Proceedings of the 4th Biennial Conference
of the
African Farm Management Association

Farm and Farmer Organisation for Sustainable Agriculture in Africa

Edited by
Johann Laubscher

26 - 30 January 1998
University of Stellenbosch, South Africa

DEVELOPING TECHNOLOGY FOR AGRICULTURE IN SUB-SAHARAN AFRICA: EVOLUTION OF IDEAS AND SOME CRITICAL QUESTIONS

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ABSTRACT

In evaluating technology development in Sub-Saharan Africa, the constraint of seasonal-labour availability has frequently been emphasised. However, the most pressing constraint for most regions is the availability of quality land. To respond to this constraint in semi-arid regions, we need to focus on the combination of water availability and soil fertility. After discussing the high-potential/low-potential issue, two critical research problems are examined:

1. The effect of structural adjustment on agricultural intensification. With a lag higher purchased input use became more profitable than prior to devaluation in a field study in the Sahel.

2. The potential effects of the introduction of improved water retention techniques in semi-arid *regions. Important differences in techniques depend upon soil characteristics and the degree of mechanisation. The water retention then makes the higher use of inorganic fertiliser more profitable and less risky.*

1. Introduction

The debate about extensification versus intensification has been going on for a long time in Sub-Saharan agriculture. In the first section we consider the emphasis put on overcoming seasonal labour shortages v. the various measures to increase crop yields.

In a broad definition of technology development, the high-potential/low-potential region debate becomes relevant. We raise two specific questions about the development of agricultural technology and provide some empirical analysis:

1. What are the expected effects of structural adjustment on the intensification of food -crop production?
2. Will the water-retention techniques be an important component of yield increases in the semi-arid and hillside regions?

Then we consider the problems of the evolution of input and products markets and finally make some concluding observations.

2. Constraints to agricultural output increases

The conventional wisdom has been that the principal constraint to agricultural development in Sub-Saharan African agriculture is the shortage of seasonal labour at critical periods. According to this argument, the extensification option of expanding land area is still available for most regions. In contrast with Asia, a hired labour pool is not available for temporary work (Delgado and Renade, 1987). Technology recommendations are for the more rapid introduction of animal traction and herbicides.

The introduction of animal traction has generally occurred as agriculture has intensified, i.e., the cultivation of heavier soils and production of a cash crop (Pingali, Bigot, and Binswanger, 1987; McIntire, Bourzat, and Pingali, 1992). Both heavier soils and cash crops are associated with higher purchased input levels, inorganic fertilisers, pesticides, and improved seeds. So there appears to be a complementarity between higher purchased input levels and animal traction. It results from some combination of increased seasonal demand for labour as intensification occurs, and the availability of higher incomes in these more intensive systems. It enables the capital investment in the animal and implements.

With continuing rapid population growth, this emphasis on seasonal labour needs to be re-examined because of the (1) slow growth of the industrial sector and service sectors in the '80s and '90s, (2) disappearance of the agricultural frontiers with population pressure, and (3) increasing importance of soil and other natural resource degradation.

Increasingly the principal constraint is the supply of quality land.[1] In semi-arid regions, this implies doing something about water availability and soil fertility. In sub-humid regions, the principal constraint is soil fertility. For both agro-ecological regions, once the agronomic conditions are improved, the returns to improved seeds are substantially increased (Byerlee, 1996). The important point is to first improve the agronomic environment and then introduce new cultivars rather than the opposite of trying to make minor, low-cost changes as with new cultivars alone or just manure, rotations, or some combination of improved farmer practices (see Sanders, Shapiro, and Ramaswamy, 1996).

