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A Study of Maize Technology Diffusion in Ghana: Some Preliminary Results

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Maize is Ghana's most important cereal crop (being grown on more than 500,000 ha), and improving the efficiency of its production is a key to the country's agricultural development. A considerable amount of effort has been devoted to maize research and extension in Ghana over the past decade.

The survey reported on here was carried out as part of the Ghana Grains Development Project (GGDP), which began in 1979. The goal of the project is to strengthen research and extension capacity in Ghana, with a focus on the development and demonstration of grower recommendations for maize and cowpeas. The Crops Research Institute (CRI) is the executing agency for the government of Ghana, and the country's Grains and Legumes Development Board (GLDB) and Ministry of Agriculture (MOA) are participating as well. Another executing agency is the International Maize and Wheat Improvement Center (CIMMYT), which has based one or two agronomists in Ghana since the project's inception. The International Institute of Tropical Agriculture (IITA) is represented on the management committee of the project and has a cowpea breeder/agronomist stationed in Ghana.

The GGDP has fostered a broad strategy for technology development and transfer. While supporting research at the experiment station on plant breeding and crop management, the project has placed particular emphasis on developing a capacity to carry out research on farmers' fields. CRI and GLDB staff have managed an exceptionally large number of on-farm trials in the course of the project. The most important result of this research is a set of practical grower recommendations for maize and cowpea that is promoted through the project's extension activities. The project has emphasized close links between on-farm research and extension and has promoted an extensive demonstration program managed by GLDB staff and MOA extension agents. The extension effort has included the development of production guides aimed at extension agents and farmers. Annual workshops are held to discuss project results among the collaborating institutions and to plan future work.

The recommendations developed by the project have been useful in other extension efforts as well. In its training and visit extension program, for example, the World Bank Volta Region Agricultural Development Project (VORADEP) has collaborated closely with the project. Diffusion of recommendations for maize has been substantially increased by the efforts of the SG 2000 Project, which began working with the Extension Services Department of the MOA in 1986. The SG 2000 Project introduced farmers to improved maize technology by establishing large demonstration plots—referred to as production test plots (PTPs)—on farmers' fields and by providing inputs with supervised credit (Martínez et al. 1990).

In examining the adoption of new maize technology, this paper focuses on three elements: variety, fertilization, and plant population. The technical changes promoted among farmers are summarized in Table 1. CRI maize breeders have developed a number of improved maize varieties, and these have been tested in farmers' fields, where they yield more than local maize varieties under a wide range of management conditions. On-farm trials were used to develop recommendations for fertilizer use on maize. The recommendations vary according to agroecological zone and field history and have been readjusted to take account of the changing relation between maize and fertilizer prices in Ghana. Current fertilizer recommendations include the application of compound fertilizer at or near planting and a topdressing of nitrogenous fertilizer six weeks after planting. On-farm experiments also helped develop recommendations for improving traditional plant populations, including line planting, closer spacing between hills, and fewer seeds per hill. More complete information on the recommendations is given in a production guide published by the project (GGDP 1990).

The 1990 Survey

Economists from CRI and GLDB have undertaken several surveys as part of GGDP activities. The objectives of these studies are to provide feedback to the on-farm research effort and to assess progress in technology diffusion. While previous surveys were confined to single areas, the one undertaken in 1990 covered six areas of the country, which were chosen to represent the range of environments in Ghana where maize is an important crop (Figure 1). It should be emphasized that, although the six areas are representative, the results of the survey cannot be used to derive national level statistics regarding the use of maize technology. The results reported here are from a random sample of about 330 maize farmers in the six survey areas.

