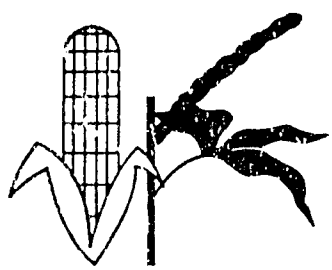
Changing Maize Production Practices of Small-Scale Farmers in the Brong-Ahafo Region, Ghana



GHANA GRAINS DEVELOPMENT PROJECT

Changing Maize Production Practices of Small-Scale Farmers in the Brong-Ahafo Region, Ghana

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PREFACE

The Ghana Grains Development Project has been active in Ghana since 1979. It involves the Grains and Legumes Development Board (GLDB), the Crops Research Institute (CRI), and the Ministry of Agriculture (MOA) in an effort to develop methods for increasing the production of maize and cowpeas in Ghana. The project is sponsored by the Canadian International Development Agency (CIDA) with the technical support of the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute for Tropical Agriculture (IITA).

The project has featured the combination of on-station research with an extensive program of on-farm experimentation throughout the country. The results of the experimental program have been used to develop recommendations for farmers. One of the principal ways of bringing these recommendations to farmers has been through what are called "verification-demonstrations," which are planted on farmers' fields and compare the farmers' practice with one or two alternatives. As this activity increased rapidly over the past several years, and as we began to get evidence of farmer acceptance of the recommendations, we decided it would be worthwhile to begin assessing the degree of adoption.

The area selected to begin looking at the adoption of new practices and described in this study is in the Brong-Ahafo Region. This is an area where maize is an important commercial crop, where the extension program is well established, and where we thought it possible to conduct a fair test of the acceptance of our maize production recommendations.

We hoped to use the results of the study both to measure our progress and to discover challenges for the future. The study fulfilled both of those purposes. We are encouraged by the generally high rates of adoption evident in the study area, and we have found that the survey provides detailed information on farmers' practices and problems that is useful for helping to set program priorities.

The survey was done in May 1986 and involved the work of a large number of people. Project economists Kofi Marfo and A.A. Dankyi were involved in the design

and testing of the questionnaire, worked as enumerators, and then participated in the analysis and write-up of the survey. Robert Tripp from the CIMMYT Economics Program in Mexico came to Ghana to work on the survey and also helped analyze and write up the results. Michael Read, CIMMYT Maize Program staff member posted to Ghana, was involved in the organization of the survey work, as well as the design and analysis. Project agronomists contributed to the survey, participating in its design and later working as enumerators, and their efforts are responsible for the high quality of the results. We would like to give special recognition to Boa Amponsem, Henry Asumadu, Osei Kwabena, and Kojo Poku of the Grains and Legumes Development Board; Godwin Aflakpui of the Crops Research Institute; and C.K. Senezah, extension liason officer for the Ministry of Agriculture. Staff of the Ministry of Agriculture and the Grains and Legumes Development Board in the survey area also contributed to the efficiency of the survey.

We are encouraged by the adoption that has already taken place, but are also aware of the immense amount of work that still needs to be done to improve maize and cowpea production in Ghana. Surveys such as the one reported here help us assess our position and plan future work, and we hope to promote similar studies in other parts of the country.

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EXECUTIVE SUMMARY

This paper reports the results of a study of the adoption of new maize production practices in one area of the Brong-Ahafo Region of Ghana. The research and extension effort responsible for the recommendations of new practices are part of the activities of the Ghana Grains Development Project, and the project proposed to measure the degree to which its recommendations were being taken up by farmers.

A survey was taken in one of the more important maize production areas in Ghana to examine the adoption of new varieties, row planting, and the use of fertilizer. Farmers in the survey managed a little over 2 ha of maize, on the average, and maize was usually their most important source of cash income. Eight villages where extension had been active were selected for the study. It is felt that the results of the survey fairly represent maize production practices in most of the area where extension is active.

The adoption of the recommended practices has been quite high. This is especially true for those farmers who have monocropped maize. About one half of the area is planted to improved maize varieties, and the majority of farmers have experience with buying commercial seed. Row planting is also used by the majority of farmers, with the result that plant spacing and population is better managed than in fields that are random planted. Despite supply shortages, almost half of the farmers are using some fertilizer on their maize. Rates naturally vary, and there is a tendency to apply the fertilizer later than is recommended.

An examination of the adoption history of these farmers reveals a pattern of careful stepwise testing of the components of the recommended alternatives, rather than a sudden switch to the complete set of recommended practices. Many farmers surveyed had attended a verification-demonstration, which was certainly one of the important elements in the extension strategy that brought the information to the attention of the farmers. Extension activities are farmers' most important source of information on these recommendations, with advice from fellow farmers playing an important role as well. There is no evidence that the extension message is missing either women farmers or those with little or no education.

Variations in farmer circumstances help to explain the patterns of adoption that have been observed. Farmers' concern for the storability and marketability of the improved varieties has probably limited their adoption to some degree. Row planting, though accepted by the majority of farmers, is more difficult on fields that have many stumps or other obstacles, and does require a bit more time at planting. Variations in fertilizer use can be partly explained by the shortage of fertilizer in the area, but a more important factor is probably the fertility of farmer's fields. Farmers recognize that fertilizer gives its greatest response on fields that have been continuously cropped and on fields where plant populations are adequate, and it is these fields that receive the most fertilizer. An understanding of these and other farmer circumstances helps researchers to target their recommendations more precisely.

1.
THE RESEARCH AREA AND THE RECOMMENDATIONS

The Survey Area

The survey was carried out in the Brong-Ahafo Region, in a portion of the Agricultural Districts of Techiman, Nkoranza, Wenchi, and Kintampo (Figure 1). Maize is an important crop in this area, which is part of Ghana's transition zone between the forest and the savanna. Most of the maize is planted during March and April. A substantial amount of maize is also planted in September, during the minor rains, but this study examined only practices during the major season. The Ministry of Agriculture estimates that about 35,000 ha of maize were planted in these four districts during the major season of 1986.

