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180 Technology Development and Agricultural Policy in the Sahel—Burkina Faso and Niger

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Introduction

In the 1950s and 1960s, the Sahel experienced a high rainfall period. With improvements in public health, population growth accelerated. Farmers and herders were able to move north into more marginal rainfall regions. The acute droughts of 1968 to 1973 and 1982 to 1984 and the chronic low rainfall problem since 1968 have precipitated a series of farmer, national government, and international donor responses to the Sahelian crisis (Sen, 1981; Glantz, 1986; Mellor and Gavian, 1987).

Many of the short-run farmer responses are further contributing to the problems of technology development. The first section of the paper is concerned with these farm level responses to continuing low rainfall and higher population pressure. The second section develops a theory of technology development for the Sahel based upon farm level results in Burkina Faso and Niger in programs over almost a decade. Finally, public policy support necessary for supporting the introduction of new technologies is considered in the third section.

Farmer Response to Drought and Increasing Man-Land Pressure

In both Burkina Faso and Niger, farmers have been shortening the traditional fallow system with increasing population pressure. The decline of the fallow system has not been replaced with higher levels of chemical fertilizer except in higher rainfall regions such as southwest Burkina Faso. Hence, soil fertility has been declining and soil erosion accelerating. As the land quality deteriorates, cereal yields have been falling and the more stress tolerant millet (*Pennisetum typhoides*) is being utilized to replace sorghum [*Sorghum bicolor* (L.) Moench] on the heavier soils (Ames, 1986). On the sandy dune soils, millet is already the predominant crop and there are only very small areas of sorghum such as below the legume trees and on the water recession areas. With declining soil fertility, farmers attempt to maintain family cereal consumption levels by expanding the crop area into more marginal agricultural zones. Hence, the amount of communal land for livestock is reduced and the area available is often over-grazed. Mixed farming systems and improved rotations with legumes are practices which increase organic matter content and improve soil fertility levels. However, the Sahelian farmer must first devote his attention to cereal productivity.

The Sahelian farmer combines crops and cultivars of different season length to take advantage of differences in soil quality and as a portfolio decision. Long-season cultivars have higher yield potential but are riskier in bad years. The farmer has a range of locally-adapted cultivars on his farm and in the region. Over the last decade, shorter-season traditional cultivars of sorghum and millet have become widely disseminated in Burkina Faso (Vierich and Stoop, 1987). A similar phenomenon occurred with short-season cowpea (*Vigna sinensis*) in Niger. In another long period of better weather, such as in the 1950s and 1960s, a proportional shift in portfolio mix back towards the longer-season cultivars would be expected.

Small farmers increase their cultivated area to maintain their cereal consumption goals. This strategy further depletes and degrades their limited soil resources. Purchasing inputs to increase soil fertility is risky because of the variation in water availability and other factors. Hence, it will be necessary to develop an integrated technology development program to respond to this crisis of declining cereal yields and depleted soil resources.

Improving the Agronomic Environment in the Sahel

There has been much debate on the constraints to increasing cereal productivity in the Sahel. For some time, seasonal labor scarcity was advanced as the major constraint to agricultural output increases and most Sahelian countries have had programs to subsidize the introduction of animal traction, some for 30 to 40 years. Still, the introduction of animal traction has been minimal in semiarid West Africa, estimated at approximately 15% utilization of the cultivated crop area in the mid-1980s (Matlon, 1987).

The importance of the constraint of water availability is obvious from the definition of the region as semiarid. Unfortunately, just making water available with very low soil nutrient levels generally has a limited response. Even at slightly higher nutrient levels, cereals

will quickly mine the available nutrients. Applying fertilizers (organic or inorganic) without an assured water supply is economically risky since the response to fertilizer is dependent upon the availability of water at critical stages of plant development. Without increased water availability, the fertilizer response has been extremely variable in semiarid regions of the Sahel below 800 mm. (For summaries of empirical evidence, see Matlon, 1987, pp. 73-75; Nagy et al., 1987, pp. 44-46.) Hence, the risks to farmers purchasing this input have been large. However, the availability of water retention techniques increases the return to fertilizer and reduces the economic risk (Nagy et al., 1987). Combining the two, increased water availability and moderate fertilizer levels, has been shown to result in large and consistent increases of sorghum yields (Nagy et al., 1987). These innovations also are highly profitable at low levels of risk to the farmers.

