Improving Marketing Strategies to Accelerate Technological change for the basic Cereal: The Niger Case

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Introduction

Niger is characterized by low and erratic rainfall and low soil fertility. Increased agricultural production will require increased input use because of low nutrient levels in the soil and continuing nutrient depletion as the fallow system beaks down with population pressure. Despite the availability of new technologies developed by agricultural research, adoption rates have generally been low. In regions where substantial adoption rates have been reported, farmers are reducing the quantities of inorganic fertilizer use because of decrease in the profitability due mainly to lower relative price of traditional cereals.

Low cereal prices have been identified as one of the principal cause of slow intensification in Sahelian countries (Sanders et al., 1996). Investment in food crops has not been very profitable due to severe price variation (seasonal and between years), and governmental preoccupation with keeping food prices low. At harvest due to increased supply of grain, millet prices are at their lowest point of the year, yet farmers have to sell at that time because of income requirement for household and farm expenses. Moreover, in good rainfall years, the millet price collapses, due to the higher supply and inelastic demand. Finally in bad rainfall season when supply is short, millet price do not get to fully increase because government and NGOs often intervene by selling grain on the market at lower price.

Higher and more stable prices lead to increase in purchased input use as well as increased production (Jayne et al., 1997, and Rohrbach, 1989, cited in Yangeen et al, 1997). Angé, 1997 (cited in Yangeen, 1997) noted that low output price is reducing the use of fertilizers. Rather than risk or lack of liquidity, adoption of the new technologies is slowed by low expected prices received by farmers due to seasonal price variation and price collapse in good rainfall years. Another problem is that in adverse rainfall years, the public sector and NGO provide food staples at subsidized prices driving down the price received by farmers (or merchant) in these years.

Higher prices can have short-run, adverse effects on both urban consumers and many farmers purchasing food supplies as well. This creates pressure on the government to ensure low food prices for urban consumers (Bates, 1981) and for producers who are temporary food buyers. Even in a normal cropping season, small farmers often shift from net food sellers at harvest to net food buyers later in the year (Barrett, 1996). Nevertheless, in the long run, increased producer prices are expected to lead to continuing increases in supply with falling per-unit output costs and lower food prices for the country. Many farmers will then still be able to make money due to decreasing costs. This seems to be a more appropriate objective than consistently discouraging farmers from increasing productivity by depressing product prices.

The main objective in this study is to analyze the effects of higher output prices on adoption of improved Fertilizer Based Technologies (FBT) by farmers in Niger. The study also evaluates the income effects of various agricultural policies aimed at increasing prices received by farmers.

We, (1) present the millet price variation (2) discuss introduction of new technologies (3) present the farm model used in the analysis (4) analyze the potential effects of three price policies and combinations of them and (5) draw some policy implications in the conclusions.

Millet price variation

Following a good rainfall season in the Sahel, millet production is high and prices quickly collapse. Sanders et al, 1996 argued that the high price variability especially the low prices observed in good years is a principal constraint to fertilizer application to millet and sorghum in Sahelian countries. Governments in that region are doing little to help their farmers increase their profitability from the basic grains. Producers' prices are often kept from increasing because governments are preoccupied with low food prices due to concerns of urban population (Angé, 1997, cited in Yangeen 1997). The use of few soil-fertility improvements in Niger appears to be a direct consequence of the low output prices relative to input prices; these discourage farmers from purchasing inputs necessary for increased production (Evéquoz and Yadji, 1998). The potential for intensification of the production of millet is being reduced by the continued efforts of the government to keep food prices down. For example, in July 2001, the government put 10,000 metric tons of millet on the market at a price of 100 FCFA/kg while the market price was 210 FCFA/kg in Niamey (Agence France Presse, 2001).

