ECONOMIC ANALYSIS OF 1989/90 MOA/FAO FERTILIZER DEMONSTRATIONS

Introduction

During the 1989/90 season, the MOA/FAO fertilizer programme implemented 56 demonstration sites spread throughout all five Rural Development Projects (RDPs) of Lilongwe Agricultural Development Division. Each site featured the following practices on a 40m x 20m plot:

	practices	variety	fertilizer
Plot 1:	farmer practice	farmer seed	farmer's fertilizer practice
Plot 2:	farmer practice	farmer seed	40 N 10 P (recommended practice, local maize)
Plot 3:	improved practice (mainly insistence on recommended density, weeding)	hybrid maize	no fertilizer
Plot 4:	improved practice	hybrid maize	90 N 40 P (recommended practice, hybrid maize)

Agronomic analysis and economic analysis using value-cost ratios were performed for each of 47 sites that were harvested.

A more detailed agronomic analysis was performed on 21 of the sites. The 26 omitted sites were left out for the following reasons. On 13 of these omitted sites some treatments had to be replanted (mainly because of poor germination of the hybrid seed ?? check this). On 11 of the sites that were left out the farmer practice/farmer variety included hybrid maize, use of fertilizer, or both. On two of the sites that were left, farmer practice included local maize and no fertilizer, but the hybrid was MH 12. Of the 21 sites included in the analysis, in 12 the hybrid was NSCM 41 and in 9 the hybrid was MH 16. These sites were kept for analysis because they could most clearly indicate effects caused by use of fertilizer and those caused by use of particular hybrid varieties. One implicit assumption in the analysis that follows is that differences in spacing, weeding, etc. do not contribute significantly to effects perceived as caused by fertilization or variety. Another assumption is that the sites included are representative of a single recommendation domain, in other words that both natural and economic conditions over the included farms are sufficiently similar that a combined analysis can be justified.

Grain Yields

Mean grain yields per treatment are shown in Table 1. Analysis of variance showed highly significant effects caused by treatment. Since fertilization levels were different on local and hybrid maize, it was not possible to differentiate precisely the effects of fertilizer from those of variety or to ascertain their interaction, but comparison of treatment means showed that both fertilizer and variety make important contributions to yield differences. In addition, yield distributions for each of the four treatments given each variety (NSCM 41 and MH 16) were plotted and visually compared (Figs 1 and 2). These confirmed the results of the ANOVA analysis of means. Yields for hybrid maize with fertilizer were considerably higher than for any of the other three treatments, and yields for local maize <u>without</u> fertilizer were somewhat lower than for any of the other treatments. Though for both NSCM 41 and MH 16 mean yields for fertilized local were approximately 250 kg/ha above those for unfertilized hybrid, the distributions of yields for these two technological options were roughly similar.

