ACCELERATING AGRICULTURAL INTENSIFICATION IN THE RISKIER ENVIRONMENTS OF SUB-SAHARAN AFRICA

by

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Abstract:
High population growth rates and declining soil quality in risky production and marketing environments present a challenge to policy makers concerned with promoting the agricultural intensification needed to address structural food deficits. This paper discusses efforts by Sasakawa Global 2000 to introduce science-based technologies to farmers dealing with fragile soils, inadequate rainfall, excessive pressure on natural resources and poorly developed infrastructure–all of which increase the production, price, income, and institutional risks associated with agricultural intensification. The paper examines the profitability and risks associated with the proposed technologies from both the researcher's and the farmer's perspectives. Some farmers unexpectedly evaluate the technologies more favorably than researchers. Agroeconomic and socioeconomic implications of these findings are discussed.

Key words:
agricultural intensification, soil degradation, fertilizer, Sasakawa Global 2000, Africa, risk

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1 The Challenge

There is a consensus that SSA lags behind the rest of the world in terms of agricultural productivity. This has serious implications for food security given rapid rates of population growth, reduction in cultivable land per capita, and deterioration in soil quality due to continuous cultivation with little restoration of nutrients or organic matter. On World Food Day the UN released results of a recent study warning that continuing soil degradation in SSA will bring about starvation and poverty on an unprecedented level with up to 60% of Africans going hungry by 2025 (Financial Times, 16 October 1999). Although some important increases in SSA agricultural productivity have been realized in recent years, progress in food crops has been slow.

Much of SSA's food supply comes from coarse grains (millet, sorghum, maize) grown using few improved inputs. These crops are grown in less favorable agroecological environments (poor soils, low and unreliable rainfall, high incidence of plant pests and diseases) by farmers who are poorly linked to input, output, and credit markets. There has been substantial debate during the last two decades concerning the best approach for improving agricultural productivity in these challenging environments. Some (Lipton 1989; Smith et al. 1994, Borlaug and Dowswell 1995) believe that agricultural development in SSA has good potential if farmers simply increase the use of improved technologies. Others (Harrison 1990; Spencer 1995; Lynam and Blackie 1991) believe that SSA producers face enormous financial constraints and risks so conserving and better using existing natural resources is the more appropriate path.

2 The Sasakawa-Global 2000 (SG) Approach

Since the mid-1980s SG has been one of the key proponents of a high external input approach for improving cereal production in SSA. From 1986-96 SG implemented programs in nine countries , focusing frequently on high potential crops and high potential zones. SG efforts to increase yields through pilot programs that promoted 1/4-1/2 hectare demonstration plots cultivated by farmers receiving inputs on credit from extension programs run by local ministries of agriculture with assistance from SG have received much praise (though the sustainability of the technology adoption remains a hotly debated issue, particularly where input, output, and credit markets are poorly developed).

In 1996, SG initiated new programs in Mali and Burkina Faso with the objective of adapting SG methods to some of SSA's most risk-prone production and marketing environments. As the severity of constraints associated with fragile soils, inadequate rainfall, excessive pressure on natural resources, and poorly developed infrastructure increases; the production, price, income, and institutional risk of introducing intensive production technologies also rises. Under such circumstances, understanding the entire spectrum of agroecological and socioeconomic factors that influence production and income becomes very important. This paper synthesizes the results from one year of multi-disciplinary research on SG's introduction of new millet technologies to farmers in the Segou Region of Mali and discusses the implications of these results for all who are concerned with promoting agricultural intensification in high-risk areas.

3 Objectives and Methods

The objectives of this paper are to: (1) describe the program participants and the technologies proposed, (2) present survey results concerning farmers' perceptions of production risks and the impact of SG technologies on these risks, (3) examine the role that prices and degree of market integration play in farmers' production/input use decisions, (4) present survey results concerning the profitability of proposed technologies, and (5) discuss implications of study results for agricultural intensification efforts throughout SSA. The analyses are based on a survey of SG participant farmers conducted during the 1999 cropping season. Data include input/output parameters used to calculate crop budgets for both the SG test plot and a control plot, farm/farmer characteristics, and qualitative information about risk perceptions and the role that prices play in shaping production decisions.

