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AGRICULTURAL TECHNOLOGY DEVELOPMENT

IN BURKINA FASO

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In developing new technology the first requirement is the identification of the most pressing constraints to yield increase. Much confusion has been introduced in the agricultural economics literature on sub-Saharan Africa by treating the constraints problem as if there were only two factors of production, land and labor. Following this type of analysis, seasonal labor shortages are frequently defined as the most pressing constraint and animal traction advocated as an appropriate technological innovation. This is not terribly helpful in a semi-arid environment such as the Central Plateau of Burkina Faso where in many locales the increasing man-land pressure has been causing a decrease in the fallow period. Hence, cereal yields have been falling and soil fertility deteriorating.

A broader definition of production factors would make constraint identification obvious from the geographic description. Much of Burkina Faso is semi-arid so the most pressing constraint is water. Improved water conservation techniques have been developed in many regions of the world. Unfortunately, on the Central Plateau when there is water available, soil fertility quickly becomes limiting. In the absence of water, fertilizer utilization is risky in semi-arid regions.

The above was the simple agronomic rationale for the development and testing of systems of tied ridges combined with fertilization. Tied ridging is a water conservation technique of constructing ridges perpendicularly so that an area of approximately one square meter is surrounded by ridges. Within this area rainfall will be trapped and the cereal is planted on the ridges.

With improved water retention there are higher returns and less risk from fertilizer. Farm level testing of this practice has been undertaken in all three major cereals, sorghum, millet, and corn. The sorghum results have been the best. Either tied ridges alone or fertilization alone substantially increased sorghum yields in farm level testing; however, the largest gains of an approximate tripling of yields in three of the four villages were obtained with the combination of these two agronomic improvements.

Are these technologies profitable? Simple budgeting of costs and returns have been reported elsewhere (SAFGRAD-FSU Annual Report, 1984; Ohm, Nagy, and Sawadogo, 1985). To summarize, both fertilization and tied ridges alone were profitable in almost all cases. Profit levels were substantially increased with the combination of these activities

(SAFGRAD-FSU, 1984 Annual Report).

The next critical question in the evaluation is whether the technology fits into the farmers' production systems. Based upon various farm surveys, representative farm models utilizing linear programming were constructed (see Roth and Sanders, 1984). The following questions about the potential new technologies were then considered in these models: (1) would the new technologies be adopted on the model farms: (2) what would be their income effect and (3) what are the most pressing constraints preventing adoption?

Sorghum is only planted in the higher fertility soils on the top sequence of the Central Plateau (Stoop, et al., 1982). In the representative farm of the total cultivated area of 4.8 ha. sorghum was only grown on 1.4 ha. The predominant crop was millet with 3.15 hectares plus small areas of corn, rice, and peanuts. In the model solution the tied ridges were introduced in all the corn land, the .15 most fertile hectares nearest the village where the village refuse is dumped and the animals kept. The tied ridges were also adopted on most of the sorghum land. Since the various tied ridge and/or fertilization technologies were not consistently profitable on the poorer millet land, these activities were not considered in the modeling. On these lower fertility soils on which millet is customarily grown, there is less water retention. Hence, the utilization of fertilization was not profitable on most farms.

In the model, the tied ridging-fertilization technology was not introduced on all the sorghum area because the seasonal labor requirement for tying the ridging was large and this operation needed to be done at one of two periods, in which there were many other labor requirements. One hundred man hours/hectare was estimated as the labor requirements for tying or making the perpendicular ridges if animal traction were utilized to make the original ridges. A further reduction in labor requirements would enable an expansion of the combination of tied ridges-fertilization onto the rest of the potential sorghum area.

The modeling results indicated the sensitivity of farm income to this labor requirement. Presently, in Burkina Faso, 45 prototype animal drawn ridgers were farm tested in the 1985 crop season. So the farm research is attempting to resolve this seasonal labor constraint. If the animal traction ridger can successfully further reduce the seasonal labor requirements, then the next big gain would be from the extension of this tied ridge-fertilization technology into the millet area. Given the present land use indicated by these representative farms, increased efforts need to be put into agronomically adapting the tied ridge-fertilization combination for the lower quality millet soils.

Tied ridges is a labor intensive technique, which needs to be performed either at first weeding or planting. An animal traction ridger may increase the profitability of animal traction as well as making this more intensive land use possible. The next section considers the extensive development strategy of animal traction.

Extensive Agricultural Technology

Development in Burkina Faso

Since the beginning of the 20th century, animal traction mechanization has been promoted in sub-Saharan Africa. Yet less than 15 percent of the semi-arid tropical area cultivated in Africa now employs animal traction (Spencer, 1985, p. 7). In Burkina Faso, both international and national agencies have been promoting animal traction since the seventies (Munzinger, 1982, p. 25). Nevertheless, outside of the southern and western regions of Burkina Faso, introduction has been slow. This section evaluates some effects of animal traction in several villages in Burkina Faso and considers some of the factors leading to differences in profitability estimates and hence adoption potential.