For most regions, the critical first requirement will be to increase the levels of inorganic fertilisers. For the poorly buffered soils, inorganic fertilisers will need to be combined with organic fertilisers. There has been much discussion of different methods of increasing soil fertility, as if there were substitutes for inorganic fertilisers at the low levels of soil nutrients (especially N and P).[2] Sub-Saharan Africa is unlikely to become an innovator in soil-fertilisation methods. Everywhere else in the world that crop yields are substantially increased, inorganic fertilisers are a basic component frequently complemented with other soil-fertility improvement techniques. Certainly, it continues to be important to search for lower-cost fertilisation methods for the future. But Sub-Saharan Africa needs to take advantage of what is known now about soil fertility and rapidly increase the consumption of inorganic fertilisers (Larson and Frisvold, 1996).

3. High-potential and low-potential regions

The major successes of the Green Revolution have been in the better resource regions with irrigation or with sufficient but not excessive rainfall. Also these regions have generally had good soil resources. Clearly, agricultural research in the better areas needs to be maintained and probably even increased because of its importance in maintaining the food supply. Maintenance research will be critical so as not to lose the gains that have been made as biological change plus annual variability take place. Agricultural systems are characterised by continual change, so good agricultural institutions are critical to maintain productivity gains.

For the next generation of technologies, should the focus be on continuing to make improvements in the better-endowed regions or in the more marginal zones (for wheat see Byerlee and Morris, 1993)? With the concentration of many of the poor people in the world on the less-endowed regions, some suggest a push to concentrate more technology development research there. Five hundred million poor people (36% of the rural poor) live on the 24% of the land in developing countries falling in this category (Hazell and Garrett, Oct. 1996).

A critical question is the efficiency of the investment in agricultural research in the less-endowed or marginal areas. Technology often changes these areas from being marginal. For the semi-arid regions and the hillsides, techniques are needed that hold the water in the soil, since these techniques shift the response to soil-fertility amendments upward. When more water and fertiliser can be made available, there are advantages for semi-arid regions over higher-rainfall regions due to the lower incidence of plant diseases in drier conditions.

Levels of fertilisation will be different for the two types of region. Both will need inorganic fertilisers, which can then be complemented with organic fertilisers, cereal-legume rotations, and a series of other technologies to increase soil fertility. When water is added to the drier regions or runoff is contained on the hillsides, these regions can and will use higher input levels and produce higher-value products.

Where soil fertility is constraining, as in most of the agricultural area of Sub-Saharan Africa, the critical question is whether it will be profitable to utilise inorganic fertilisers or whether it becomes profitable with some other combined new technologies, such as new cultivars and/or reasonable policy changes. If neither, there should be planning for alternatives to crop production for the region (Sanders, Shapiro, and Ramaswamy, 1996, Ch. 5).

It is important to recognise the complementarity of many other soil-fertility techniques with inorganic fertilisers. But where the principal nutrient constraints are nitrogen and phosphorus, it will generally be necessary to start with inorganic fertilisers. An exception will be with legumes, which can effectively fix nitrogen. But even in this case, phosphorous fertilisers will still be a necessary input, often combined with micronutrients.

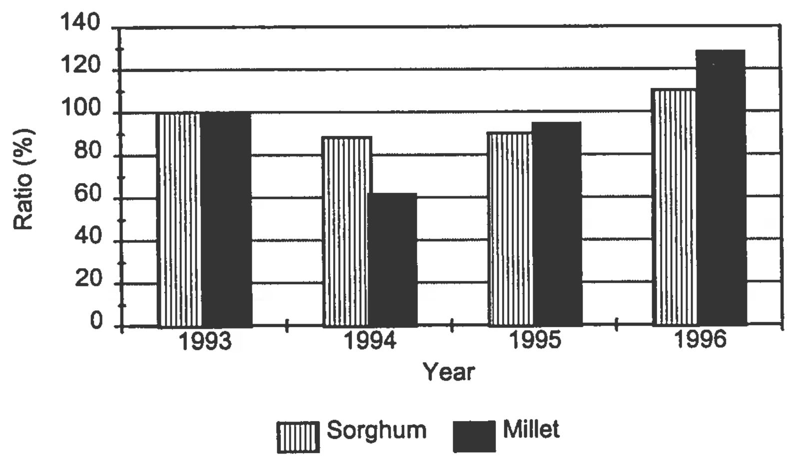
Once the agronomic environment is improved by taking care of the requirements for water and soil nutrients, returns will be high from the introduction of new cultivars and insect and disease control. These same technology-development principles of first improving soil fertility and then moving to new cultivars and associated technologies are also relevant for the sub-humid zone. For these three zones (semi-arid, hillsides, and sub-humid) we have now covered most of the crop production area of the tropics, except for the humid regions where the soil-fertility constraint can be even more pressing due to continued leaching from heavy rainfall.

