costly fertilizer supply situation, it might be well to look carefully into the possibility of the use of manure instead of chemical fertilizers. T. Rasmussen has looked into this matter and found it most encouraging. Very few peasants in his survey sample used manure on their maize fields, but both of the two sample farmers who used manure obtained highest yields found in their villages [Bo and Rasmussen, p. 66].

4. Farm Management Aspects

The fourth category of constraints is the farm management considerations facing the small scale farmers. Typically, East African small farmers have varieties of food crops in their fields and also very often have some cash crops for exports. The farmer tries to get as much income as his resources permit, and this may not always favour maize production. For instance if the farmer sees that by putting more emphasis on coffee production he could earn higher income, he may deemphasize maize production, and this may be considered as constraints from the view of adopting new maize varieties.

However, available evidence shows that in many cases the expansion of cash crops brought in positive effects rather than negative effects. For instance, Bantje found in Mbozi District in Tanzania that the introduction of coffee necessitated intensification of farming operations and thus it became rational to use chemical fertilizers. The money required to purchase fertilizer can only be generated by growing coffee. Thus, in this case the cash crop and the food crop productions are complementary. The important thing to watch in the farm management considerations is the timing of each farming operation so that seasonal labour bottlenecks do not appear. There is another factor of female labour here as labour inputs for maize are mostly done by woman. Agricultural extension services may well put emphasis on women in such cases. Adoption of new variety maize would be much influenced by this timing and labour allocation factors in the farmer's agricultural calendar.

It is often said that early planting of maize which is recommended by agricultural experimental stations is difficult for farmers to implement not only because the soil is hard to break before the on-set of rains, but also this is when cash is short as the proceed from the sales of the other crops are not yet paid. This makes it much harder for peasant farmers to purchase seasonal inputs.

IV. Conclusions

Due to very rapid increase of population, and even faster rate of urbanization, the increase of food production, especially that of the staple food has become an urgent matter. In East Africa, the dominant staple food is maize. The increase of maize production has been progressing mainly through the introduction of high yielding varieties such as hybrid seeds.

The small scale farmers in both Kenya and Tanzania are rather quick in adopting hybrid maize. The rate of adoption is significantly higher in the high potential areas with higher and more stable rainfall than in the lower potential area with lower and less stable rainfall. Thus the difference in the adoption rate is much influenced by ecological and climatic conditions. As the population increases, more and more marginal land will be brought under cultivation. It is urgent that better

varieties of seeds which are drought registant, highly responsive to low level inputs, and also highly resistant against pests and deseases could be developed so that those farmers living in the marginal semi-arid areas are benefited more. When we see the use of high yielding varieties among various class of farmers, it is clear that the use is not confined to the larger and wealthier farmers. Small scale peasant farmers have also strongly shown interest in grasping the new opportunity, and this was more noticeable in the higher altitude areas.

There are however four kinds of constraints facing the small farmers, when they adopt high yielding maize varieties. These are (a) information, (b) availability of seasonal inputs, (c) costs, and (d) farm management aspects. All of these constraints were discussed, and some recommendations were suggested in the previous sections. These include the beneficial use of neighbour to neighbour transmission of information, necessity of improving delivery of seasonal inputs, possible use of manure in supplementing chemical fertilizers, and the importance of farm management studies in the consideration of adoption of high yielding maize varieties.

NOTE

*Kenya government defines smallholders as those who own 8 ha of land or less and they comprise 98% of the farm households. It has been pointed out that 83% of all the smallholders actually own less than 2 ha. See Ikeno, J.(1986, Table 3).

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