Table 1. Maize technology included in adoption study

Technology	Traditional practice	Improved practice
Variety	Local unimproved varieties	Improved open-pollinated maize varieties: Dobidi, Okumasa, Aburotia, others
Fertilization	No fertilizer	Starter fertilizer and topdressing
Planting	Random planting; hills widely spaced; 3-4 seeds per hill	Row planting; 90-cm rows, 40 cm between hills; 2-3 seeds per hill

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We are still analyzing the survey results and expect to make a full report available later in 1991. This paper points out highlights from the initial analysis. We begin by briefly reviewing some features of maize production in Ghana. We then consider the diffusion of maize varieties, fertilizer, and improved planting practices, followed by a summary of data regarding the role of extension in maize technology diffusion. The paper concludes by discussing the implications of these preliminary survey results.

Maize Farming in Ghana

Maize is planted under a wide variety of conditions in Ghana, from forest in the south to Guinea savanna in the north. The major agroecological region for maize, though, is the area referred to as the "transition zone," lying between forest and savanna (Figure 1). Rainfall in the transition and forest zones is bimodal, which makes two planting seasons possible. The major season begins in March or April and the minor season in July. Further north in the savanna, a single planting season begins in April or May.

Maize fields may be prepared by tractor, cutlass, or hoe. Maize is grown both as a monocrop and intercrop. In the forest areas, maize is often intercropped with cassava or other root crops, while in the north it may be intercropped with sorghum, legumes, or both. Whether monocropped or intercropped, all maize is weeded by hand. After harvest it is dried and stored on farm for use or sale.

Any analysis of the adoption of maize technology in Ghana must take into account the fact that maize is largely a commercial crop. For the majority of farmers in our survey, maize was either their first or second most important cash crop. More than 70% of the farmers surveyed sold more than half of their maize, mostly to traders. Many farmers store their maize for three to six months before selling it.

Maize is also consumed on the farm in a variety of preparations, including several types of steamed, fermented maize dough, porridges and gruels, and roasted green ears. Although maize is an important part of many farm household

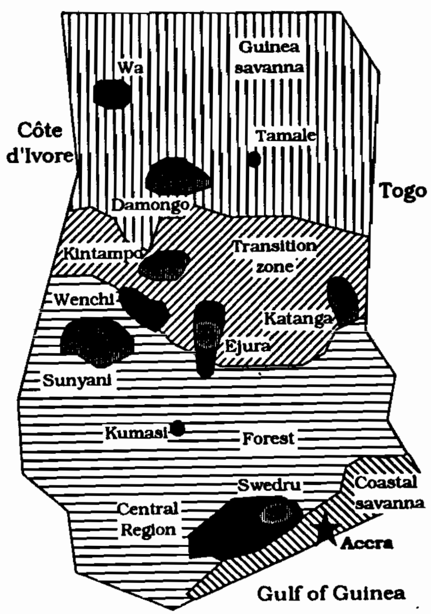

Figure 1. Location of farmer surveys carried out by the Ghana Grains Development Project.

diets, it is not as predominant as in many areas of eastern or southern Africa. In southern Ghana maize is complemented by crops such as cassava and plantain, while in the north it shares importance as a staple with crops such as sorghum and yam. Farmers rarely buy maize grain for household use; only about 11% of the farmers interviewed reported buying as much as 50 kg of maize grain in the past year. More than half of the households surveyed, however, reported that they regularly bought some type of prepared maize. Preparation of the most popular maize dishes requires wet milling, fermentation, and other operations that are difficult at the household level. These maize foods, particularly *kenkey* and *banku*, are popular convenience foods in Ghana's towns and cities and account for a major proportion of the maize that is marketed.

The following analysis thus looks at the adoption of maize technology by farmers for whom maize is an important source of cash income as well as an important element of their diet. Changes in maize production practices represent the results of more than 10 years of research and extension aimed at improving maize productivity in Ghana.

Maize Varieties

We estimate that in 1990 approximately 49% of the maize area in the survey was planted to improved varieties. The farmers surveyed reported that only 34% of their maize fields were sown to improved varieties in 1987. More than 58% of the farmers were planting an improved variety in at least part of their fields in 1990. When asked to name all of the maize varieties they were planting, farmers gave the responses indicated in Figure 2. In 43% of these instances, farmers gave the name of an improved variety, while in 15.4% they could not recall the name but referred to the variety simply as "agric" (i.e., from the Ministry of Agriculture). The remaining maize varieties are local unimproved materials, for which farmers often do not have specific names.