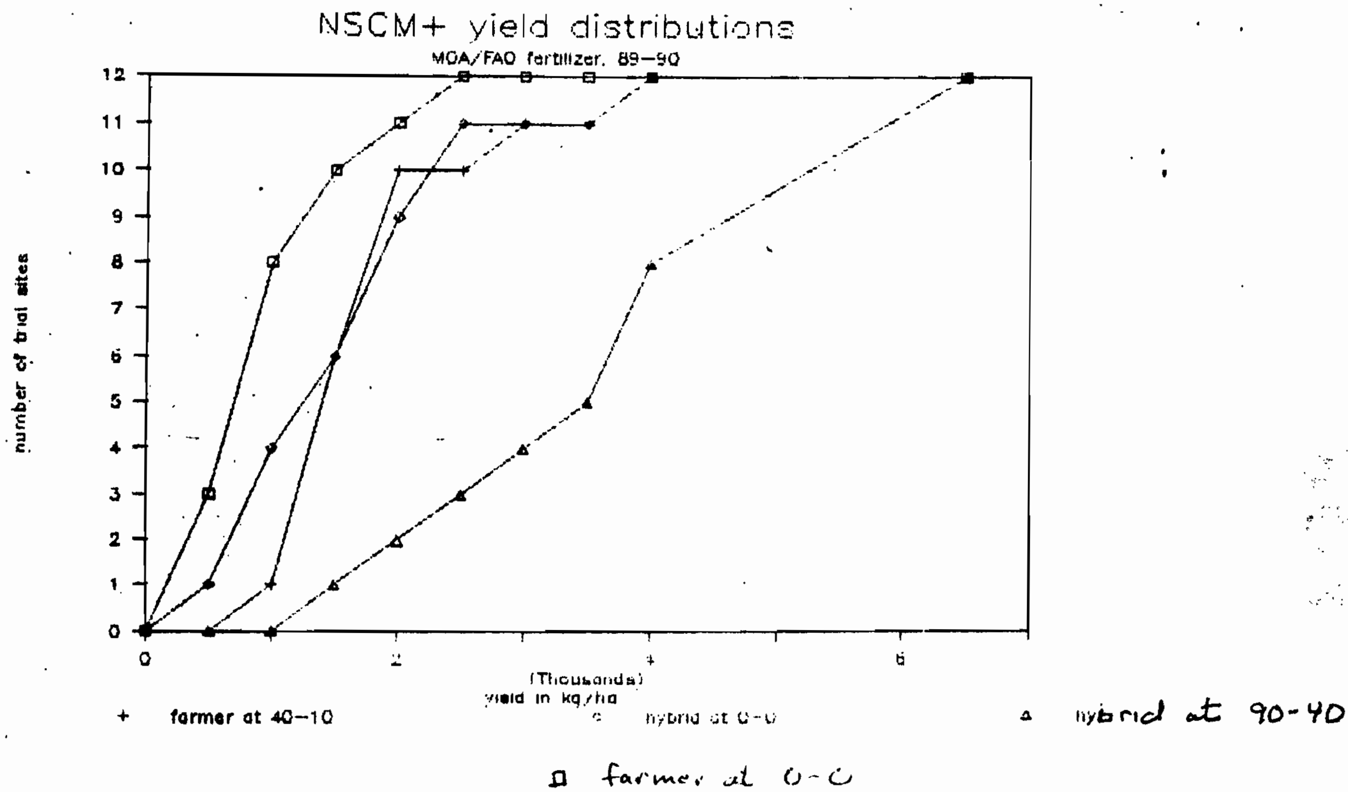
Table 1
Grain Yields in Kg/Ha

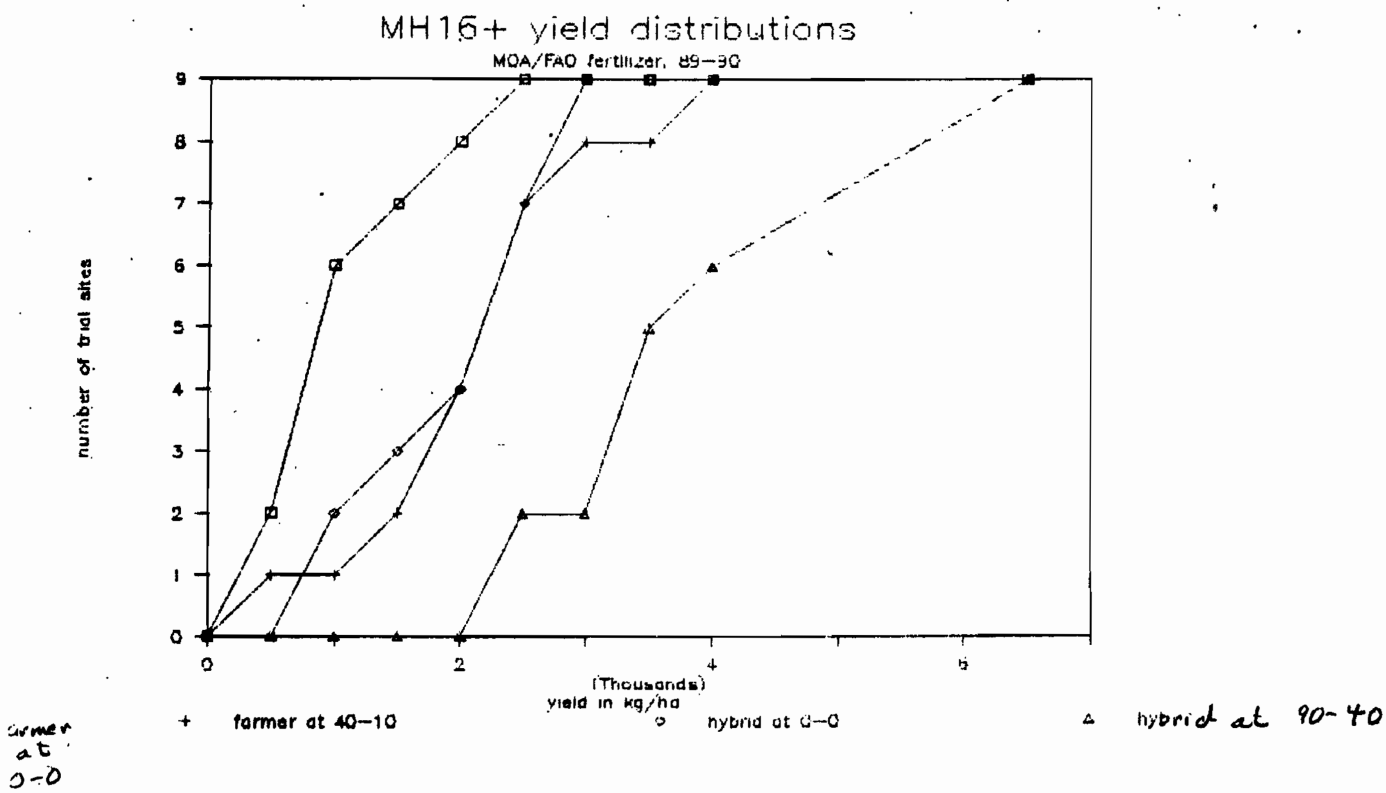
	Hybrid Variety used in treatments 3 and 4	
	NSCM 41	MH 16
Treatment		
1	868	1077
2	1703	2023
3	1456	1758
4	3649	3901