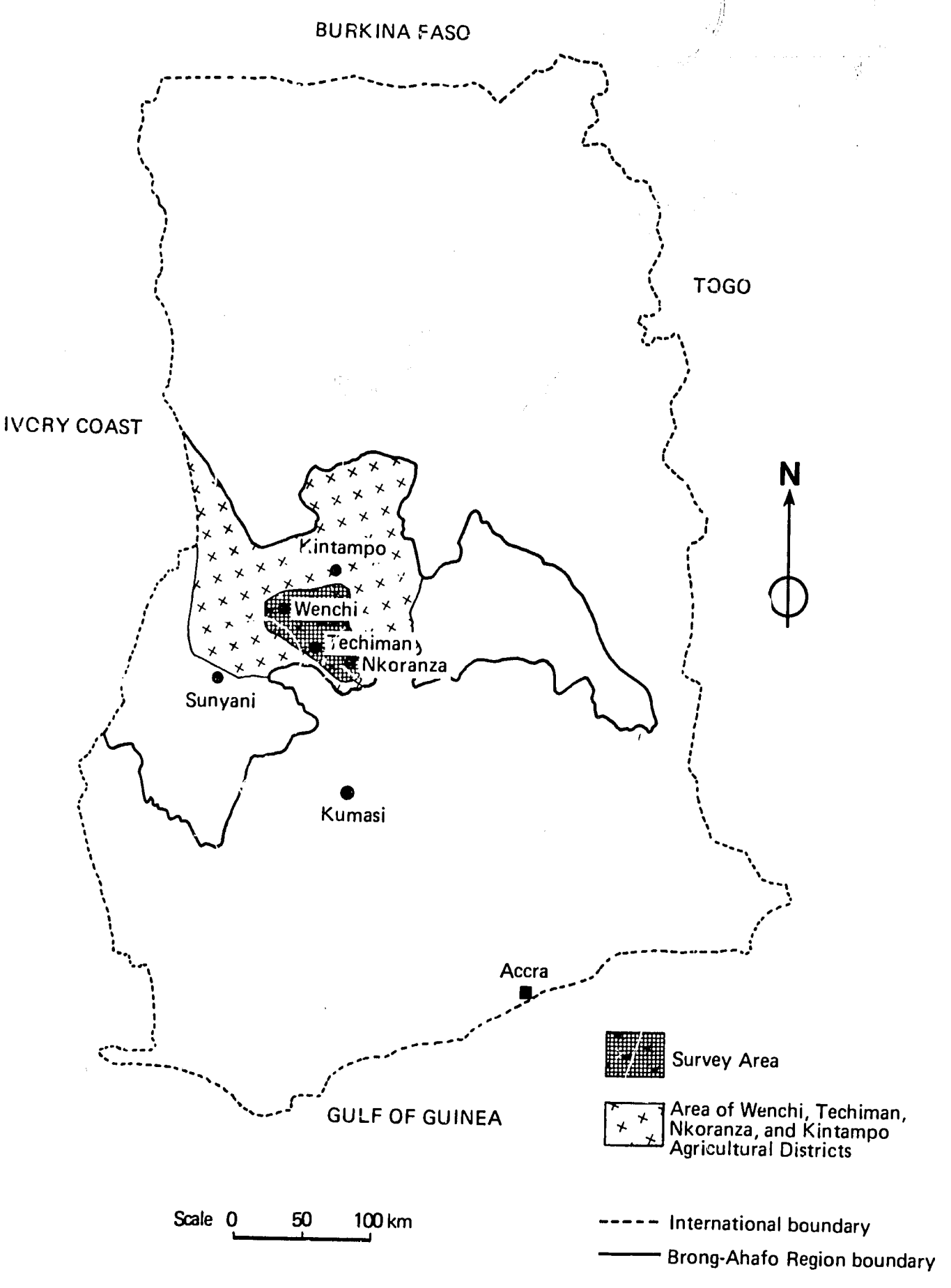
The survey was confined to farmers who were growing between 0.2 and 8.0 ha (0.5 to 20 acres) of maize in the major season of 1986, criteria which account for the vast majority of maize growers in the area. These farmers averaged about 2.2 ha of maize. About a third of them had more than one maize field, and the average size of a farmer's largest maize field was 1.8 ha. Most of the fields are owned under traditional law by the farmers, but about 20% of the farmers in the sample were either renting or sharecropping.

About half of the fields were prepared by hand (slash and burn) and half by tractor. Maize planting may be done by family labor, hired labor, or both; only 15% of the farmers relied exclusively on hired labor, whereas 44% used only family labor. Maize is planted by hand, in holes made with the tip of a cutlass, and weeding is also done by hand (4% of the farmers used herbicides). Fertilizer is available locally and is used by about half of the farmers. Maize may be monocropped or intercropped with some combination of cassava, cocoyam, and plantain. About one-third of the maize fields were intercropped.

The maize is harvested by hand and may be stored for a variable period of time before sale. Most of the maize is sold, as root crops are more prominent in the local

Map of Ghana

Figure 1.



diet than maize. About 80% of the farmers reported maize to be their most important source of income. The maize may be sold to private buyers or to the government Food Distribution Corporation.

The Sample

The survey was done in May 1986 in the following villages: Tromeso, Awisa (Wenchi); Nkwabeng, Nkoranza Kissima, Akumsa Dumase (Nkoranza); Jema, New Pamdu (Kintampo); and Aworowa (Techiman). These villages were chosen because of the presence of either a Ministry of Agriculture (MOA) or Grains and Legumes Development Board (GLDB) representative who had performed a verification-demonstration in 1985. In each of the villages a sample of five farmers was randomly drawn from the list of people who had attended the demonstration, and an additional five farmers were drawn from the general population, using lists of farmers developed by the extension agents. Inability to locate one of the attendees reduced the total sample to 79 farmers. This sampling method was chosen because one of the original objectives of the study had been to compare farmers who had attended demonstrations with those who had not. As it turned out, many of the farmers in the general population had also attended a demonstration in previous years. It will be seen later that there were no significant differences between attendees and those who had never attended. Thus we feel the data from this study fairly represent the practices of maize farmers in villages in the area where extension is fairly active.