Figure 3 shows the source of seed of the improved varieties that farmers planted. Almost 40% of the seed was obtained from other farmers and another 30% from extension agents, in many cases those working with the SG 2000 Project. Less than 20% of the seed currently used was purchased from an official source. The low proportion of seed purchased through commercial channels is disappointing and indicates serious deficiencies in Ghana's seed system. Farmers can grow open-pollinated varieties for three or four years before having to buy fresh seed; 77.6% of the improved seed planted by the farmers surveyed is four years old or less. But given that much of this seed comes from

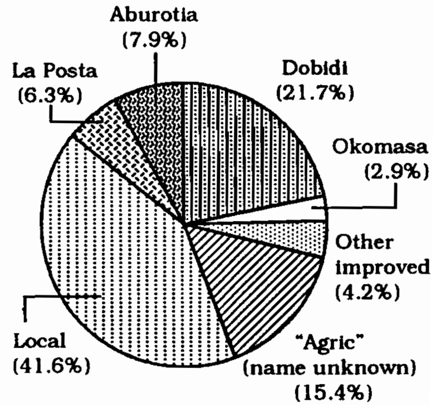

Figure 2. Instances of maize variety use (major and secondary varieties planted in maize fields).

other farmers' fields and that few of the farmers acquire fresh seed on a regular basis, much remains to be done in developing a viable seed industry that will enable growers to take advantage of the improved maize varieties produced by CRI.

Acceptance of improved maize varieties differs sharply among regions, as shown in Table 2. Farmers in the forest areas are much less likely to use improved varieties than those in the transition zone or savanna. Table 3 indicates farmers' reasons for not adopting or for rejecting the new varieties. The most important is unavailability of seed—further evidence of the inadequacy of the seed distribution system.

Farmers are also concerned about problems in marketing grain of improved varieties, particularly in Sunyani and Swedru, where acceptance of the new varieties is lowest. The principal impediment seems to be the belief that the new varieties do not make acceptable *kenkey*. There is evidence that at least in certain markets and at certain times of the year traders may favor local varieties over improved ones. Though various tests have shown that good kenkey and other maize preparations can be made from improved maize, further extension efforts and testing, involving *kenkey* makers, is required to satisfy their doubts about the cooking quality of the new varieties.

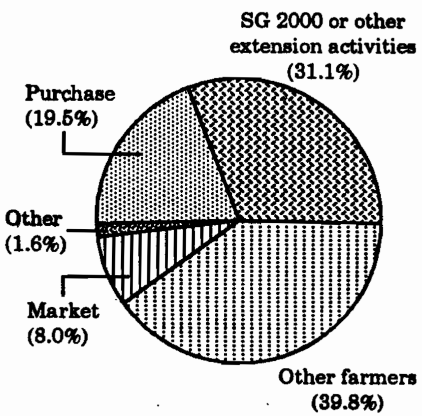

Figure 3. Source of seed of improved maize.

Table 2. Use of improved maize varieties, by location

Location	Zone	Percentage of area planted to improved varieties
Swedru	Forest	18.4
Sunyani	Forest	6.6
Kintampo	Transition	68.1
Ejura	Transition	73.4
Katanga	Transition	48.4
Damongo	Guinea savanna	82.4
Total		49.2

Table 3. Farmers' reasons for not using improved varieties

Reason	Never adopted (%)*	Adopted and rejected (%)**
Unavailability of seed	62.2	63.6
Lack of knowledge	28.6	0.0
Storage problems	26.5	39.4
Marketing problems	20.4	48.5
Cooking quality	8.2	6.1
Yield	2.0	6.1
(Number of farmers)	(98)	(33)

Note: The percentage total is more than 100% because farmers gave multiple answers.
* Farmers who have never used an improved maize variety.
** Farmers who used an improved maize variety at least once but were not using it in 1990.