4 Risk-Sensitive Technology Packages: An Incremental Approach

Although past SG programs have focused on high external input packages, the Sahelian programs now underway are working with a variety of cost-reducing, efficiency-augmenting techniques. Another aspect is the use of incremental steps so that farmers can gradually move from current practices to input-intensive practices, improving their skills and financial capacity to work with new technologies year by year. The Segou millet program offers farmers options for three levels of intensification representing increasing costs, risks, and yields: (a) improved seed and mildew protection, (b) package 'a' plus light/low-cost fertilization, and (c) package 'a' plus heavy/higher-cost fertilization.

Mildew, which can destroy as much as 60% of a millet crop, is a key constraint in the region; hence, the Level A package is a short-cycle seed variety and an anti-mildew treatment called Apron+. Moving up to level B, farmers add an 'improved' compost -- normal compost supplemented with rock phosphate. This option was just introduced in 1999 and results are not yet available. Level C -- for farmers having tried the first two levels as well as those willing to move directly to this level -- consists of improved seed, Apron+, compost, 25 kg/.25 ha of natural phosphate (PNT), and 25 kg/.25 ha of NPK (bulk-blended 23-13-13 with S/MgO/Zn).

5 Participant Farmers

General Characteristics. One of the most striking characteristics of participants is their heavy reliance on millet production for food and income. Eighty-eight percent rank their production for home consumption as their principal source of income; for 37% of this group, home consumed production represents 75% or more of total household income from all sources while for the remaining 63% it represents at least 50%. Only 27% of participants claimed to have other sources of income from which they would be willing to reimburse their input credit if their millet crop failed. On average, participant households comprised 17 persons and 10.3 hectares (about 0.6 ha per family member). The principal crop is millet for 87% of participants, sorghum for 7% and a millet/sorghum mix for 5%. Other crops grown are peanuts (66% of participants), Bambara nuts (55%), fonio (46%) and cowpeas (42%). Average levels of productive resources include 3.7 traction animals, 2.4 non-traction animals, 1.8 animal drawn plows/cultivators and 1.2 animal drawn carts. Use of credit for agricultural purposes is not common among participants; only 10% claimed to have agricultural credit other than that obtained from SG. All but 26% had participated in earlier demonstration or model farmer programs, yet only14% had some prior knowledge of the specific packages promoted by SG. We do not have comparable statistics for the Segou Region in general, but our impression is that these participants are generally better educated (43% of household heads able to read and write in French, Bambara, or Arabic) and own more productive resources than the average farmers in the region.

Risk Perceptions. Farmers identified the three most important risk factors limiting their agricultural production (we report scores of weighted frequencies: the most important problem received a weight of 3, the second 2, and the third 1). In this Sahelian zone where one tends to think of poor rains as the major constraint, farmers gave slightly more importance to the problem of unreliable access to inputs (score of 132 for inputs vs. 116 for rain), with bird damage and declining soil fertility coming in third and forth position (scores of 92 and 64). The importance given to inputs suggests that this group of farmers already recognizes the ability of external inputs to increase yields. Having identified the three principal factors thought to increase production risk, farmers evaluated the extent to which SG technologies were alleviating these problems. Their replies strongly contradicted the conventional wisdom that use of external inputs (particularly expensive fertilizers) increases risks; most participants (96%) claimed that the SG technologies **reduced** the risk of crop loss associated with the above mentioned problems; only 3% -- all Level C farmers -- viewed the technologies as risk augmenting.

Farmers were asked to explain their perceptions concerning the impact of the SG technologies on risk. The most common reply (62%) was ‘generic’-- that the entire combination of inputs diminished the risk of getting very low millet yields (as discussed below, farmers risk perceptions are shaped more by fears of low productivity than concerns about financial risks associated with input costs). Reduction of risk due to attacks by birds, rats, and termites was the next most common reply (16%); apparently the Apron+ makes seed unpalatable thereby reducing animal/insect damage. Several farmers (8%) commented that SG technologies reduced risks associated with poor access to land because they could increase yields on existing land. Reduction of risks associated with poor rains was mentioned by 5% -- primarily a reference to the shorter cycle seed varieties. The key concern of the 3% of farmers indicating that SG technologies increased risk was the problem of not being able to pay back the credit for the relatively expensive Level C package.