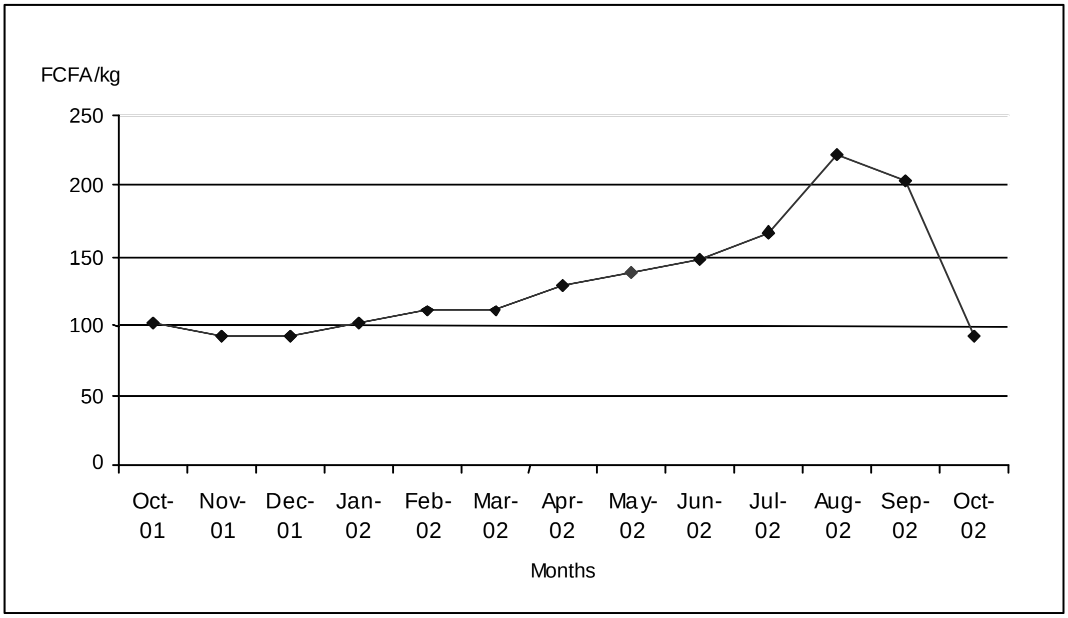

Figure 1. Millet Prices in Sae-Saboua, Maradi Niger, 2001-2002

This price collapse from both good weather and public policy discourages farmers from investing in purchased inputs (such as inorganic fertilizers and quality seeds) needed to increase their production. Instead, they continue to use a low input production strategy because it corresponds best to their low output price environment.

Historically with good rainfall conditions, prices of traditional cereals collapse. In the short run, this is a serious problem and can delay the intensification process. Millet price often start low at harvest then gradually they start to climb until they reach their peak in the "Soudure[1]" period. Once the new harvest is anticipated price start to fall to their low point in the harvest season (Figure 1).

Another recent example of price collapse has been the significant fall in cereal prices that occurred in Mali between 1998 and 2000 during three years of above normal cereal production. Millet prices also vary substantially between years depending on the type of year and supply availability. Figure 2 depicts bi-weekly millet prices observed in Dakar Senegal during the past three years. The inter-annual price variation is also a concern because the wide variation in price reduces over time profitability of investment in traditional crops.

[1] Also called the "hungry season", it is the period when food reserves are almost gone and the new crops are not yet ready fro harvest.

Why do prices collapse in good rainfall years? People can eat only so much of their basic staple, so it is difficult to increase consumption rapidly for the basic food markets or to find new markets once the price has collapsed. For the crops experiencing rapid technological change in the Sahel, price collapse has not been as frequent. For cotton, parastatals have historically fixed the prices. Rice has had rapidly growing urban markets. The niche crops of fruits, grain legumes, other vegetables, and flowers have been exported and as yet there has no been market saturation. Moderating the price collapses of the basic food staples by developing new markets is expected to encourage a more rapid introduction of new technologies.