Another concern that farmers commonly express is that the new varieties do not store well. This is almost certainly related to their poorer husk cover, which allows weevils and other insects to enter the maize ears while they are still in the field. The strongest complaints about storage come from farmers in the more humid areas of the country. Further breeding, combined with adequate storage technology, should resolve this problem.

Finally, although the new varieties are grown under a wide range of conditions in Ghana, they are most likely to be found where maize is grown as a monocrop (or intercropped with other grains or legumes) and where other recommended production practices are followed (Table 4).

Fertilizer Use

When the GGDP was initiated, fertilizer use on maize was very low, despite a considerable amount of research and extension work intended to introduce farmers to fertilizer. The project developed further information on fertilizer responses in farmers' fields and then verified and demonstrated practical rates and methods of fertilizer application.

Most farmers in Ghana are familiar with chemical fertilizer; nearly 50% of those surveyed had experience in applying this input to maize. Figure 4 shows trends in the purchase of fertilizer for this crop over the past four years. The upward trend through 1989 is broken by a sharp decline in 1990. The principal reason is almost certainly the higher price of

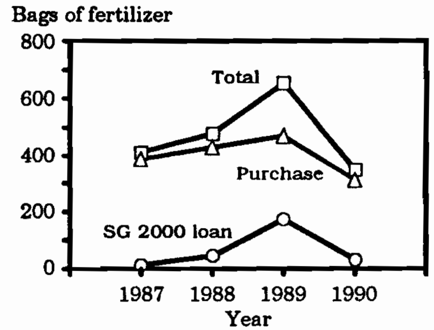

Figure 4. Fertilizer use, 1987-90 (bags of fertilizer used on maize by farmers who have grown maize for least four years).

Table 4. Use of improved varieties, by cropping system or practice

Cropping system or practice	Number of fields	Fields with improved varieties (%)
Intercropped with root crops	151	25.2
Intercropped with grains or legumes	75	78.7
Monocropped*	191	67.0
Random planted, no fertilizer	69	39.1
Random planted, fertilizer	9	88.9
Row planted, no fertilizer	28	82.1
Row planted, fertilizer	59	83.1

* Fields planted on ridges were not included.

fertilizer over the last two years, occasioned by a gradual removal of the government subsidy. Another reason is that the rains were erratic and late in 1990, making farmers cautious about investing in this input. Finally, it should be noted that a considerable part of the increase in fertilizer use in 1989 was due to SG 2000's credit program. When loans dropped sharply during 1990, the more limited availability of credit undoubtedly had an effect on fertilizer use.

Fertilizer use on maize varies significantly among the districts covered in the survey. Figure 5 shows the proportion of maize fields receiving fertilizer in each district and illustrates how fertilizer use is related to field history. In districts where fields are continuously cropped for long periods, fertilizer use is highest. In all of the districts where fertilizer use is common, it is most likely to be applied on older fields.

Other factors influence the use of fertilizer as well. Monocropped fields, for example, are more likely to be fertilized.

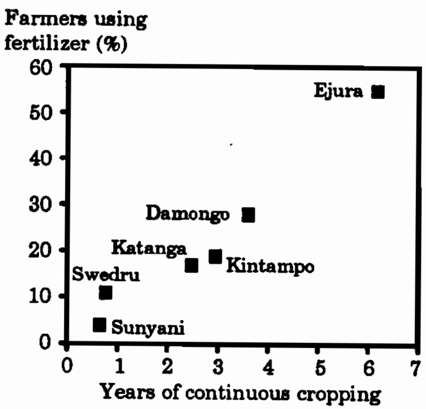

Figure 5. Fertilizer use on maize, by cropping history.

Sharecroppers are less inclined to use fertilizer, since they are generally responsible for purchasing all inputs but are obliged to give one-third of the harvest to the land owner. Fertilizer use is also related to other recommended practices. As indicated in Table 5, application on monocropped maize is almost nonexistent in fields that are random planted to local varieties. Farmers who use an improved variety, on the other hand, are more likely to apply fertilizer, particularly if they plant in rows (i.e., achieve adequate plant populations), making fertilizer application easier.