Price Sensitivity and Market Participation. Adoption literature suggests that the primary motivation for using new technologies, whether output is valued through the market or in home consumption, is the opportunity to increase net income. We were surprised to find that many participants did not appear to be evaluating the technology packages from a net income or profit perspective. There is fairly strong survey evidence that millet production decisions for approximately half the farmers interviewed are shaped more by a desire for cereal self-sufficiency than by market prices and net income. Forty-nine percent of farmers claimed that 1998 millet prices had no influence on their 1999 production decisions. Over a longer time period (1994-1999) 43% claimed that millet price had had no influence while 13% claimed that price had occasionally influenced decisions and 44% claimed that price was always considered.

Among the 49% of farmers claiming that 1998 prices didn't influence 1999 production decisions, 53% pointed out that their planting decisions were based entirely on food self-sufficiency objectives, 13% said that their goal was to increase production regardless of market prices, 9% claimed that market prices were too volatile to be a factor in making production decisions, another 9% indicated that millet prices were generally too low to stimulate production of a marketable surplus (suggesting that price really does play a role in decisions!), and 6% indicated that their goal was primarily food self-sufficiency -- sales were only considered in the rare cases when production surpluses were achieved.

For the 51% of farmers who did use prices as input to 1999 production decisions, 47% said that higher prices inspired them to increase and/or intensify production (some as a means of avoiding purchases of high-priced cereals, others in an effort to market a surplus); 31% said that price changes led them to diversify (generally moving out of millet into more profitable crops).

Much of the fertilizer adoption literature suggests that sustainable adoption is more likely to occur among farmers who produce marketable surpluses of crops that can provide adequate income to cover input costs. The high degree of autarky prevailing among SG participant farmers (37% declaring that more than 75% of income comes from home produced/consumed production) and the large share of farmers (49%) apparently not considering prices in their production decisions raises serious questions about the long-run sustainability of adoption for the relatively expensive Level C package. Although some of the explanations as to why prices did not influence production suggest that prices may play a more importance role than farmers acknowledge, informal discussions with many participants suggest that there are few farmers who have a clear strategy linking production and marketing decisions.

6 Profitability of Participants Test Plots

Although a focal point of the SG approach to technology promotion is the use of farmer-managed control and test plots, the control plots frequently do not represent a true control because farmers use *normal* practices. What is *normal* can differ among farmers – some control plots received applications of inorganic fertilizers and/or Apron+, others received quantities of manure that differed from those applied to the test plot, and others received nothing but traditional seed. This variability makes life easier for participants but it makes it difficult to accurately measure the yield response and profitability of the recommended package. In an effort to evaluate the impact of fertilizer recommendations we restrict the present analysis of the Level C technology to participants who (1) did not use any fertilizer on their control plots and (2) applied the same amount of manure on both the control and the test plots.

Partial budget results (Table 1) show that in 1999 the Level A technology (costing 1,025 FCFA/.25 ha plot) was much more profitable than the Level C technology (average cost of 7,173 FCFA/.25 ha plot). All Level A farmers realized positive returns. The value/cost ratio for the package was 10 and the average net benefit was 9615 FCFA. This net benefit is the equivalent of what one would earn by hiring out labor services for 13 days at the prevailing agricultural wage. Farmers were unanimous in their praise for this package.

Table 1.Yields and Benefits of SG Technologies

	Level A Package	Level C Package
Cases	40	26
Avg. yield increase	133	138
Avg. value of increased production (FCFA)	10640	11031
Avg. supplemental cost for test plot (FCFA)	1025	7173
Net benefit (FCFA)	9615	3858
Value/Cost ratio	10	1.5

Source: INSAH/MSU/SG 1999 survey data, Segou Region.
Notes:
(1) US$1.00 = 600 FCFA;
(2) Millet price is 80 F/kg (1998/99 mean in the study zone).
(3) Level C package costs is 8150 fcfa; average supplemental costs are slightly less because we made adjustments for cases where

Average returns to the Level C package were 3858 FCFA and the value/cost ratio only 1.5.[1] Although a common rule of thumb is that a v/c must be at least two to stimulate demand for a technology package (even three or four

[1]A shortcoming of the partial budget analysis is that the slow-release phosphate rock is unlikely to have produced a yield response in the year it was applied. A multi-year analysis of the package capable of measuring residual effects could raise the profitability.

in risky environments like the Sahel), 53% of the farmers thought the package was "profitable". The average return masks a high degree of variability. Ten farmers had losses ranging from 1000 to 9000 CFAF. Four of these ten farmers who had losses from 1000 to 5000 CFAF, considered the package profitable. Among the farmers with positive returns, 43% either found the package unprofitable or only marginally so; returns for this group were in the 500-10,000 CFAF range. The five farmers with returns greater than 10,000 FCFA were unanimous that the package was profitable.