The bottom line is that the priority for most regions will need to be increasing soil fertility. Where water is insufficient or disruptive (on the hillsides, taking the farm down into the valley), water control has to be taken care of first and then combined with soil-fertility improvement. Rapid increased consumption of inorganic fertilisers is necessary all over the continent, including semi-arid and hillside zones, once water control investments are undertaken there. Hence, much of the distinction between high- and low-potential regions is sterile, since investments in infrastructure, water control, and even changing markets with economic growth can shift low-potential to high-potential regions, as those familiar with Australian, California, Arizona, Texas, or Israeli agriculture already know.

4. Two critical questions for designing agricultural technology in the next decade

The first question is the impact of the recent policy changes of structural adjustment, in this case devaluation, on the intensification of food-crop production. One of the principal explanations for previous failures to intensify food crop production has been poor public policy resulting in subsidising cereal imports and penalising domestic cereal and tuber producers.[3] Now, with structural adjustments, agriculture is supposed to become more profitable. However, the initial effect on agriculture of structural adjustment has been to increase the price of inputs, especially inorganic fertilisers and pesticides, by removing input subsidies and then subsequently with devaluation. There has been pessimism on ever finding technologies and policies that would sufficiently increase the profitability of the intensification of traditional cereals to interest farmers (Bosc and Hanak-Freud, 1994). Since increased use of inorganic fertiliser is critical for increasing cereal yields, we need to look into this question in more detail.

In the CFA countries, there was 100% devaluation in January 1994. Increases in crop prices relative to fertiliser are expected to encourage a shift to more fertilisation. For the administered prices of cotton, use of inorganic fertiliser is pervasive in Franco-phone Africa. Malian cotton price increases consistently accompanied the increases in the prices of inorganic fertilisers. The prices for cereals declined in 1994 and 1995 due to stock accumulation in the good rainfall year of 1993 and the failure of the government to get out of the cereal business. Production levels were normal in 1995 but exports of cereals increased substantially.[4] Cereal prices relative to fertiliser increased 33% for millet and 20% for sorghum (Fig. 1) between 1995 and 1996.



Source: Coulibaly, Vitale, and Sanders, 1997.
Figure 1. Farm-level cereal/fertiliser price ratios, 1993-1996

The devaluation (and the increased exports) gives a window of opportunity[5] for the domestic food-production sector to become more profitable with higher prices. There needs to be a quick response from this sector to increase output. Otherwise pressures from the urban sector to return to subsidies on food imports will build up, thereby again discouraging increased production of the traditional cereal and tuber crops in West Africa (Bates, 1981).

With programming, we look at the potential response from farmers in the Sudanian zone of southern Mali to the higher cereal prices of 1996. Comparing two models with different risk aversion of farmers in the pre-devaluation case, the risk aversion apparently kept out the fertilisation of sorghum with a new cultivar. This is consistent with farmer practices (Tables 1 and 2). The higher sorghum (relative to fertiliser) prices of 1996 then overcame this risk aversion and farmers adopted the new sorghum cultivar with fertilisation, according to model results. Liquidity or credit is not the principal constraint. Farmers have livestock, which is highly liquid. In practice, they seldom cash in their livestock, even though the returns from selling and investing two small ruminants or one-half a cow are very high. In the short run, it is unlikely that a good credit system will be quickly developed for the food crops, so it is important to look for alternative internal liquidity sources.