When farmers were asked why they did not use fertilizer, the two principal responses they gave were high cost and adequate soil fertility (Table 6). In 1990 the price of fertilizer (in terms of maize) was about twice as high as it was in 1987 because of the removal of subsidies on this input. A number of farmers claimed that they are not using fertilizer because their fields do not require it. For farmers who have experience with fertilizer, this response did in fact correlate with fields that have recently been in fallow.

Table 5. Fertilizer use, by planting practice (monocropped maize)

Planting practice	No. of fields	Fields receiving fertilizer (%)
Random, local variety	43	2.3
Random, improved variety	35	22.9
Row, local variety	15	66.7
Row, improved variety	72	68.1

Note: Fields planted on ridges were not included.

Our initial analysis of fertilizer practices shows that farmers tend to follow the recommendations with respect to type, timing, and rate of application. The principal exception is a tendency to apply starter fertilizer more than two weeks after planting. Many farmers prefer to wait until they are certain of having a good plant stand and adequate rainfall.

Planting Practices

In order to take advantage of improved varieties and fertilizer, it is important that farmers achieve adequate plant populations. The GGDP has developed recommendations for plant spacing and simple methods for making rows (using strings or sighting poles) and measuring distances (using a cutlass). In this analysis row planting is used as a proxy for improved planting practices, the aim of which is improved plant populations. This survey confirmed that farmers who row plant use fewer seeds per hill and previous surveys have shown that in row-planted fields the distances between hills are smaller.

In analyzing the adoption of row planting, we have eliminated farmers (particularly in Damongo and Kintampo) who traditionally prepare their fields by forming ridges with a hoe. Of the fields included in the survey, 36.3% were row planted. This practice is most often applied in monocropped fields and fields with longer cropping histories. These two factors are related. Row planting is easier in fields that have been cropped continuously and are free of stumps and other obstacles. As mentioned above, row planting is often associated with fertilizer use and improved varieties.

Farmers who were not planting in rows were asked why they had not adopted this practice (Table 7). Those who had never adopted it cited lack of knowledge and extra labor. Among those who had experience with row planting, the principal reason for abandoning the practice was the extra labor involved, which is mainly a result of the larger number of hills made. Though many farmers learn row planting and use the technique to their advantage, obviously the extra labor involved has discouraged others.

Table 6. Farmers' reasons for not using fertilizer on maize

Reason	Never adopted (%)*	Adopted and rejected (%)
Cash/price	50.7	53.0
Soil is good	29.0	29.9
Unavailability	2.9	7.7
Lack of knowledge	12.3	0.9
Other	5.1	8.5
(Number of farmers)	(138)	(117)

* See notes on Table 3.

Table 7. Farmers' reasons for not row planting maize

	Never adopted (%)*	Adopted but rejected (%)
Too much work	38.8	65.0
Lack of knowledge	41.3	2.5
Difficult with intercrop	9.9	7.5
Other	9.9	25.0
(Number of farmers)	(121)	(40)

* See notes on Table 3.

Extension

Considerable progress has been made in the diffusion of new maize technology among Ghanaian farmers. This progress is due both to a practical, well-focused research strategy and to the efforts of various extension programs. To determine the contribution of extension, we asked farmers how they first learned about the recommended practices. As is apparent from Table 8, extension has played an important role in introducing farmers to new technology. Farmers also learn a great deal from one another, however, especially about improved varieties.

The extension services have promoted maize recommendations through a wide range of activities, including demonstrations and field days organized by extension officers who have received training from the GGDP, SG 2000, and other projects. We asked farmers a number of questions that tested their knowledge of the recommendations and ranked their responses on an eight-point scale. The results indicate that there is a clear relationship between extension activities and farmers' knowledge. Those who have either attended a demonstration or participated in the SG 2000 Project have much higher scores than those with no extension contact.