Only 15% (12/79) of the sampled farmers are female. Women are active farmers in this area, but they tend to concentrate more on food crops than on commercial crops. Whether the sample is biased towards men is unclear, but it is a factor that deserves attention in further studies of this kind. It is important to note, however, that no significant differences were found between the farming practices of the women and those of the men in the sample, except that women were more likely to intercrop their maize.

Extension Activities

The four agricultural districts in the study contain a total of 38 subdistricts. Each of these has a Technical Officer and/or a Senior Technical Assistant of the MOA. In addition, there are 19 GLDB supervisors stationed in villages and towns in the four districts. All of the GLDB staff, and many of the MOA extension agents, are

responsible for using "verification-demonstrations" as a tool for the extension of maize recommendations. A verification-demonstration consists of three plots; one represents the farmers' practice and the other two represent recommended options. Farmers are invited to the plot for formal presentations at planting, mid-season, and harvest. At harvest the yields of the plots are calculated and discussed with the farmers in conjunction with information on the costs of the various options. The verification-demonstration strategy was initiated by the Ghana Grains Development Project in 1980, using GLDB staff, and has grown rapidly; a large number of MOA personnel are now included as well. Although other national and local level agricultural and rural development projects have operated in the area in the past, the efforts of the Grains Project have been the major vehicle for promoting new maize technology in the area in recent years.

The MOA takes responsibility for selling fertilizer and maize seed. Fertilizer is available at the district capitals. Sales for 1983-1985 in the area averaged about 1200 tons of compound fertilizer (mostly 15:15:15) and about 270 tons of ammonium sulphate, but fertilizer is often not available. In 1986 GLDB personnel began selling maize seed at the village level.

The Recommendations

The recommendations whose adoption was measured in this study are shown in Table 1. These recommendations were developed from several years of on-farm experiments throughout the country and, beginning in 1980, were included in verification-demonstrations. These were not only a useful extension tool, but because the results were analyzed each year the verification-demonstrations became an important source of information for refining the recommendations.

The recommended practices for variety, planting, and fertilization were responsible for an increase of approximately 1 t/ha of maize over the farmers' practice (Table 2). The economic analysis of these trials has shown the recommendation to give an acceptable marginal rate of return over the farmers' practice (at least 100%), except in 1984, when maize prices collapsed.

Table 1. Recommended practices for maize production in the study area

Practice	Recommendation
Variety	Improved variety. La Posta or Dobidi (full season); Aburotia (medium maturity).
Planting	In rows 90 cm apart;[a] 40 cm between hills in the row; 2 seeds/hill.
Fertilizer	2.5 bags of compound fertilizer (15:15:15) per hectare applied on the surface two weeks after planting; 2.5 bags of ammonium sulphate per hectare applied on the surface 5 to 6 weeks after planting. Equivalent to 45-19-19 kg $N:P_2O_5:K_2O$.[b]

[a] 75 cm for medium-maturity varieties
[b] This recommendation depends on soil fertility. Where soils are very low in fertility, twice these rates are recommended. If land is newly cleared, little or no fertilizer may be necessary.

Table 2. Results of verification-demonstrations in transition zone

Practice	Yield (kg/ha)				
	1981	1982	1983	1984	1985
Farmer practice	1780	1880	1580	1950	1680
Recommendation[a]	3150	3200	2500	3050	3450
Difference	1370	1320	920	1100	1770
Number of sites	21	71	77	93	69

[a] 2.5 bags/ha each of 15:15:15 and ammonium sulphate

Other research results allow an examination of the performance of the individual elements of the recommendation. A wide range of experiments has shown the improved varieties to be superior to local varieties under virtually all management conditions. Table 3 shows the results of a variety experiment planted in 1985 in which farmers were given two new varieties (Dobidi and Aburotia) and asked to plant and manage them in exactly the same way they managed their own variety.

Table 3. Results of farmer-managed variety experiment, transition zone, 12 sites, 1985

Variety	Maize yield (kg/ha)
Farmer's	2180
Aburotia	2460
Dobidi	2780

A number of improved maize varieties have been released in Ghana over the past two decades. Of the recommended varieties, La Posta has been available since the mid-1970s. Dobidi and Aburotia were released in 1985 and 1986 was the first year they were widely available to farmers.

Good evidence of fertilizer response over a wide range of maize management practices has also been obtained. A farmer-managed fertilizer experiment, for instance, showed that 5 bags/ha each of compound fertilizer and ammonium sulphate gave an average yield increase of more than 700 kg/ha of maize (Table 4). Although maize prices vary widely throughout the year, a comparison of maize field price at harvest time with the field price of nitrogen over the past several years shows that 3-5 kg of maize are necessary to purchase 1 kg of nitrogen and that, for most maize fields that are not planted on newly cleared land, the recommended application of fertilizer is economic. Although local maize varieties respond well to fertilizer, there is evidence that the improved varieties are more responsive.

Table 4. Results of farmer-managed fertilizer experiment, transition zone, 8 sites, 1985

Treatment	Maize yield (kg/ha)
No fertilizer	880
90-38-38 kg $N:P_2O_5:K_2O$	1610

Experimental evidence on plant density and spatial arrangement is a bit more problematic. Farmers used to plant their maize at random, rather than in rows, with relatively large distances between hills and a high number of seeds per hill. There are a number of reasons for this, including the low fertility of some fields, the necessity to plant quickly, and the expectation of high losses before stand establishment due to birds, rodents, and insects. Experimental work showed some advantage to improved spacing and a concomitant reduction in the number of seeds per hill. These changes in planting practices are more likely to give increases in yield in fields with adequate fertility.