Economic Analysis

Economic analysis was then performed on the data, since yield alone is not the only criterion in farmer decision making. Two types of analysis were done. First, the mean yields shown above were used, along with a number of different assumptions about prices and costs, for partial budget analysis. The results for the trials using NSCM 41 were almost identical to the results for MH 16, so only the former will be presented here.

Second, yields from individual farmer trial sites were used to construct <u>distributions</u> of net returns. These distributions were also developed using different price and cost assumptions. As the partial budget analysis based on the means showed little


NSCM+ yield distributions
MOA/FAO fertilizer. 89-90
number of trial sites
0
1
2
3
4
5
6
7
8
9
10
11
12
0
2
4
6
(Thousands)
yield in kg/ha
+ farmer at 40-10
◇ hybrid at 0-0
△ hybrid at 90-40
□ farmer at 0-0


MH16+ yield distributions
MOA/FAO fertilizer, 89–90
number of trial sites
(Thousands)
yield in kg/ha
farmer at 40–10
hybrid at 0–0
hybrid at 90-40
armer at 0-0

difference between the sites with NSCM 41 and those with MH 16, this was done only for NSCM 41 sites, since this analysis was somewhat more time consuming. The returns distributions were inspected visually, and simple first and second order stochastic dominance comparisons were made, pairwise, for each of the four treatments. In other words, for each set of assumptions, the distribution of returns for treatment 1 was compared to the distribution of returns for treatment 2, that for treatment 3, and that for treatment 4; and so on until all comparisons using two treatments were made. Treatments that were dominated in a first or second order sense by any other treatment were eliminated from further consideration. This is because if distribution *x* dominates distribution *y* in a first order sense, all decision makers prefer *x* to *y*; if distribution *x* dominates distribution *y* in a second order sense, all risk averse decision makers prefer *x* to *y*. In most cases this reduced the number of treatments to be considered, but usually more than one treatment remained. Without further knowledge of or assumptions regarding the risk preferences of the farmer, we cannot say with certainty which of the remaining treatments would be preferred.

Analysis is crude and preliminary. In particular, data from 1990/91 trials should be helpful in casting further light on some outstanding issues. Nonetheless, it is interesting to see how the clear-cut yield advantages of fertilized hybrid maize do not always translate into clear-cut economic advantage, depending on the assumptions made.

Assumptions

Many different assumptions regarding prices and costs can be made. The assumptions used in the analysis are spelled out below; in the actual analysis, the combinations of assumptions thought to be most realistic will be identified.

Yield Adjustments

Since the trials were conducted on farmers' fields with an attempt to duplicate actual farmer conditions, reported yields were only adjusted downwards by 5 percent to account for possible differences between trial yields and yields under farmer conditions, before the economic analysis began.