Use of inorganic fertiliser will need to be rapidly increased before it can play a central role in achieving crop yield increases. If the output elasticity of fertilisers were 0.4 to 0.5, then fertiliser use would need to increase 8 to 10% annually to attain an output growth rate of 4% from yield increases (Bumb and Baanante, 1996). Governments will have to use foreign exchange and farmers will have to spend money from their pockets to increase the use of inorganic fertilisers. The rate of increased use of inorganic fertiliser may be a good indicator of the progress of countries developing their agricultural sectors. To obtain the full return from inorganic fertilisers these will often need to be combined with other soil-fertility-increasing inputs. However, it is important to emphasise that these other practices are complements rather than substitutes for inorganic fertilisers at the present low levels of nitrogen and phosphorus in most of Sub-Saharan soils.

For more intensive agriculture (higher input use) to be profitable, higher output prices and continuing investment in the infrastructure of rural areas will be necessary. For most countries, this will be income redistribution from urban to rural areas. The urban poor, government bureaucrats, and the rest of the urban middle class already find these changes, especially higher food prices, threatening and are resisting them. The ability of African governments to implement structural-adjustment programmes and even their desire to continue them will undoubtedly depend upon continuing pressures from donors. A recent review of structural adjustment by the World Bank found that the agricultural sector was still taxed by overvalued exchange rates and government interventions and that no adjusting country was following good macroeconomic policies (World Bank, 1994, pp. 184, 186).

With the massive misunderstandings between developed and developing countries on the objectives and implementation of structural adjustment, it is not surprising that structural adjustment has not been completely implemented. So a critical future issue in Sub-Saharan Africa is whether policymakers and the urban sectors of developing countries can be convinced that structural adjustment is in their long-run interest, especially the painful phases of the adjustment process.

Table 1: Linear Programming Results (Risk Neutral)

		Before Devaluation		Current Prices
Crop	Technology[a]	Farm Observations	Model Results	Model Results[b]
Sorghum	Local variety with no inorganic fertiliser	3	0	0
Millet	Local variety with no inorganic fertiliser	8	11	8.7
Sorghum	Improved variety with 100 kg/ha of compound cereal fertiliser[c]	0	2.3	4.5
Groundnut	Improved variety with 100 kg/ha of compound cereal fertiliser[c]	2	0.6	0.6
Cowpea	Improved variety with 100 kg/ha of compound cereal fertiliser[c]	0.5	0.4	0
	TOTAL RETURNS (US$)[d,e,f,g]	1,749	1,711	2,332

[a] The soil-preparation technique of ridging is included with all activities.
[b] This scenario assumed farmers' liquidity increased in proportion to livestock prices (130% increase).
[c] The composition of compound cereal fertiliser is: N:P:K (15:15:15).
[d] Drop prices used in calculating total returns are producer prices averaged over one year.
[e] Total returns include home consumption (valued at producer price) plus market sales minus out-of-pocket expenses.
[f] Total returns are given in 1996 US$ and were calculated using a consumer price index (*International Financial Statistics*, June 1996).
[g] Rates of return on purchased inputs for model results were 600 and 500% for the before-devaluation and current-price scenarios, respectively.

Table 2. Farm-Programming Model Results for Before Devaluation and With Current Prices (Risk Averse)[a]

Crop	Technology[b]	Before Devaluation Farm Observations	Before Devaluation Model Results	Current Prices Model Results[c]
Sorghum	Local variety with no inorganic fertiliser	3	0	0
Millet	Local variety with no inorganic fertiliser	8	11.5	10.1
Sorghum	Improved variety with 100 kg/ha of compound cereal fertiliser[d]	0	0	3.2
Groundnut	Improved variety with 100 kg/ha of compound cereal fertiliser[d]	2	1.4	0.6
Cowpea	Improved variety with 100 kg/ha of compound cereal fertiliser[d]	0.5	0.5	I0.4
	TOTAL RETURNS (US)[e,f,g]	1,749	1,711	2,332