For animal traction to be profitable in the budgeting analysis undertaken with farm level data in Burkina Faso, the utilization rate needs to be reasonably high, 30 days or 150 hours. Low utilization levels can result from:

(a) Small farm family size. To fully utilize a draft team, 6 active family members or more appear to be necessary. In the villages studied, the mean family size in animal traction utilizing households was approximately twice that in households not utilizing animal traction;

(b) The learning curve phenomenon is important. It takes 3 to 5 years for farmers to master the technology;

(c) Combination of implements. A weeder is critical for overcoming seasonal labor bottlenecks. Combining the weeder with the plough can provide yield effects but animal traction ploughing is found infrequently in semi-arid West Africa (Charreau, 1978, p. 326). There may be a water retention effect from animal traction ploughing for semi-arid regions;

(d) Late rains. The opportunity for ploughing is very limited with late rains. When the rains begin early, the plough can be used extensively. In this ploughing operation, oxen have a definite advantage over donkeys since oxen are stronger and ploughing is more power intensive.

Internal rates of return were calculated over an eight year payback period for the purchase of the animal and the equipment. This calculation includes maintenance, depreciation, and expected losses. The observed internal rates of return were 26 percent and 35 percent, respectively, for oxen and donkeys. If higher levels of use of the plough and the cultivator and shorter learning curves could be achieved to more efficiently mechanize several operations and to expand the area cultivated, these internal rates of return could be increased to 68 percent and 114 percent, respectively (Jaeger, 1985).

Field observations showed that adoption of animal traction was moderately profitable but could be much more profitable if the 4-6 year time period for learning were shortened and both the plough and the cultivator were utilized. The more profitable complete (cultivation and ploughing) mechanization is achieved with oxen. If only cultivation is mechanized or if the feed supply were limited, then donkey traction would be the most profitable. However, at high utilization rates of 100 hours or more, oxen traction results in superior profitability.

Some of the variation in the performance of animal traction between regions may be explained by the learning curve and the number of operations mechanized. To achieve these high rates of return, farmers need to rapidly master the use of the animal cultivator and the plough. They also need to expand the area cultivated over a shorter time period. The failure to fully utilize animal traction by expanding land area cultivated and mechanizing several operations leads to much lower returns and hence, by inference, may explain why some other field studies have found much lower returns to animal traction (Sargent, et al., 1981).

In the Central Plateau, with its poor soils and declining cereal yields the use of animal traction to expand the area cultivated may exacerbate soil fertility declines by bringing under cultivation that land which would otherwise be left in fallow. Since animal traction can reduce yields through soil erosion, leaching, and oxidation of organize material, its use on the Central Plateau needs to be combined with yield increasing technologies.

Conclusions

There is an increasing consensus in the international donor community that more investment needs to be put into the development of national agricultural research institutions in sub-Saharan agriculture. These institutions will be receiving new varieties from international agricultural research organizations and carrying out specific agricultural projects with funds provided by many different donors. These national research institutions need to identify their research priorities to be able to select among the multiple donors and projects. Agronomical research to resolve water and soil problems and animal traction implements to overcome seasonal labor constraints are expected to be applied research areas with high short term payoffs for region specific adaptation and further farm level testing.

Improved water retention makes higher fertilization less risky, but the introduction of the tied ridges is constrained by the large seasonal labor requirements. The results appear to indicate that, in the Sahel, yield increasing technologies cannot be considered in isolation from labor-augmenting technologies such as animal traction. The empirical evidence here is that the complementary effects of the combined technologies to increase land and labor productivity are very large. Some farmers may adopt one innovation at a time and these changes are often but not always profitable on the farms (SAFGRAD, 1982, 1983, 1984); however, low cost methods to combine these

technologies are a very high return agronomic and economic research activity.

Putting the three together (tied ridges, fertilization, and the animal traction ridger) won't be easy because farmers tend to adopt things one at a time in a sequencing operation. A sequential pattern reduces the risk and the complexity of the changes, but does not enable the farmer to take advantage of the large interactions available from the combined utilization of several inputs. The combined or package approach will have much higher costs and management requirements than sequential adoption. Further field research is necessary to reduce these two requirements and thereby facilitate adoption.

Once the agronomic environment is improved, a larger return and greater success rate with new varieties of maize, sorghum, and millet is expected than has occurred in the past. The most important point may be that with the irregular rainfall and fragile and low fertility soils characterizing semi-arid Burkina Faso, agronomic innovations, involving water retention and soil fertility improvements, may need to preceed varietal development.

After the "Green Revolution" of the late sixties and seventies, plant breeding has been the central focus of most international and national agricultural research organizations. The lack of success of plant breeding in the Sahel and the evidence of high potential returns presented here for improved agronomy may indicate that the initial highest returns to applied agricultural research in harsh environments may be in improved agronomy, especially if the complementary or synergistic effects from combined input utilization can be achieved.

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