Output Valuation

One common argument for the relatively slow uptake of hybrid maize in Malawi relative to that in Zimbabwe or Kenya is that the dent hybrids, because of their inferior storage and processing characteristics under current farmer conditions, are not as superior to local flint maize as yield figures alone would indicate. If this is true, farmers implicitly value harder endosperm maize higher than maize with softer endosperm.

In the economic analysis, two different ways of capturing the possible difference in value were employed. First, the common assumption was employed that for food deficit households, local maize for consumption might be valued at the price at which the household would buy, not sell maize. Alternatively, yields for treatments 3 and 4, for hybrid maize, were adjusted downward to represent processing losses. In certain cases, as will be seen below, both assumptions (price differentials plus downward yield adjustments for hybrid maize) were made. This would result in the greatest discrimination against hybrid maize and in favor of local maize.

In the first instance of differential valuation, three different types of household were envisioned. Household Type 1 is a food deficit household for which, at the margin, local maize is valued at the buying, or consumption, price, and hybrid maize is valued at the selling price. Household Type 2 is a food deficit household that does not consider hybrid and local maize any different; in other words at the margin both grain types are valued at the buying price. Household Type 3 is a food surplus household that again, at the margin, does not consider hybrid and local maize any different; in other words both hybrid and local are valued at the <u>selling</u> price.

In the analysis, for household Type 1, local maize is priced at the 1989/90 ADMARC buying price of MK 0.32/kg <u>plus</u> MK 0.02/kg transport cost (because the true value of purchased maize at the farm includes transport from purchase point) <u>minus</u> MK 0.02/kg harvesting cost, for a net of MK 0.32/kg. Hybrid maize is priced at the 1989/90 ADMARC <u>selling</u> price of MK 0.26/kg <u>minus</u> MK 0.02/kg transport cost (because the farmer is assumed to bear the cost of transporting maize from the farm to the selling point) <u>minus</u> MK 0.02/kg harvesting cost, for a net of MK 0.22/kg.

For household Type 2, both hybrid and local maize are priced at MK 0.32/kg; and for household Type 3, both are priced at MK 0.22/kg. A summary of these pricing assumptions is shown in Table 2.

Table 2
Output Price Assumptions for Economic Analysis
(Price in MK/kg)

	local maize	hybrid maize
Household Type 1	0.32	0.22
Household Type 2	0.32	0.32
Household Type 3	0.22	0.22

The second method of capturing the difference in valuation is to assume that the "true yield" of hybrid maize, when converted to flour, is less than the "true yield" of local maize converted to flour because of storage and processing losses. Under this set of assumptions, trial yields of hybrid were reduced by a further 25 percent to represent processing losses, and the price of hybrid was reduced by MK 0.01/kg to reflect the cost of actellic dust to counter storage losses.

Input Costs

Costs that varied by treatment included fertilizer, seed, and labor. Hybrid seed was valued at the 1989/90 ADMARC price of MK 1.40/kg for NSCM 41, plus an additional MK 0.02/kg for transportation, giving a total of MK 1.42/kg. The effects of the current subsidy on hybrid seed were not considered. Local seed was valued at the grain price.

Fertilizer was assumed to come from DAP and urea. Under the first assumption, prices used were the 1989/90 ADMARC prices, with an additional MK 1.00/50 kg bag added for transportation costs. This would imply field prices of roughly MK 1.65/kg N and MK 1.20/kg P_2O_5. The second assumption was added to the analysis so the effects of the current subsidies on DAP and urea could be examined. Without subsidy, the field price of N would be roughly MK 2.19/kg and the field price of P_2O_5 would be roughly MK 1.59/kg. It should be remembered, however, that the subsidy roughly offsets the extra transportation charges caused by war in Mozambique, and should Malawi's optimum external transportation routes be restored and fully utilized, future unsubsidized fertilizer prices might be quite close to current subsidized prices.

Finally, labor for fertilizer application was costed at MK 7.00/ha for both the 40-10 and 90-40 treatments.