[a] Results were obtained using a relative risk-aversion coefficient of 2.5.
[b] The soil-preparation technique of ridging is included with all activities.
[c] This scenario assumed farmers' liquidity increased in proportion to livestock prices (130% increase).
[d] The composition of compound cereal fertiliser is: N:P:K (15:15:15).
[e] Crop prices used in calculating total returns are producer prices averaged over one year.
[f] Total returns include home consumption (valued at producer price) plus market sales minus out-of-pocket expenses.
[g] Total returns are given in 1996 US$ and were calculated using a consumer price index (*International Financial Statistics,* June 1996).

The second question is on the importance of water-harvesting techniques in semi-arid *regions*. In the literature, the potential impact of water harvesting is often underestimated (Crosson and Anderson, 1994, p. 20; and Rosegrant, 1997, p.13). Why? There appear to be two reasons for this.

1. The wide range of techniques used for water harvesting across soil types is not generally appreciated. The objective of all these techniques is to make more water available in conditions where irrigation is not feasible and thereby shift upward the response to soil-fertility amendments and reduce their riskiness. An important distinction is between the heavier soils with more clay (here crusting and infiltration are the water-retention problem) and the sandier soils (where the principal concern is to slow the percolation or the speed with which the water passes through the soil). Water harvesting is normally thought of just for the heavier soils and we associate it with bunds, ridges, terraces, and catchments of various types. However, there are important techniques of water control for the sandy soils. For example, increased organic matter can slow the passage of water through the soil and thereby make more available to the plant roots. Even raising both plant densities and fertilisation has been shown to increase the efficiency of water use in these sandy soils (Shapiro and Sanders, 1997).

2. Another reason for underestimating the potential importance of water harvesting on the heavier or crusting soils is the general association of these techniques with the extremely labour intensive measures practised on degraded soils or on the hillsides. It is necessary to distinguish between Type I and Type II water-retention technologies. Type I technologies are a response to falling yields from the decline of the fallow system and the resulting soil degradation. They require enormous labour inputs but the labour can be applied outside of the agricultural season. The dikes or bunds on the contour, the zai (the traditional system on the Mossi Plateau of digging small holes in the field to hold water and planting the cereals on the edges), the bench terraces on the hillsides, and for sandy soils several extremely labour-intensive methods for extending the supply of organic fertilisers (corralled feeding of cattle, compost heaps) have all been diffusing rapidly across the Sahelian countries in the last decade (Sanders, Shapiro, and Ramaswamy, 1996).

Since yields have already fallen substantially in these degraded areas, the relative yield gains are large from a very low base. However, farmers adopt these techniques only when their opportunity costs are very low because the absolute yield gains and returns are small. Hence, the concentration of these practices is in the most degraded poorest resource-base regions – such as the Yatenga Plateau in Burkina Faso. The Type I water-retention techniques are generally combined with small quantities of manure applied as in the holes of the zai or behind the bunds.

The important technologies for the future are the Type II technologies. These include the ridges on the contour done all over southern Mali with animal traction, tied ridges, and improved land preparation. Type II technologies are generally introduced in regions before soil degradation and population pressures have become serious problems. These areas often have better soils and rainfall resources than the areas of concentration of Type I techniques.

Most Type II water-retention techniques need to be undertaken during the crop season. Since seasonal-labour constraints can become critical at first weeding or planting, the use of animal traction and improved implements is often required for the introduction of Type II technologies. These Type II water-retention techniques are generally combined with inorganic fertilisers (Table 3). The yield effects are substantially larger absolutely than those of Type I, since the water-retention effects and improvements in soil fertility are both much larger. It is not necessary for the opportunity costs of farmers to be extremely low for them to be interested in these techniques. Since soil conditions tend to be better, initial yields before technology introduction are not as low absolutely as on the degraded soils. Hence, the Type II technologies generally result in smaller relative yield increases than the Type I but larger absolute yield gains (Table 3).