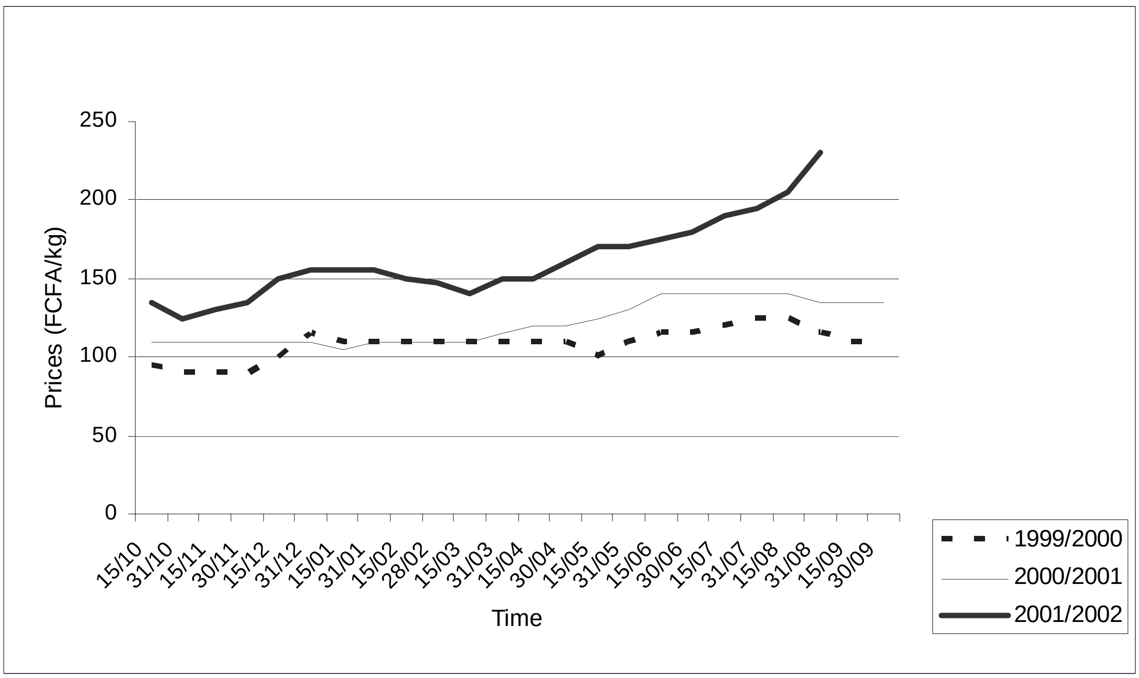

Figure 2. Bi-weekly Millet prices in Dakar, Senegal, 1999-2002.

New technologies

For soil fertility restoration (or improvement), inorganic fertilizer is critical. There are no alternatives to provide N and P cheaper though there are alternatives to complement the use of inorganic fertilizer. Despite the unfavorable economic environment, some farmers in the study region are using small quantities. In the study sample, 61% were using some inorganic fertilizer generally combined with manure and put in the seed pocket with the seed (Abdoulaye, 2002). Scientists have developed other improved technologies with inorganic fertilizer to allow farmers to increase fertilizer use efficiency and quantity applied.

The new technologies were developed and tested by ICRISAT/IFDC in on-farm trials, conducted by farmers in the region from 1996-2000. The improved fertilizer based technologies (FBT), not presently being utilized by farmers, consist of higher quality fertilization (improved micro doses, 20 kg/ha of DAP) and improved moderate doses of inorganic fertilizer (50 kg/ha of SSP and 60 kg/ha of NPK) and a higher manure and crop residue activity (2700 kg/ha of each).

In the improved FBT (new technologies), fertilizer is applied using a side dressing method (applied to the plant usually after first weeding), which is different from farmers' current practice of mixing seed and inorganic fertilizer. This leads to an increased labor requirement but is still more efficient than broadcasting fertilizer because the fertilizer is applied more directly to the plant. Three sources of nutrients are used with the new technologies: Diammonium phosphate (DAP, 18-46-0), super simple phosphate (SSP, 0-18-0) and complex fertilizer (NPK, 15-15-15). In addition to fertilizer and application methods, improved millet varieties developed at INRAN and ICRISAT are also included in the new technologies package. The new technologies are available in the modeling for sole crop millet activities and millet/cowpea activities with and without new cultivars in both cases.

Farmers' Objectives and Modeling

The study was conducted in villages surrounding the Fakara Plateau in the administrative regions of Boboye and Kollo in western Niger[2]. A sample of 100 farmers was randomly drawn and interviewed in five villages. Questionnaires in each cover household resource availability, crop production and sales and other non-agricultural activities. Farm interviews indicate that when making planting decisions, farmers are not only concerned with having enough food for the family but also with being able to meet their income requirements at harvest.