Cost of Operating Capital

The farmer was assumed to require a minimum marginal rate of return (minimum acceptable MRR) on operating capital of 100 percent. In other words, at the margin, each MK 1.00 spent on the next more expensive treatment had to return that MK 1.00 plus an additional MK 1.00 in order for the more expensive treatment to be considered. It is sometimes argued that the minimum acceptable MRR in Malawi is 25 percent. This is well below CIMMYT's rules of thumb, in cases where MRR's are difficult to calculate, of 50 percent for technologies that are not too dissimilar to current technology, and 100 percent for technologies that require larger changes in farmer practice. Yet the same analysts often claim that small farmers in Malawi do not adopt new technologies because they are "too expensive," which does not support the assumption of a low minimum acceptable MRR. In the following analysis, a relatively high minimum acceptable

MRR was chosen to reflect the acute scarcity of operating capital that many small farmers in Malawi face.

To make the analysis of distributions comparable to the analysis of mean returns through partial budget analysis, capital costs were subtracted from net returns for each treatment before returns distributions were compared. In other words, total costs that vary were subtracted a <u>second</u> time from net returns before distributions were compared. (If the minimum acceptable MRR had been assumed to be 50 percent, <u>half</u> of total costs that vary would have been subtracted from net returns before distributions of net returns were compared.)

Results

In total, the analysis could be carried out under 12 different scenarios, or combinations of assumptions since 3 x 2 x 2 = 12. This is because there were three different assumptions about marginal valuation of local and hybrid maize; two different assumptions about whether additional deductions should be made from hybrid returns because of processing and storage losses; and two different assumptions about fertilizer prices. Some of these scenarios might be more plausible than others, as will be argued below, but results for all scenarios are described in Table 3. For each scenario, the treatment picked as best by the partial

Table 3
Partial Budget and Distributional Analysis of Net Returns

HOUSEHOLD 1

	no deductions for processing/storage	further deductions from hybrid returns for processing/storage
fert. subsd.	mean analysis local maize with fertilizer stochastic dominance analysis only fertilized local & fertilized hybrid fertilized hybrid brings best returns but considerably more downside risk	mean analysis local maize with fertilizer stochastic dominance analysis only fertilized local
fert. unsbsd.	mean analysis local maize with fertilizer stochastic dominance analysis only fertilized local & unfertilized local very little to choose between the two	mean analysis local maize with fertilizer stochastic dominance analysis only fertilized local & unfertilized fert. local looks only slightly better

HOUSEHOLD 2

	no deductions for processing/storage	further deductions from hybrid returns for processing/storage
fert. subsd.	mean analysis hybrid maize with fertilizer stochastic dominance analysis only fertilized hybrid, unfertilized hybrid, & fertilized local fertilized hybrid gives very high returns, but slight downside risk.	mean analysis local maize with fertilizer stochastic dominance analysis only fertilized local & fertilized hybrid fertilized hybrid brings higher returns but considerably more downside risk.
fert. unsbsd.	mean analysis hybrid maize with fertilizer stochastic dominance analysis only fertilized hybrid unfertilized hybrid, & unfertilized local fertilized hybrid gives very high returns, but some downside risk.	mean analysis local maize with fertilizer stochastic dominance analysis only unfertilized hybrid, fertilized local & unfertilized local, no clear pattern

HOUSEHOLD 3

	no deductions for processing/storage	further deductions from hybrid returns for processing/storage
fert. subsd.	mean analysis hybrid maize with fertilizer stochastic dominance analysis only fertilized hybrid, unfertilized hybrid, and unfertilized local. fertilized hybrid very high return, but considerable downside risk	mean analysis local maize with fertilizer stochastic dominance analysis only unfertilized local
fert. unsbsd.	mean analysis hybrid maize without fertilizer stochastic dominance analysis only unfertilized hybrid and unfertilized local unfertilized hybrid generally better but slightly more downside risk	mean analysis local maize without fertilizer stochastic dominance analysis only unfertilized local

budget analysis is listed under the heading "mean analysis." The treatments that are not eliminated by pairwise first and second order stochastic dominance criteria are listed under the heading "stochastic dominance analysis." In addition, some further brief interpretative comments based on visual inspection of the distribution of returns are listed there.

Food Deficit Households--Current

It will be argued here that food deficit households do currently value dent hybrids differently than they do flint locals. The most realistic combinations of assumptions may be either those listed in Table 3 under household 1, no deductions for processing/storage, fertilizer subsidized; or household 2, deductions for processing/storage, fertilizer subsidized. In the first case prices are different for local and hybrid; in the second case yield deductions are made from hybrid maize to reflect processing and storage losses. In both cases partial budget analysis, based on mean yields, suggests of the four treatments, local maize with fertilizer will be preferred.