In semi-arid regions, farmers are utilising labour-intensive, out-of-season techniques (Type I and organic fertilisers). With science and experiment station adaptation, it is possible to respond to the same constraints (water availability, soil fertility) but in more input demanding ways that substantially increase yields (Type II and inorganic fertilisers). It is not a choice between diffusing best-farmer practices versus science from the experiment station but a process of identifying the constraints pressing on farmers by observing the practices that they adopt and then improving the response with scientific concepts and purchased inputs.

The Type II techniques will be critical to the increased use of inorganic fertiliser in semi-arid regions; a considerable jump in productivity is possible from the combined inputs. Some of the Type II technologies will require strategic public support. For example, several hundred prototype animal-traction tied ridges were distributed in Burkina Faso during the mid-'80s. Engineering modifications and/or support of local repair shops are apparently necessary to respond to the mechanical problems encountered in various types of heavier soils. But the furrow diker on tractors is found all over the High Plains of Texas (U.S.A.), so there is no reason to expect that these problems cannot be resolved for animal traction in the Sahel.

Table 3. Yields and Percentages of Farmers Taking Cash Losses from fertilisation and Tied Ridges in Sorghum Production in Farm Trial Villages, 1983 and 1984

Year/Village	No. of Farmers	Traction Source	Yields				% of Farmers Losing Cash	
			Control	Tied Ridges	Fertilisation	Tied Ridges and fertilisation	Fertilisation	Tied Ridges and fertilisation
1984								
Nedogo	11	Manual	157	416	431	652	27	9
Nedogo	18	Donkey	173	425	355	773	50	0
Bangasse	12	Manual	293	456	616	994	8	17
Dissankuy	25	Ox	447	588	681	855	28	0
Diapangou	19	Manual	335	571	729	1006	26	0
Diapangou	19	Donkey	498	688	849	1133	21	0
Diapangou	19	Ox	466	704	839	1177		0
1983								
Nedogo	3	Manual	430	484	547	851	56	0
Nedogo	11	Donkey	444	644	604	962	58	42
Bangasse	12	Manual	406	493	705	690	21	17
Diapangou	24	Manual	363	441	719	753	8	8
Diapangou	25	Donkey	481	552	837	871	12	16
Diapangou	25	Ox	526	578	857	991	20	12

Source: Sanders, Shapiro, and Ramaswamy, 1996

5. Evolution of the input and product markets

The importance of increasing the use of inorganic fertiliser and improved seeds was emphasised for the agricultural-transformation process. Also, the problem of the price collapse of the traditional food crops with good weather and/or rapid technological change needs to be anticipated. The use of traditional cereals in bread, beer, and animal feed is going to be an important component of the technological-change process to make demand more elastic and thereby moderate the price collapse in good weather years and from the diffusion of new technologies.

The evolution of input and product markets in the development process and how to make this process more efficient need to be studied, especially the roles of the public and private sectors. For example, in the mid-'80s when the sorghum price collapsed, all the private producers of the hybrid Hageen Dura-1 in Sudan, left the industry. The two public seed-producers continued to produce hybrid sorghum. But by the end of the '80s, they were unable to respond rapidly to the accelerated increase in the demand for the hybrid (Sanders, Shapiro, and Ramaswamy, 1996). Private producers are undoubtedly critical *now* in the Sudan to respond to a rapidly increasing demand for the hybrid and to invest more in quality controls. But diffusion would have stopped earlier if two public agencies had not continued their involvement.

A re-evaluation of the roles of the public and private sectors in the initial stages of the development process for the lower-income countries is appropriate. In this stage, private companies find it difficult to make money; risk levels are high, so private companies often are not willing to become involved.