Presently, one water retention technique of constructing ridges on the contour is being rapidly introduced by farmers with public agency support in the depleted soils of the Central Plateau of Burkina Faso (Sanders et al., 1987). The effect of this technique depends on the distance between the ridges and whether it is combined with soil fertility improvements. One advantage of this ridging is that labor is available for doing it in the dry season. Other water retention techniques, such as tied ridges and improved land preparation, have shown a larger effect on yields in repeated farm-level testing, but these techniques need to be undertaken during the crop season when labor demands for agriculture are higher. (For a summary of water retention techniques, see Matlock, 1987.)

This combination of water retention and chemical fertilizer has a large yield effect on the heavier soils where crusting frequently reduces infiltration. On the sandy dune soils, there is a different problem of retaining water around the roots. Here the same principle of water retention and soil fertility improvement has been obtained with higher plant densities and chemical fertilizer (ICRISAT, 1985, 1986, 1987); however, further economic analysis is necessary before designing a technological package.

Due to the previous riskiness of fertilizer use, the necessity for cash outlays, and the need to obtain the fertilizers at specific times, farm-level and experiment station research in the Sahel have been evaluating alternatives to chemical fertilizer. The principal emphasis in farm level research has been to better utilize available animal (manure) and plant materials (crop residues). On the experiment station, inoculation research for biological nitrogen fixation and, more recently, research on mycorrhizae has been supported. In addition, the solubility problem of local rock phosphate has been studied at the experiment station and farm level in the Sahel (Vlek et al., 1987; Nagy et al., 1987).

In spite of this farm level and experiment station research, the utilization of organic and local inorganic fertilizers appears to be declining in the Sahel. As communal grazing land becomes less available, there are less animals. The technical and economic problems associated with manure, crop residues, and rock phosphates, as alternatives to improved chemical fertilizer, have not been resolved (Nagy et al., 1987). At the low levels of soil nutrients in most of the Sahel, inorganic and organic fertilizers are complements rather than substitutes. The inorganic fertilizers are necessary to supply the N and P with minimum risk (Sanders, 1988). Organic fertilizers then can be used to improve the ability of the soils to retain water and for other trace elements.

Over the next 5 to 10 years, the principal source of fertilizer for the Sahel (and the rest of Sub-Saharan agriculture) is expected to be imported chemical fertilizer. Inorganic fertilizer has proven effects, is concentrated, and can be used to overcome the basic constraints of low levels of N and P. The alternatives are either not available, are higher cost, or just do not function effectively yet at the farm level (Nagy et al., 1987; Vlek et al., 1987). Governmental policy needs to be undertaken to improve marketing infrastructure for chemical fertilizer and to plan for the foreign exchange requirements of these importations.

Public Policy Support for This Improved Agronomic Technology

The policy recommendations are for a chemical fertilizer subsidy and a price floor for good rainfall years. Fertilizer subsidies were apparently very effective in facilitating increased fertilizer consumption in the higher-rainfall regions of Burkina Faso and Niger. Fertilizer consumption has already declined with the gradual elimination of these subsidies over the last 3 years (Sanders et al., 1987). Chemical fertilizer is presently utilized at very low levels in the Sahel, except in the higher-rainfall regions. In the lower-rainfall regions, large cereal yield increases have been obtained on farmers' fields with the combination of water-retention measures and chemical fertilizers (Nagy et al., 1987).

Producers adopting new combined technologies face a learning curve. The management requirements of introducing several new technologies simultaneously are high; hence, farmers are expected to only gradually obtain the full benefits of new cost-reducing technologies over a number of years, and a strong case, therefore, can be made for a temporary fertilizer subsidy in the Sahel. Another review of agricultural technology in Sub-Saharan Africa recommends subsidizing chemical fertilizer distribution (Mellor et al., 1987). Without the subsidies, adoption will be slower and public sector research adapting new technologies will have less interest in the cereals. (For the case against fertilizer subsidies, see World Bank, 1986, pp. 95-97.)