Risk analysis eliminates both unfertilized local and unfertilized hybrid treatments from consideration, as both are dominated by fertilized local. When the two remaining treatments, fertilized hybrid and fertilized local, are compared, there is a greater chance of getting both the highest and the lowest returns with hybrid; another way of saying this would be to indicate that though hybrid can bring relatively high returns to the food deficit household, there is significant *downside risk* in using hybrid.

Another question could be asked would be "Would the food deficit household that cannot afford <u>any</u> fertilizer prefer to grow local or hybrid?" This comparison could be made by considering only the <u>unfertilized</u> treatments. Here the two sets of assumptions (household 1, no deductions, or household 2 with deductions) lead to different results. With the pricing assumptions used for household 1 and no yield reduction assumptions, partial budget analysis predicts this household would prefer unfertilized local to unfertilized hybrid; and the distribution of returns for unfertilized local dominates the distribution for unfertilized hybrid in the second order sense. With yield reduction assumptions and the pricing assumptions used for household 2, partial budget analysis predicts the household would prefer unfertilized hybrid to unfertilized local. The distribution of returns is slightly better for unfertilized hybrid over much of the range, but there is also slightly more downside risk with unfertilized hybrid. Under both sets of assumptions the distributions for unfertilized hybrid returns and unfertilized local returns are fairly close.

All of these assumptions predict what farmers might choose to do <u>at the margin</u>, in other words what they would do if they could add a little more land in a given technology. Given the complications of household decision making in rural Malawi, some households may choose to grow both local and hybrid maize. In this case one might ask the question "Should the maize be fertilized at the recommended rate?" This question might be answered by comparing the returns for the fertilized local treatment to the unfertilized local treatment, and by comparing the returns for the fertilized hybrid treatment to the unfertilized hybrid treatment.

For both sets of assumptions we have been considering here to represent the food deficit household most accurately, analysis based on means indicates that for both local and hybrid, fertilization at the recommended rate is superior to not fertilizing. For local, risk analysis still unequivocally supports the recommendation of fertilization. For hybrid, fertilization at the recommended rate does in general bring much higher returns than not fertilizing, but there is greater downside risk with fertilization. In other words based on these trial results, food deficit households who choose to grow local should certainly fertilize it if they can afford to; food deficit households who choose to grow hybrid should also fertilize it, but they should be aware that they do face a significant risk of lower than average, even negative returns.

Finally, one might consider a different kind of food deficit household, one that discriminates against dent hybrid both through the pricing assumption and the yield reduction assumption. As expected, this household would hardly consider growing hybrid maize. It would, however, probably choose to apply fertilizer to its local maize at the recommended rate if it could afford it. If for some reason it did choose to grow hybrid despite its apparent disadvantages, however, it would probably choose <u>not</u> to fertilize it, as the combination of high costs of inputs and implicitly low value of output would make fertilization unattractive.

Food Surplus Households--Current

Food surplus households that sell maize might be characterized by two different sets of assumptions. If at the margin all surplus maize is sold to ADMARC at the ADMARC price, the food surplus household is probably best described as household 3 (same price, the selling price, for both local and hybrid maize) with no deductions made for storage or processing losses. If a food surplus household sells surplus hybrid maize to ADMARC, but can receive a higher price for local maize, it might possibly be described as household 1, with no deductions for storage or processing.

Under the first set of assumptions the food surplus household would choose, at the margin, to grow fertilized hybrid maize based on mean analysis. Risk analysis as defined above only eliminates fertilized local maize from consideration. Of the three remaining returns distributions, fertilized hybrid does in general give much higher returns, but there is considerable downside risk with fertilized hybrid as well. Under the realistic assumption that even the food surplus household would choose to grow local maize, both mean and distributional analysis indicate the somewhat surprising result that at the margin, it would be preferable not to fertilize this local maize. This is because additional local maize would be offered for sale at the relatively low ADMARC price. The additional yield from fertilizing local maize would not, in this instance, be sufficient to cover the cost of the fertilizer.