Given the small sample size for the Level C technology package, linguistic problems associated with translating words such as "profitable" into local languages, and participating farmers' limited experience with purchased inputs and agricultural production for commercial purposes, we do not want to make too much of the apparent differences between the profitability analysis and farmers' perceptions of profitability at this point in time. Informal discussions with farmers provide some insights. Several farmers appeared to have evaluated the technology from a whole-farm perspective; although the cost of inputs was greater than the market value of increased production, farmers valued the increased cereal production enough to cover input costs with receipts from other farm activities (animal or peanut sales). In the long run, producing more millet on less land frees up land (and perhaps labor) for production of other crops. Another insight from informal discussions was that many farmers in this drought-prone zone (where one measure of social standing is the number of full granaries a household possesses) might have been more interested in maximizing cereal production than cash income. These insights suggest that SG may want to spend more time in the future doing profitability analyses jointly with farmers in an effort to improve researchers' and extension agents' understanding of farmers' evaluation methods and criteria.

Given that SG efforts to introduce improved techniques to Segou cereal farmers is in its infancy (3rd year of test plots) and SG was unable to properly test their intermediate Level B technology, it is too soon to draw broad generalizations about the overall effort. The program design, based on the sequential introduction of more expensive and risky technologies in this zone of relatively poor farmers, has substantial merit. Farmers gained experience in the SG approach the first year using the very low-risk Level A package–they were extremely satisfied with the results. The rapid jump up to Level C technology appears problematic given our analysis of financial returns, BUT farmers remain enthusiastic about the higher yields obtained. The next few years of the program will be critical as SG searches for some combination of ARM practices and inorganic fertilizers that can be financially sustainable over time.

Farmers were asked what could be done to improve adoption and profitability of these technologies. Among the most frequently mentioned suggestions were: assistance with acquiring more animal traction equipment, greater flexibility in package composition (input selection *à la carte*), more timely input delivery, and better monitoring by extension agents.

7 Lessons Learned and General Implications

SG has taken a bold step by introducing high external input technologies to farmers in risky production and marketing environments. The program is young, but already there are some important insights concerning the agroeconomic and socioeconomic aspects of promoting agricultural intensification in high-risk environments of SSA.

Agro-economic lessons. Although the technologies introduced have gotten high ratings from farmers for increasing yields and decreasing production risk, both yield response and aggregate yields remain modest and few farmers are producing marketable surpluses. Without marketable surpluses, agricultural intensification is unlikely to contribute to the development of food marketing systems that provide all consumers (including farmers) with low-cost, reliable food supplies -- a prerequisite for all types of broad-based economic growth. There is strong survey evidence that in the short-run, low-cost, improved seed and seed treatments can increase incomes to a much greater extent than more expensive fertility enhancing technologies. The dilemma is that the short-run gains due to the former are unlikely to be sustained without some increased use of the latter. The challenge of identifying profitable soil enhancing technologies for low-productivity, high-risk areas remains. This requires not only more agronomic research to identify the most productive combinations of PNT, NPK, organic matter, and soil conservation investments but also financial analyses to evaluate profitability and ways of reducing input costs.

Socio-economic lessons. If agricultural intensification is to promote an agricultural transformation capable of rendering the dire UN predictions for the year 2025 invalid, more effort must be devoted to moving farmers in high-risk areas from a production strategy focused on food self-sufficiency to one focused on increasing overall farm and household income. Survey results on farmers' risk perceptions, use of price signals, degree of market integration, and methods of evaluating returns to new technologies suggest a need for extension programs focused on developing farmer skills in marketing, financial analysis, and evaluation of debt carrying capacity. The situation in SSA is too precarious to sit back and think that once the right technology is identified all else will fall into place – particularly in high-risk production areas.

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