[2] Information on the production system and agriculture in Niger can be found in Abdoulaye, 2002.

A minimum income is needed at harvest to pay for many household expenses including temporary migration, debts acquired before and during the crop season, ceremonies, educational expenditures, clothing and payment to labor (direct and indirect). At harvest crop production sales are the main source of income for farmers. Coming off the rainy season, fodder is available along with crop by products for livestock feeding and farmers prefer to keep their livestock as a saving (or insurance) for later.

Subsistence farmers get their food from the crops they raise. In rural Niger most meals are millet based, the main cereal crop grown in the country. At harvest, grain is stored after harvest to be used later (Abdoulaye and Lowenberg-DeBoer, 2000). There is a trade-off between storing enough harvest to meet annual food requirements and selling some at harvest to meet income requirements. In bad years when it is difficult to satisfy both objectives, farmers in this region choose to satisfy their immediate (harvest time) income requirements and to rely on the market to provide their food requirement latter.

Producing their own food instead of purchasing it from the market comes with a cost to farmers. That cost is the opportunity cost (shadow value) of millet which indicates how farmers value having their own food stock. This cost will be determined using the subsistence food constraint and the associated millet purchase variable. Millet market price is pre-multiplying by a coefficient (λ, which is initially set equal to 1, then the model is calibrated to determine its final value), which represents the premium farmers are willing to add to the market value in order to produce and store their own food.

In the farm model, those two goals (subsistence and harvest income) are accounted for as a mean of handling risk in the system. This is an alternative way of handling production risk based on farmer's actual production goals (Sidibé, 2000, Vitale, 2001). It has the advantage of being simple and easier to verify with farmers than the more abstract trade-offs between expected income and variance used in the general framework of risk analysis. Both subsistence and harvest income constraints are satisfied using crop output. Millet grain is used both for harvest income goal and for subsistence food requirements.

Rural households often have livestock and non-agricultural activities, which are also included in the farm model. Livestock and non-agricultural activities represent alternative investments to cropping activities. The model, then, maximizes expected income subject to the two safety constraints, plus the resource availability constraints and other accounting constraints. The mathematical formulation of the farm model is as follows:

$$Max \quad EW = \sum_{s=1}^{5} \theta_s w_s \qquad (1)$$

subject to

$$P_{1is} q_{1is} \geq \bar{I}, \quad (2 \leq s \leq 5), \quad for \ all \ i \ (crops) \qquad (2)$$

$$C_s + B_s \geq \bar{C}, \quad (2 \leq s \leq 5) \qquad (3)$$

$$C_{is} + q_{1is} + q_{2is} = Q_{is}, \quad for \ all \ s \ and \ i \qquad (4)$$

$$\sum_i a_{ij} x_i + \sum_t a_{tj} x_t \leq bj, \quad for \ all \ j \qquad (5)$$

$$Q_{is} = \sum_i y_{is} x_i, \quad for \ all \ s \qquad (6)$$

$$w_s = \sum_i P_{2is} q_{2is} + \sum_t r_{ts} - \sum_i c_i h_{si} - \lambda P_{2is} B_s \qquad (7)$$

$$\sum_s \theta_s (w_s + (\sum_i P_{1is} q_{1is}) + p_{cs} c_s) = \Psi \qquad (8)$$

Where:

The subscripts are: s for states of nature, i for crops, t=other activities, 1 and 2 for crop sale periods (1=harvest and 2= price recovery period), j=resources.

E is the expectation operator

W_s is the value of after harvest sales plus net returns to other activities

θ_s is the probability of state s with $\sum_s \theta_s = 1$.

P_{2is} and q_{2is} are price and quantity sold respectively for crop i in state s in price recovery period (6 months after harvest).

r_j is the return to the jth livestock or non-agricultural activity.

c_i and h_{si} are the input cost per hectare and number of hectares of the ith crop activity in state s, respectively.

λ is the premium farmers are prepared to pay for avoiding market dependence in obtaining their basic grain supply, initially set equal to 1.