Under the second set of assumptions, that is that the surplus household could sell local maize at a higher price, the results of the analysis become identical to those in one of the food deficit cases considered in the previous section and rather different from those just listed. At the margin, the household would prefer growing local maize with fertilizer by analysis based on mean yields. When the distribution is considered, it indicates that fertilized hybrid does bring higher returns but that it also brings returns that are considerably lower than those from fertilized local.

The fact that it is difficult to observe surplus producers offering a great deal of local maize on the market, while they do offer hybrid maize, even though it appears local maize is more highly valued, indicates that neither set of assumptions above may adequately capture the market and institutional setting facing the surplus producer. If we do use the data to ask the relatively simple question of whether the surplus producer who is growing hybrid should fertilize it, the answer under both set of assumptions is "yes," although fertilizing hybrid as usual creates considerably greater risk at the low end of the distribution.

<u>Effects of the Fertilizer Subsidy Under Current Assumptions</u>

Nutrient-grain price ratios in Malawi are relatively high, even by African standards. The importation of high analysis fertilizers and the subsidies still applied to these high analysis fertilizers has reduced the impact somewhat at the farm level. Without going into the macroeconomic pros and cons of fertilizer subsidies, we will consider here briefly the farm level impact of removing the subsidy from high analysis fertilizers. The assumptions regarding the differences between flint locals and dent hybrids made in the previous sections still hold.

The food deficit households of the types just considered would probably still prefer to grow fertilized local maize, although the advantage over unfertilized local becomes less than in the case of the subsidy. Fertilized hybrid maize becomes the least likely option to the food deficit households under these assumptions.

The food surplus household that sold both local and hybrid maize at prices close to the ADMARC price (after adjustments for harvesting and storage, as we have always maintained here) would now probably prefer at the margin to grow hybrid maize without fertilizer. If this household continued, as is likely, to grow local maize, it would also choose not to fertilize it.

If, alternatively, the food surplus household could sell additional local maize at a higher price it might choose to fertilize local maize.

In other words, for many different kinds of households a removal of the fertilizer subsidy would make it less likely that they use fertilizer, as expected, although they might still fertilize local maize depending on how highly they valued it. The use of hybrid maize would also in all likelihood be reduced.

Food Deficit Households--No Difference Between Hybrid and Local

Now we shall assume that new hybrids become available that are comparable in their storage and processing characteristics to farmers' current varieties, and that farmers no longer differentiate between local and hybrid in terms of value. In this case the food deficit household would be most likely to be represented by Household 2 (same high price for hybrid or local), no reductions for processing or storage, and with fertilizer subsidies. In this case mean analysis predicts the household would choose hybrid maize with fertilizer. Distribution analysis eliminates unfertilized local. Fertilized hybrid does in general give very high returns, although there is slightly more downside risk involved in the use of fertilized hybrid.

Food Surplus Households--No Difference Between Hybrid and Local

If consumers and the market no longer make any implicit or explicit differentiation between local and hybrid maize, the situation of the surplus producer would be like the first kind of surplus producer considered above. This farmer would face a lower price at the margin for any kind of maize than would the deficit producer. He would choose fertilized hybrid maize based on analysis of the means; distribution analysis eliminates only unfertilized local in this case. Fertilized hybrid would carry with it considerable downside risk, however, more so at the margin than for the deficit producer because of the lower value of the output.

Removal of Fertilizer Subsidies--No Difference Between Hybrid and Local

If subsidies were removed in a situation where there were no differences perceived between hybrid and local maize, the deficit producer might continue to fertilize, because of the higher value of maize to such a producer. The surplus producer, again, somewhat ironically, might not. However in this case both types of producer would continue to prefer hybrid maize. The effects of the subsidy removal would be more likely only to affect use of fertilizer, and not to affect use of hybrid maize, if there were no perceived differences in processing and storage between the two.

Conclusions

The economic analysis indicates that despite the clear yield advantages from planting hybrid, and the clear yield advantages from using fertilizer, what farmers actually might prefer to do rests on a number of assumptions. Clearly the currently accepted preference for local maize, probably due to processing and storage considerations, can quite justifiably make farmers reluctant to use the recommended seed-fertilizer technology. This reemphasizes the importance of developing high yielding varieties that are acceptable to farmers for home storage and consumption.

This varietal preference also affects the fertilization decision, under current conditions. In particular, food deficit households who can afford the fertilizer are likely in many cases