2.
ADOPTION OF RECOMMENDATIONS

Adoption Rates

The survey showed quite high rates of adoption of the recommendations for variety, planting method, and fertilization, summarized in Table 5. Over 80% of the farmers have experience with each one of the recommended practices. In 1986, 81% of the farmers were using an improved variety on at least a part of their maize field, and 58% were using an improved variety on at least half of their largest maize field. More than two-thirds of the farmers used row planting on at least part of their maize field, and 57% followed this practice on their largest field. A little under half of the farmers used fertilizer on some of their maize, and 43% applied fertilizer to their largest maize field.

Table 5. Adoption of recommended practices[a]

Practice	Ever used (%)	Used in 1986 (%)	Used on largest maize field in 1986 (%)
Improved variety	88.6	81.0	58.2[b]
Row planting	82.3	68.4	57.0
Fertilizer	83.5	46.8[c]	42.9[c]

[a] N = 79
[b] Farmers who use an improved variety on at least half of their largest maize field
[c] N = 77

The maize cropping system had a strong influence on the adoption of these recommendations. Farmers were much more likely to follow the recommendations in monocropped maize fields than in intercropped fields (Table 6). The gap in the use of the recommended practices in mono- and intercropped fields is greatest for fertilizer and least for variety. Reasons for these differences will be discussed below. It should also be pointed out that, although adoption rates are above 60% for each

of the recommendations in monocropped fields, in only 36% of these fields were all three of the recommended practices followed.

Table 6. Adoption of recommendations by cropping system (farmers who followed recommendation on largest maize field, 1986)

Practice	Maize planted as monocrop (%)	Maize planted as intercrop (%)
Improved variety	70.4	32.0
Row planting	74.1	20.0
Fertilizer (N)	60.4 (54)[a]	4.2 (25)[b]

[a] N = 53 for fertilizer
[b] N = 24 for fertilizer

Summary indices of farmer practices are useful for measuring the degree of acceptance of recommendations, but a more in-depth examination of farmers' experience with each of the recommendations is necessary in order to understand the true impact of the extension effort, and to identify problems that require further attention. The rest of this chapter looks at each of the recommendations in more detail.

Variety

The improved varieties have been widely accepted. The survey results estimate that just about 50% of the maize area in the study villages is planted to improved maize varieties. The newly released varieties Dobidi and Aburotia are already found on many farmers' fields, although the bulk of the improved maize is still the variety La Posta, which has been available for more than a decade.

The object of demonstrating improved varieties to farmers was not only to introduce new materials, but also to encourage them to buy commercial seed. Seed of the open-pollinated maize varieties that are recommended can then be selected from the farmer's own harvest. If care is taken in seed selection, new seed needs to be purchased [illegible] once every three or four years.

Fifty-five (78.6%) of the 70 farmers who have used improved varieties have experience in buying seed from the MOA, the Ghana Seed Company, or the GLDB, and 51 of them (72.9%) purchased commercial seed the first time they used a new variety. Most of the rest obtained the seed for a new variety from another farmer, in some cases from the harvest of a verification-demonstration plot. The survey showed that farmers take considerable care in obtaining seed of local or improved varieties. In very few cases do farmers buy their seed in the market, where maize of various varieties may be mixed before sale (Table 7).

Table 7. Source of maize seed, all fields, 1986 (N=131)

Source	Percent
Own harvest	44.3
Commercial seed	34.4
Neighbor	19.1
Market	2.3
Total	100.1

Row Planting

The object of the recommendation for row planting was to improve the spatial arrangement and population of maize fields by establishing a higher number of hills but a lower number of seeds per hill. If maize is planted in rows it is also much easier to apply the correct amount of fertilizer. The recommendation calls for 90 cm between rows and 40 cm between hills, with 2 seeds per hill. The majority of the farmers are using an adequate spacing between rows, but the spacing between hills tends to be greater than the recommendation (Table 8).

There is good evidence that farmers who monocrop maize achieve better plant spacing and density when row planting than when random planting (Table 9). Row planters have a higher number of hills per hectare and a lower number of seeds per hill, and come much closer to the recommended practices, than do those who random plant.

Table 8. Planting distances used by famers row planting monocrop maize, 1986

Distance between rows (cm)	Number of farmers	Distance between hills (cm)	Number of farmers
0 - 79	4	0 - 29	0
80 - 100	33	30 - 50	18
101 +	3	51 +	22
Total farmers	40		40

Table 9. Planting practices of farmers with monocrop maize, 1986

Practice	Recommendation	Mean for farmers who row plant (N=40)	Mean for farmers who random plant (N=14)	Significance of difference by T-test
Hills/ha	27,777	24,717	17,525	< .05
Seeds/hill	2	2.62	3.50	< .001

When the recommendation was originally being promoted, farmers were taught to plant in lines using strings or ropes. More recently, the recommendation has been to use sighting poles, with the feeling that this is easier for farmers to manage and just as effective. Some farmers have taken up this new method, although the majority continue to use strings or ropes.

Fertilizer Use

The fertilizer recommendation asks farmers to first apply a top dressing of compound fertilizer followed by a side dressing of ammonium sulphate. Fertilizer supplies have been inadequate, and it has been difficult for some farmers to acquire fertilizer, especially ammonium sulphate. When farmers are able to obtain both fertilizers, most of them make two separate applications, although some farmers mix the two and apply them at the same time (Table 10).

Table 10. Fertilizer use on maize, 1986

Fertilizer used	Number of famers
Compound and ammonium sulphate	19
(Applied together)	(6)
(Applied separately)	(13)
Compound only	16
Ammonium sulphate only	1
Total	36

For both compound fertilizer and ammonium sulphate, farmers tend to apply the fertilizer later than is recommended (Table 11). The rate of application varies widely, as might be expected (Table 12). The amount of fertilizer applied will depend on the availability of fertilizer, the farmer's cash resources, and the fertility of the field. More compound fertilizer is used because it is much more easily available than ammonium sulphate.