6. Conclusions

It is time to bury some issues that people have been preoccupied with in Sub-Saharan Africa. The Malthusian spectre is at the top of that list. Rapid agricultural output growth can be accomplished in Sub-Saharan Africa as in the rest of the world with increasing use of inorganic fertiliser, better water management, and new cultivars. Agricultural technology development and diffusion are simple. They are not nuclear science. Providing good policy support so that agriculture is profitable and reducing price instability, especially the price collapse of traditional food products in good rainfall years will certainly help accelerate this transformation process to input-intensive, higher-yielding crop production. Facilitating the evolution and increasing the efficiency of input and product markets will be very important components of this process.

The discussion of seasonal-labour markets as the principal constraint to Sub-Saharan African development is certainly out of date if it ever were relevant. Rapid population growth, the disappearance of the fallow system of restoring land fertility, slow growth of non-farm employment, sustainability concerns, and increasing soil degradation all indicate the need for increasing soil fertility. All of these topics are presently discussed over much of the continent. Unfortunately, there will be no magic solutions. The search for a low-cost solution has been a distraction to researchers and policymakers. In the harsh environment of much of Sub-Saharan African agriculture, we need to stop looking for shortcuts and trick solutions (such as organic fertilisers, rock phosphate, and rotations) that do not involve farmers spending money and governments utilising foreign exchange. Science, experiment stations, and the effects of combined purchased inputs will be required.

The importance of water-control techniques, in contrast with irrigation is consistently underestimated in the literature. There is a wide range of these techniques, including those that just hold the water in the sandier soils, as well as a series of measures to reduce runoff where crusting is the problem. These are not just indigenous techniques. The most important ones for the next decade have large potential yield effects (when combined with inorganic fertilisers) and need to be undertaken during the crop season, generally with animal traction and not just as emergency measures on the most degraded or most easily degraded regions (hillsides).

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NOTES

[1] I have to admit my bias here of principally working in the Sahelian countries and Sudan rather than in Angola, Zaire, and Zambia. Nevertheless, all over the continent there is concern with fallow systems breaking down and the high costs of infrastructure for opening up new land areas. We show (Sanders, Shapiro, and Ramaswamy, 1996) that even with the opening up of new frontier areas in Burkina Faso after the reduction of river blindness, a successful long-term settlement process required the intensification of agriculture.

[2] For a thorough discussion of the complementarity between inorganic and organic fertilisers and the requirement for using inorganic fertiliser, see McIntire, Bourzat, and Pingali (1992), Ch. 5: "The Pattern of Soil Fertility Maintenance." They say: "Manure is more expensive than fertiliser (inorganic) because it is so much less concentrated" (p. 87). Also see Pingali and Rosegrant (1995, p. 175), who point out that "commercially oriented food production systems are not possible in the absence of chemical fertiliser systems."

[3] The parastatals handling cereal trade have been concerned mainly with keeping urban prices low rather than with farmer incentives. These parastatals and overvalued exchange rates are the main culprits for output prices distortions. Input subsidies were expected to offset some or all of these price distortions. However, this tactic worked only for cash crops or for specific development programmes since the inputs for intensifying agriculture were otherwise extremely difficult for farmers to obtain. Supply constraints are considered to be the most significant barrier explaining the low use of inorganic fertilisers in Sub-Saharan Africa (McIntire, Bourzat, and Pingali, 1992, p. 101). Structural adjustment is supposed to eliminate all of the above sources of price distortions. The impact of higher imported cereals prices on domestic cereal prices will depend upon the degree of substitutability between imported (rice and wheat) and traditional cereals (sorghum, millet, and maize) (see Reardon, 1993).

[4] When cereal exports to Cote d'Ivoire and Burkina Faso increased, a high incidence of malnutrition was

observed in Mali. I am grateful to Richard Seifman of the World Bank for this information.

[5] Of the three years, only in 1996 did the relative prices increase the incentive for intensification (higher use of inorganic fertiliser). A fundamental problem of the cereals and most traditional food products is the price collapse with good weather or rapid technological change. Demand expansion programmes or price supports have been recommended to further identification by reducing risk.