The relevant prices are real prices; hence, fertilizer costs should be considered in relation to producer prices. However, Sahelian countries have already demonstrated a preference to keep cereal prices low for the urban consumers. With higher costs for domestic cereals, output will grow slowly or stagnate and the demand for imported cereals will continue to increase. One

method for developing countries to reduce the risk and increase the profitability of new technologies for domestic cereals without the very high expenditures of high price supports is to put on a floor price for the cereals to prevent a complete price collapse in good rainfall years as in 1986.

Conclusions

Donors will soon realize that most Sahelian countries want to approximate food self-sufficiency. Moreover, the failures in the 1970s and 1980s in agricultural technology development can be resolved in the 1990s in the Sahelian countries. There is substantial potential to increase cereal yields with improved agronomy, especially water retention and chemical fertilizers (Nagy et al., 1987). To promote diffusion, developing countries need to develop an improved input marketing structure. With governmental support facilitating the importation of chemical fertilizer, building up the extension service, and designing agricultural policy to accelerate technological change, rapid increases in land productivity are possible. The rest of the world may be as surprised with the ability of some regions of the Sahel to develop its agriculture as they were by the Green Revolution impact in the late 1960s in the Indian Sub-Continent after the prolonged droughts of the mid-1960s. (Also see Mellor et al., 1987 for a similar comparison.)

References

Ames, L. 1986. A preliminary report on the evaluation of new technologies in Burkina Faso. West Lafayette, Indiana: Department of Agricultural Economics, Purdue University, Mimeo, 30 pages.

Glantz, M. 1986. Drought, famine, and the seasons in Sub-Saharan Africa. 33 pages. Mimeo prepared for the WMO/UNEP/WHO symposium on climates and human health, Leningrad.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Center. 1985. Annual report, 1984. Niamey, Niger.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Center. 1986. Annual report, 1985. Niamey, Niger.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Center. 1987. West African programs, Annual report, 1986. Niamey, Niger.

Matlock, W.G. 1987. Five small scale water management technologies. Mimeo prepared for the Office of Technology Assessment. Washington, D.C.: Congress of the United States.

Matlon, P.J. 1987. The West African semi-arid tropics. p. 59-77. *In* J.W. Mellor, C.L. Delgado, and M.J. Blackie (eds.) Accelerating food production in Sub-Saharan Africa. Baltimore: Johns Hopkins University Press.

Mellor, J.W., C.L. Delgado, and M.J. Blackie. 1987. Priorities for accelerating food production growth in Sub-Saharan Africa. p. 353-375. *In* J.W. Mellor, C.L. Delgado, and M.J. Blackie (eds.) Accelerating food production in Sub-Saharan Africa. Baltimore: Johns Hopkins University Press.

Mellor, J.W. and S. Gavian. 1987. Famine: Causes, prevention and relief. Science 235:539-545.

Nagy, J.G., J.H. Sanders, and H.W. Ohm. 1987. Cereal technology development West African semi-arid tropics: A farming systems perspective. End of Project Report, International Programs in Agriculture, West Lafayette, Indiana.

Sanders, J.H. 1988. Agricultural research and new technology introduction in Burkina Faso and Niger. West Lafayette, Indiana: Mimeo report, Department of Agricultural Economics, Purdue University.

Sanders, J.H., P. Wright, P. Granier, and K. Sawadogo. 1987. Resource management and new technologies in Burkina Faso for a stable agricultural development. A report to the West African division of the World Bank. West Lafayette, Indiana: Department of Agricultural Economics, Purdue University.

Sen, A. 1981. Poverty and famines, an essay on entitlement and deprivation. New York: Oxford University Press.

Vierich, H.I.D. and W.A. Stoop. 1987. On-going changes in the West African savanna agriculture in response to growing population and continuing low rainfall. Patancheru, P.O. Andhra Pradesh 502-324, India. ICRISAT, Mimeo report.

Viek, P.L., A.U. Mokwunye, and M.S. Mudahar. 1987. Soil fertility maintenance in Sub-Saharan Africa. Office of Technology Assessment. Washington, D.C.: Congress of the United States. Mimeo report.

World Bank. 1986. World development report. Washington, D.C.: World Bank.