Table 11. Timing of fertilizer application (most recent year)

Compound fertilizer		Ammonium sulphate	
Days after planting	Number of farmers	Days after planting	Number of farmers
0	2	29-35	6
1-7	0	36-42[a]	10
8-14[a]	13	43-49	2
15-21	12	50-56	8
22-28	24	57+	3
29+	11		

a = recommendation

Table 12. Rate of fertilizer application, most recent year

Bags/ha	Compound fertilizer (number of farmers)	Ammonium sulphate (number of farmers)
0.10 - 1.25	3	5
1.50 - 2.50	28	16
2.75 - 3.75	13	4
4.00 +	18	3

Finally, the current recommendation for fertilizer asks farmers to apply both fertilizers on the surface. Previous recommendations had asked farmers to bury the starter (compound) fertilizer at planting, but continuing analysis showed that in most cases the benefits of incorporating the fertilizer do not repay the costs. Nevertheless, the survey showed that a considerable number of farmers incorporate the fertilizer, particularly compound fertilizer.

The Adoption Sequence

It is obvious that the recommendations have found widespread acceptance with the farmers, and the survey data provide some evidence on the way that farmers have adopted these innovations. A number of studies have shown that farmers are generally cautious with recommendations, preferring to test them out a bit at a time. A good example of this is farmers' experience with the improved maize varieties. As farmers have gained more confidence with the new varieties, they have planted larger portions of their fields to them. For those farmers who first began using the improved maize varieties in 1982 or earlier, 76.2% plant at least half of their fields with the new varieties. For farmers who began using the new varieties more recently, the proportion who plant half of their fields with the new varieties is correspondingly lower (Table 13).

Table 13. Use of improved maize varieties

First year to use improved variety	Number of farmers	Farmers who plant at least half their maize to improved varieties (%)
1982 or earlier	21	76.2
1983	8	75.0
1984	13	69.2
1985	10	60.0
1986	18	44.4
Total	70	64.3

Although 53 of the farmers (67%) in the sample have used improved maize varieties, row planting, and fertilizer, they have not necessarily adopted all of these recommendations at the same time. Again, the evidence shows that farmers prefer a step-by-step approach to adoption. The data in Table 14 not only illustrate this characteristic of adoption behavior, but also provide examples of its logic. About half of the farmers began by adopting only one of the recommendations. The vast majority of them chose to adopt either fertilizer or an improved variety. There is good evidence that either one of these simple changes would provide a profitable return to the farmers, even if they did nothing else. This is less true for a simple switch to row planting, and only a few of the farmers began their adoption of recommendations in this way.

Of the farmers who adopted two of the recommendations in the same year, the majority began with a combination of row planting and fertilization, which would enable them to profit from the significant interaction of improved population with improved fertilization. A lower number of farmers began with a combination of the improved variety and fertilization, where an interaction might also be expected, and none of the farmers adopted as their first step a combination of improved variety and row planting, where an interaction is probably the least likely.

Table 14. Adoption sequence for farmers who have used all three recommendations

Recommendation adopted first	Number of farmers	Percent
Fertilizer only	13	24.5
Variety only	10	18.9
Row planting only	4	7.5
Row planting and fertilizer	9	17.0
Variety and fertilizer	4	7.5
Variety and row planting	0	0.0
Variety, row planting, and fertilizer	13	24.5
Total	53	99.9

Finally, the survey showed that 13 of the farmers adopted all three of the recommendations in the same year. It is significant that this represents only about one-fourth of the population that eventually adopted the entire package, and that the majority of farmers reached this point through a series of steps.

3.
EXPLAINING ADOPTION: EXTENSION AND THE FARMERS

Although the rates of adoption of the recommendations are quite high, there are still farmers who do not use one or more of the innovations. One way of explaining this uneven adoption pattern is to look at farmers' contact with extension; another way is to look at characteristics of the farmers themselves which may influence their receptiveness to the extension effort. Both of these factors will be examined in this chapter.

Extension

One of the original purposes of the survey had been to test the effectiveness of the verification-demonstrations by comparing the adoption behavior of those farmers who had attended this extension activity with those who had not. Lists were kept of the farmers who attended the demonstrations in 1985, and half of the sample was drawn from these lists. In addition, a number of farmers in the general population had attended verification-demonstrations in previous years. As can be seen in Table 15, there is not much difference in the practices of those who have attended these activities and those who have not. Perhaps the only exception is the higher proportion of farmers who have attended a demonstration and subsequently adopted row planting.

Table 15. Farmers' practices in 1986 and attendance at verification-demonstrations

		Farmers following recommended practices (%)		
Attendance	Number	Improved variety	Row planting[a]	Fertilizer[a]
Never	19	78.9	52.6	47.7
1985	41	85.4	51.2	31.7
1984 or earlier	14	78.6	85.7	50.0

Note: Those who attended a demonstration in 1986 not included in the analysis

[a] Practice on largest maize field

The lack of correlation between attendance at a verification-demonstration and adoption is not surprising. The verification-demonstrations are only one part of a range of extension activities carried out by the project and by other agencies. People attend demonstrations out of curiosity, interest, and at times to reinforce knowledge that they have already put into practice.

Farmers using the recommendations were asked how they first learned of them. Their answers (Table 16) show the importance of extension activities for spreading information about new practices. This is especially true for row planting, where either the verification-demonstration itself or other extension efforts provided information to more than three-fourths of the farmers who eventually adopted the practice. In the case of adopting improved varieties, information from other farmers was particularly important, as well as extension advice.

Table 16. How farmers first learned of new practice

Source of information	Improved variety (%)	Row planting (%)	Fertilizer[a] (%)
Extension activities	58.6	76.6	68.2
Other farmers	37.1	12.5	22.7
School	0.0	6.3	6.1
Not known or other	4.3	4.7	3.0
Total	100.0	100.0	100.0
(N)	(70)	(64)	(66)

[a] This table reports responses to a question about the type of fertilizer. Reponses for source of information on rates and methods of application are similar.