We were also interested in seeing if extension was reaching women farmers, who are very important in Ghanaian agriculture. In analyzing the knowledge scores of men and women farmers generally, we found that women scored significantly lower than men. But when we compared scores of men and women who had participated in the same extension activity, the difference in knowledge was not nearly so great (Table 9). When we further considered only farmers who practice monocropping (a system in which new practices have been widely adopted), we found no difference in knowledge scores between men and women. Our principal conclusion is that continued effort is needed to include women maize farmers in all extension activities.

Finally, the survey gives evidence of the particular impact of the SG 2000 Project. It is quite impressive that in a random sample of maize farmers in six areas of Ghana approximately one in every four farmers had had contact with the project. Extension agents working with the project have been an important source of seed of new varieties. We estimate that about 20% of the improved seed planted in 1990 came directly from SG 2000, and certainly some of the seed that farmers obtained from their neighbors was originally introduced by extension officers working with the project. It has also been responsible for introducing a large number of farmers to fertilizer. Moreover, as pointed out above, participation in SG 2000 is associated with high scores for knowledge about the recommendations.

As one example of the project's impact, it is interesting to compare results obtained from the present survey in Ejura with those from a survey carried out in the same area during 1987. Ejura is an important maize-growing district, and the SG 2000 Project has been very active there. We found that the use of improved varieties and fertilizer has approximately doubled in this district in three years, and much of the increase is undoubtedly due to the project's efforts.

There are some concerns, however, about the sustainability of this work. As SG 2000 expanded, particularly in 1989, the credit component of the program became much more difficult to manage. In addition, as the project began working with very large numbers of farmers, less attention was paid to targeting the extension message. Between 40 and 50% of the farmers participating in the SG 2000 program were already familiar with one or more of the recommended technologies. There were also fewer opportunities for follow-up; of the farmers who learned about fertilizer through participation in the SG 2000 Project, only 28.9% continued using it in 1990. Even so, it is important to take advantage of the enthusiasm created by SG 2000 to ensure that the extension service continues to achieve broad coverage of Ghana's maize farmers and is able to advise them on the use of new technology.

Conclusion

As pointed out above, the results discussed here represent only a preliminary analysis of the 1990 maize producer survey. Further work will certainly give us more insight into the diffusion of new maize technology. Nevertheless, from the initial results, we can draw conclusions in three areas: agricultural research, institutional requirements, and the place of maize in the Ghanaian economy.

Table 8. How farmers first learned about new technology

How learned	Variety (N = 241)	Row planting (N = 199)	Fertilizer (N = 158)	Fertilizer application (N = 149)
	Percentage of farmers			
Extension demonstration	16.6	30.2	22.2	30.2
Told by extension	29.0	23.6	40.5	34.9
Other extension method	2.5	2.5	5.1	2.0
(Total extension)	(48.1)	(56.3)	(67.8)	(67.1)
From another farmer	48.1	35.7	28.5	26.8
Other or don't know	3.7	8.0	3.8	6.1

Table 9. Knowledge score of farmers, by gender

	Total population	Participated in demonstration or SG 2000	Monocrop and participated in demonstration or SG 2000
Males	3.54	5.49	5.47
Females	2.36	4.67	5.27
(Probability T-test)	(.001)	(.05)	(NS)

Substantial investments in agricultural research have helped bring about significant changes in the maize production practices of Ghanaian farmers. The development of appropriate maize varieties, for example, was made possible by good plant breeding capacity at CRI and by a system of on-farm testing that allowed interaction among farmers, researchers, and extension agents. Even so, important challenges remain. One concern is the uneven adoption of new technology; little progress has been made where maize is intercropped with cassava, for example. The GGDP has invested considerable effort in generating recommendations for maize/cassava intercropping, but more work must be done to improve our understanding of this cropping system and to raise its efficiency.