Extension thus seems to have played an important role in introducing new technology to maize growers in the research area. It should be emphasized that this includes the extension efforts of a number of people and projects that have operated in the area. Nevertheless, the most comprehensive maize extension work currently being done in the area is that of the Ghana Grains Development Project. This effort began in 1981 and began to expand rapidly by 1982 (Figure 2). It is significant that much of the adoption of the new technologies has come since 1983 (Figure 3). For

Figure 2 Verification/Demonstrations, Ghana Grains Development Project, Brong-Ahafo Region

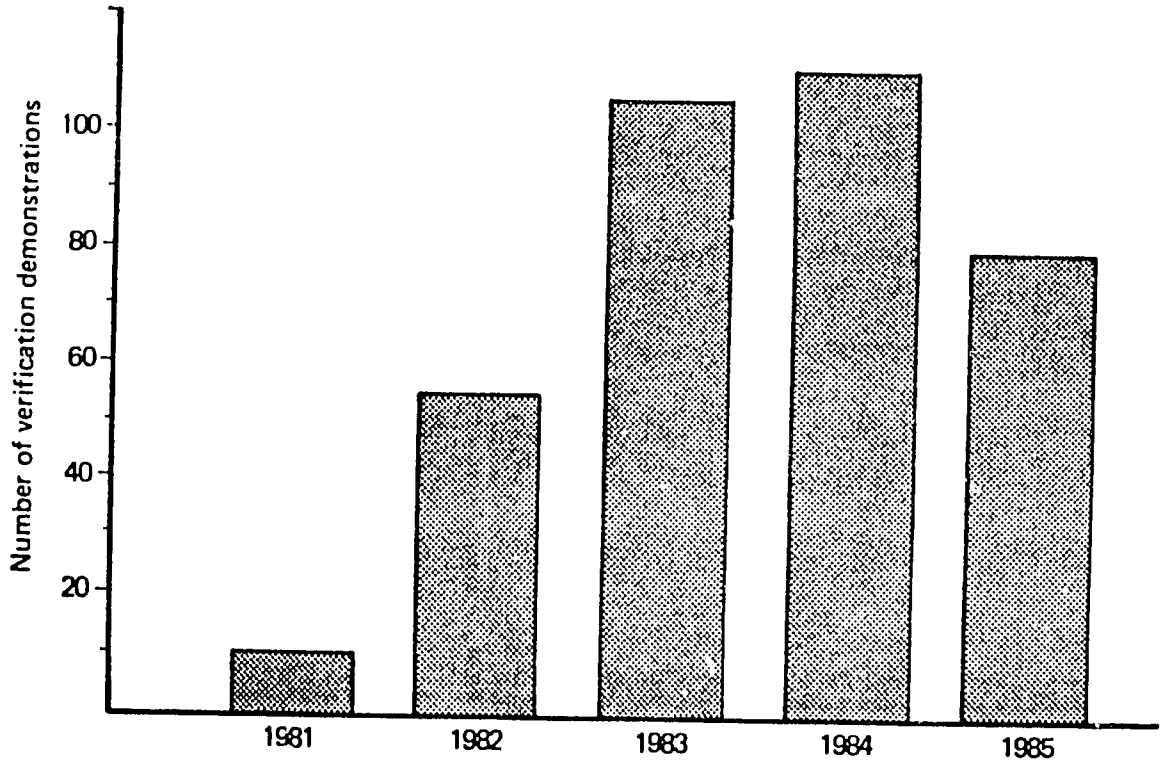
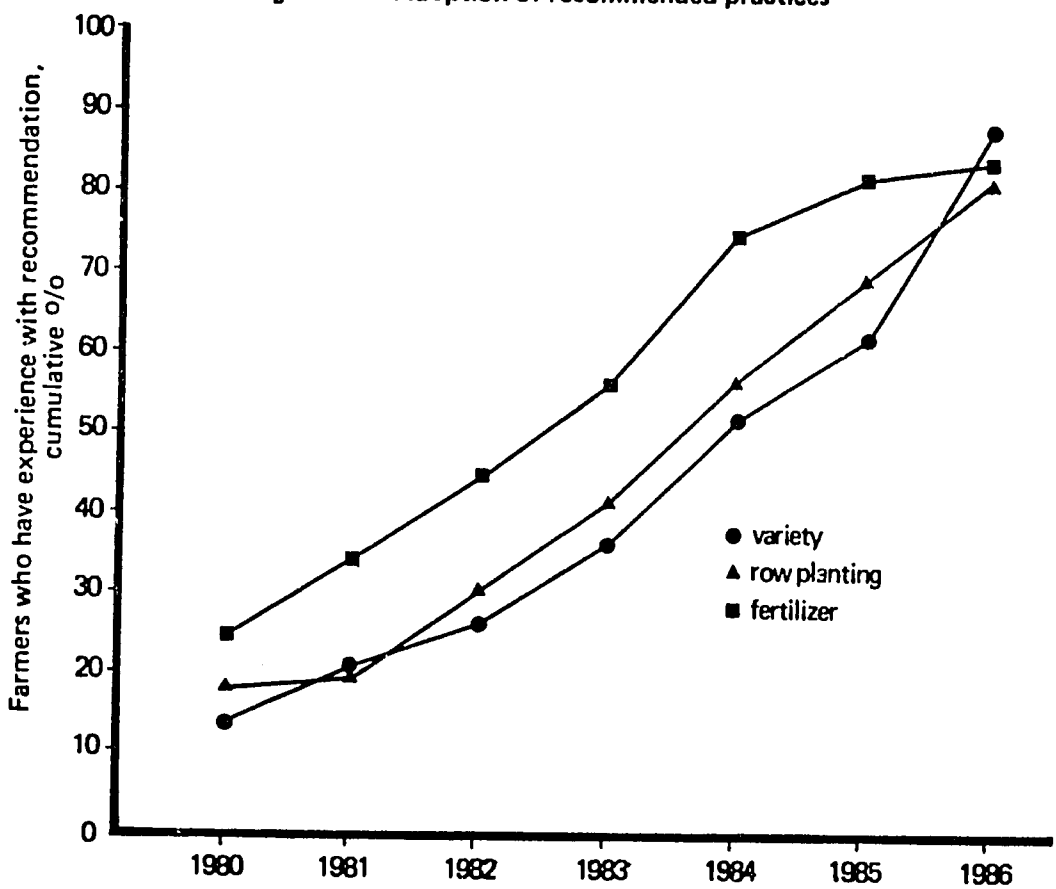


Figure 3 Adoption of recommended practices



improved varieties. 70% of those using them first planted the new variety in 1983 or later. Although the varieties Dobidi and Aburotia have just become available. 39% of the maize fields planted to an improved variety in 1986 featured one of these newly released varieties. Similarly. 63% of those using row planting began doing so in 1983 or later. Even for fertilizer use. which has been encouraged in the area for a considerable time. 46% of the adopters first used fertilizer in 1983 or later.

Characteristics of the Farmers

In certain cases. an extension effort may not reach all of the farmers in an area. Although women play an important part in agriculture. for example. extension sometimes is not directed towards them. In this study. however. the results indicate that women have adopted the recommendations on their maize fields to about the same extent as men (Table 17). Varietal use is about the same. and although a lower proportion of women grow monocrop maize. for those who do. their use of row planting and fertilizer is equivalent to that of the general population.

Table 17. Relationship of gender and education to adoption of recommendations

Group	Number	Planting improved varieties (%)	Number whose largest maize field is monocrop	Row planting, monocrop (%)	Using fertilizer, monocrop (%)
General population	79	58.2	54	74.1	59.3
Females	12	50.0	5	80.0	60.0
Two or fewer years of school	31	51.6	19	73.7	61.1

Education can also be a factor in determining the effectiveness of the extension message. but no effect of education was noted in this study. For those farmers with two years or less of schooling (Table 17). adoption rates were equivalent to those of the general population.

4.
EXPLAINING ADOPTION: FARMER CIRCUMSTANCES

Another way of looking at adoption patterns is to consider the relationship between a recommendation and farmer circumstances – the socioeconomic and natural features of the farm. Recommendations only stand a good chance of adoption if they are compatible with the resources and interests of the farm family and with the soils, climate, and biological conditions of the farm. This chapter examines some farmer circumstances that may affect the adoption of the recommendations.

Variety

Although the vast majority of the farmers are now using improved maize varieties to at least some extent, adoption is certainly not complete. One means of understanding this situation is to study farmers' opinions of the varieties. In the survey farmers were asked to compare their local maize varieties with the improved varieties (Table 18). Farmers rated the improved varieties as superior with respect to yield (with or without fertilizer) and resistance to lodging, which helps to explain

Table 18. Farmers' opinions on local and improved maize varieties

Characteristic	Number of farmers expressing opinion	Local is better (%)	Improved is better (%)	Same (%)
Yield without fertilizer	66	22.7	74.2	3.0
Yield with fertilizer	63	4.8	93.7	1.6
Lodging resistance	60	28.3	70.0	1.7
Germination	61	3.3	60.7	36.1
Storage quality	72	77.8	13.9	8.3
Cooking quality	55	72.7	23.6	3.6

their high acceptance. In addition, there were no complaints about the quality of the seed, as almost all farmers say that either the improved varieties germinate better than local varieties, or that the two are equal.

Opinions are reversed, however, when it comes to storage quality and cooking quality. The local maize is rated superior on both counts. Farmers complain that the improved maize is more easily infested with weevils (perhaps because it tends to have a poorer husk cover than the local maize.) Although farmers in this area do not depend to a great extent on maize as a staple food, concerns about cooking quality may be reflected in market prices. Private traders sometimes express a preference for local maize by buying it first, or paying a bit more for it. It is said that this preference is based on the superiority of the local maize, especially for making kenkey (steamed fermented corn dough), but this subject needs further investigation.

In any case, the agronomic qualities of the improved maize varieties would appear to outweigh any disadvantages in storage, cooking, or marketing for the majority of the farmers. Nevertheless, of nine farmers who provided information on why they have never planted or no longer plant the improved varieties, six mentioned marketing and/or storage problems.

It has also been pointed out that the improved varieties are less likely to be planted in intercropped fields (32.0%) than in monocropped fields (70.4%). The reason for this is not immediately clear, as the evidence indicates that the improved varieties are superior to the local varieties under any conditions. It may be that farmers prefer to use the improved varieties on their more important maize fields, but there is no indication that farmers see any necessary link between the improved varieties and the other recommended practices. In monocropped maize fields there is no obvious tendency for farmers to use the improved varieties more when they row plant than when they random plant, or when they use fertilizer (Table 19). The improved varieties are used under a wide variety of management practices.

Row Planting

There is a strong relationship between cropping system and row planting of maize. Only 20% of intercropped fields are row planted, while 72.2% of monocropped

Table 19. Use of improved varieties by management practice (monocropped maize)

Management practice	N	Percentage farmers using improved variety
No fertilizer, random planting	9	77.8
No fertilizer, row planting	12	58.3
Fertilizer, random planting	4	75.0
Fertilizer, row planting	28	71.4

fields are row planted. This is understandable if one considers the problems of row planting with several other crops, and the fact that intercropped fields tend to be planted on newly cleared land, where such obstacles as stumps make row planting more difficult. The characteristics of the field are also important in determining planting method for monocropped maize fields. The survey data indicate that older fields and those prepared by tractor are more likely to be row planted. Both of these factors are indicative of fields that have fewer obstacles.

Planting in rows does take more time than random planting, if only because more holes per hectare are made, but farmers seem to manage this method with little difficulty after some practice. The survey found no relationship between the type of labor (family or hired) used for planting and row planting. In addition, farmers who say they have difficulty finding labor at planting time are just as likely to row plant as those who say they have no difficulty.

Farmers can efficiently manage row planting once they have some experience with it. Half the farmers who have never row planted say that it takes too much time, but only 21.1% of the farmers who had row planted before, but were not doing so in 1986, gave time requirements as the reason for not row planting (Table 20). Nevertheless, one factor that may indicate the importance of the time element in row planting is the fact that, for monocropped maize, row-planted fields tend to be smaller than random-planted fields. The mean size of row-planted monocropped maize fields is 1.52 ha, while the mean for random-planted fields is 2.32 ha.