Farmers' progress with new varieties, enhanced fertility, and improved plant stand management raises questions about further opportunities for improving maize production, which will probably require longer term research efforts. It is likely that farmers who have already adopted the new technology available will now have to turn their attention to better weed control if they expect to achieve further increases in yields. Farmers understand the importance of weed control but have trouble mobilizing labor for timely completion of this task. About two-thirds of the farmers surveyed use hired labor in weeding their maize fields. Alternative weed control methods will have to be tested carefully and applied in a form that farmers can manage. The diverse weed populations affecting maize in Ghana present a significant challenge to research.

Long-term fertility is another item on the research agenda that should receive high priority. Though farmers are now familiar with fertilizer, changing prices and difficult growing conditions make it unlikely that use of this input for maize in Ghana will increase substantially in the near future. Any additional use of fertilizer will almost certainly be concentrated in areas where the soils and crop management make it most profitable. In the meantime, much maize is planted on fallow land, and fallow periods in most cases are becoming shorter. Alternative methods for maintaining and improving soil fertility are urgently required.

Ghana's strong research system needs to be complemented by significant changes in other institutions. Evidence from this survey leaves no doubt that as long as the country lacks an effective seed system Ghanaian farmers will not be able to take full advantage of advances in maize breeding. Local seed production and extension programs that help distribute seed may help in the short term, but they are no substitute for commercially viable seed enterprises.

The fertilizer distribution system also requires attention. Previous subsidies on fertilizer were so high that they represented a significant drain on the nation's resources and a disincentive to the rational use of this input. As the subsidy on fertilizer is removed and the MOA relinquishes responsibility for fertilizer distribution, however, there is a danger that neither farmers nor private traders will be able to adjust quickly enough to the new conditions. The road to fertilizer privatization is a difficult one (Shepherd 1989), and careful thought is needed to guide the transition.

Another important element in strengthening Ghanaian agricultural institutions is the extension service. From its first days, the GGDP emphasized the importance of strong links between research and extension. More recently, the SG 2000 Project has provided clear guidelines for a national extension approach that includes well-conceived demonstrations, generates farmer commitment, promotes community involvement, and focuses attention on inputs and credit. Future development of the extension system will demand more of these same elements: close collaboration between research and extension and a well-defined extension strategy that stresses the delivery of clear and relevant messages in the context of Ghana's highly variable farming conditions.

The SG 2000 Project has provided clear guidelines for a national extension approach that includes well-conceived demonstrations, generates farmer commitment, promotes community involvement, and focuses attention on inputs and credit.

The issue of agricultural input supply requires urgent attention. A small-farmer credit program would nicely complement an improved input system, but there are serious obstacles to this goal. Such a system would have to be economically viable, with an efficient strategy of loan management. Previous small-farmer credit programs in Ghana have shown high rates of farmer repayment but prohibitively high administrative costs (Owusu and Tetteh 1982). Everyone would welcome an efficient credit system in the service of Ghana's small farmers, but much basic work remains to be done before such a system can be realized.

Finally, it is important to place maize in a broader context. It is a key crop for Ghana and has been the focus of intensive work both by GGDP and SG 2000. The need to continue devoting research and extension resources to maize is undeniable. Even so, farmers will be able to take full advantage of new technology for increasing maize production only if there is a market for surplus grain. Currently, most of the grain sold is used to make food preparations that are sold in towns and cities. Maize is an important staple in Ghana but not the predominant one. Unless new markets for the crop are developed—involving feed, food, and industrial uses—it is unlikely that farmers will go on producing ever larger quantities of maize.

Thus, continued advances in maize production in Ghana depend on a wide range of factors. It is well known that agricultural development requires simultaneous efforts in research, extension, input supply, and marketing (Wortman and Cummings 1978). Ghana's research and extension services need continued support. Adequate systems for supplying agricultural inputs need to be established. And maize marketing and demand, as well as the place of maize in the Ghanaian food system, all require further study. It would be counterproductive to focus exclusively on one or another of these factors, and for any of them a "quick fix" is neither feasible nor desirable. Both Ghanaian and donor institutions should be prepared for a comprehensive and long-term commitment.

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