Table 20. Opinions on row planting

Opinion	Farmers who have never row planted (%)	Farmers who have previously row planted, but not in 1986 (%)
Takes too much time	50.0	21.1
Difficult with stumps in field	14.3	42.1
Other reasons or no opinion	35.7	36.8
Total	100.0	100.0
(N)	(14)	(19)

Fertilizer

Hardly any intercropped maize receives fertilizer, and it is not known if the response of the intercrop to fertilizer would be profitable for farmers. One important factor that complicates the comparison of farmers' fertilizer use on inter- and monocropped fields is the fact that intercropped fields tend to have been worked for less time and are thus more fertile. Sixty-four percent of intercropped fields were not planted the previous year, and only 16% had been cropped for two or more years. Only 15% of monocropped fields, on the other hand, were not planted the previous year, and 77% had been cropped for two or more years. Cropping history makes a big difference in a farmer's decision to use fertilizer: a farmer is much more likely to use fertilizer on an older field than on one that has been newly cleared (Table 21).

Table 21. Fertilizer use by cropping history of field

Years continuously cropped	Number of fields	Fertilizer applied (%)
0	26	11.5
1-2	17	23.5
3-5	18	55.6
6+	15	86.7

Planting method also seems to be related to fertilizer use. For both new and old fields, row planting is more likely to be associated with fertilizer use (Table 22). One explanation for this might be the relative ease of fertilizer application when maize is planted in rows. Another explanation might be farmers' perceptions of increased fertilizer efficiency with adequate plant populations.

Table 22. Fertilizer use by planting method (monocropped maize)

	Random planted	Row planted
Fertilizer	3 (25.0%)	26 (68.4%)
No fertilizer	9 (75.0%)	12 (31.6%)
Total	12 (100.0%)	38 (100.0%)

d.f. = 1 χ^2 = 7.05 $p < .01$

In general, it would seem that the farmers in the study are familiar with fertilizer and understand its use. The study indicated, for instance, that the majority of farmers who have never used fertilizer on maize have used it on other crops, so lack of knowledge does not seem to be a problem. When asked why they did not use fertilizer in 1986, farmers replied that their fields were fertile, that they tried to obtain fertilizer but were unable to, or that they had no cash (Table 23).

Table 23. Reasons for not using fertilizer on maize, 1986 (N=42)

Reason	Percentage farmers
Land is fertile	33.3
Tried to buy fertilizer, but could not obtain it	23.8
No cash	21.4
Other or no response	21.4
Total	99.9

5.
CONCLUSIONS

This study has examined the adoption of recommended practices for maize variety, row planting, and fertilization among farmers in an area of Ghana's Brong-Ahafo Region. The results are encouraging. Farmers are taking up these recommendations in ever increasing numbers. This report has tried to look at adoption in several different ways, because a single index of adoption can be quite misleading. Almost all of the farmers in the study have used at least one of the recommendations, for instance, and the vast majority continue to follow at least part of the recommended practices; but only a minority of the farmers are using all of the recommended practices on all of their fields, and almost none follow the recommendations perfectly (e.g. timing of fertilizer application or planting distance). So depending on one's criteria, adoption rates from close to zero to nearly 100% could be defended.

This report has emphasized the dynamics and the rationale of the adoption process because the authors feel that this is more important for assessing progress and identifying future needs. The indications are that the research and extension efforts of the Ghana Grains Development Project are paying off. Useful recommendations for increasing maize productivity have been developed and are being adopted by a large number of farmers. Evidence shows a steady increase in adoption, particularly over the past several years. It is worth pointing out that these changes in farming practices have taken place among farmers who with rare exceptions have no access to institutional credit, and in an economic environment that has been particularly uncertain with respect to prices and input supplies. As the situation improves, it is reasonable to expect even greater use of the recommendations.

The logic of the adoption process is also evident from the results of the survey. Farmers show an ability to test recommendations on their own and adapt them to their particular circumstances. At first they grow new varieties on a small portion of their fields, and often use only parts of a package of recommended practices. The recommendations that are utilized are those that are compatible with the farmer's resources, marketing practices, and agronomic conditions.

One of the most striking results of the study is the differential adoption of the recommendations on monocropped and intercropped maize. The use of row planting and fertilizer, in particular, appears to be much less common on intercropped fields. In Ghana's transition zone, which is the country's single most important maize production area, most maize fields are monocropped. It is reasonable to believe that the high rates of adoption found in this study will be found in many other areas of the transition zone. Closer to the forest, however, intercropping becomes much more prevalent, and the adoption of the recommended practices examined in this study will almost certainly be lower. Intercropping maize with other important food crops is a rational adaptation to the forest environment. Now that there has been significant progress in developing recommendations appropriate for monocropped maize, more attention may be turned to research on the management of the various intercropping systems prevalent in many parts of Ghana.

The recommended practices described in this study are themselves candidates for further work and refinement. Breeding efforts continue to develop superior maize varieties, suited to various environments. The importance of cooking qualities, storage, and marketability have been recognized as important criteria for screening new varieties. Planting methods may be further refined, not only for intercropping situations, but to help farmers achieve good stand establishment by protecting the seed from the various pests that threaten adequate plant populations. Fertility management will also continue to receive attention, in attempts to make more precise recommendations to farmers for their varying conditions.

Many other research objectives are being pursued as well, and it is likely that they will lead eventually to further recommendations for helping improve maize production. All the increases in maize production already accomplished because of the adoption of the current recommendations are an important consequence of the Ghana Grains Development Project work. But at least equally important has been the demonstration of a research methodology that takes account of farmers' interests and conditions, and an extension strategy that allows recommendations to be tested, debated, and assessed by farmers and extension agents. Support for this active partnership between farmers, extension workers and researchers will contribute a great deal to Ghana's future agricultural development.