P_{1is} is the price in state s for crop i at harvest.

q_{1is} is the quantity sold in state of nature s for crop i at harvest.

$\bar{I}$ is the minimum income required at harvest

$\bar{C}$ is the required quantity of millet for household subsistence

C_s is the quantity of millet produced for home consumption in state s

B_s is the quantity of millet purchased for home consumption in state s

Q_{is} is the total production of crop i in state s

x_i is the hectares of land of each cropping activity

y_{is} is the yield per hectare of activity I in state of nature s

p_{cs} is the price for millet produced and consumed by the household

Ψ is the expected total household income

a_{ij} are the technical coefficients

x_{ts} is unit of other activities (livestock and non-agricultural) in state s.

b_j is availability of resource j.

The objective function (equation 1) is the probability of the states of nature multiplied by the after harvest income (equation 7). The minimum harvest income goal is defined by equation 2. Equation 3 represents the subsistence food constraint. Equation 4 is an identity, which defines total crop output. Equation 5 determines the resource availability for all activities. Equation 6 is an identity that defines total crop output (area multiply by yield). Equation 7 defines the after harvest income to be maximized. Equation 8 is another identity used to recover annual household income.

Validation

Once new technologies (before policy) are introduced in the model, all crop area is fertilized (Table 1) because of the potential higher yields from the new technologies with fertilizer is substantial. This is an important result for this region. Soils are poor and continuous cropping without nutrient replacement can further degrade the soils.

Table 1. Model results with and without new technologies.

	Current System (No New Technologies)	Introduction of New Technologies
1. Current practices (ha)		
No fertilizer	2.68	-
Small doses of fertilizer	3.32	-
2. New technologies (ha)		
Micro doses	-	3.49
Moderate doses	-	3.51
Expected Income	336026 FCFA	435686 FCFA
Income increase from previous system	-	30%

Source: Model results

Introduction of new technologies without change in the current policy takes place and increases farm incomes (Table 1). The income increase is 30%, which comes from the higher yield potential of the improved FBT compared to traditional practices. Farmers shift towards a combination of sole crop millet with higher quality fertilization (improved micro doses with DAP) and adoption of new cultivars with the improved moderate doses of millet/cowpea technology. New varieties tend to respond better than traditional varieties to higher fertilization, as traditional varieties are selected over time for yield stability under low inputs rather than for yield response under higher input levels.

These model results are consistent with survey results and previous study in the region indicating inorganic fertilizer use by farmers (Mokwunye and Hammond, 1992). Improving prices is expected to increase diffusion and farm incomes.

Potential effect of policies

The current low relative price of millet is not favorable for continued intensification of millet based production system. In absence of the new technologies, the gains from the policies are expected to be minimal. The gain from the price policy is higher when new technologies are already present because they allow farmers to have access to more productive option.

Model simulations are used to evaluate the potential impact on new technology adoption and farm incomes of moderating the seasonal millet price collapse, reversing the current low food price public policy, the implementation of an inventory credit system (*warrantage*) and combinations of these policies.

Moderating the price collapse

Millet price collapse can be moderated by expanding the product market. Currently millet is mainly used in local dishes. There exist many potential new uses for millet in the Sahel. Research has developed several millet processed products that are on the markets. Packaged couscous and a series of other millet products are increasingly available across the Sahel especially in Dakar and Bamako. In Dakar, there are 11 local firms producing processed millet products including, Tchakri-Yogurt, Arraw, Dégué, flour and Infant food (ROCAFREMI, 2002). Moreover, some of those small scale food processors are even exporting to West Africans in Europe and the US. As with rice the new millet products can be taken out of the package and boiled.

Big gains in demand for cereals can come with the shifting dietary patterns for animal products, especially poultry. Developing the improved markets for processed human food and anticipating this rapid growth in feed grain demand can be a combined strategy for expanding domestic markets. The potential for the sorghum and millet producers to capture the demand in these emerging feed markets will depend upon their ability to compete with other grains, such as maize. Millet, however, is a good animal feed and locally produced millet can benefit from reduced transportation costs as compared to imported maize.

The initial impact of the evolution of new product markets for traditional crops such as millet is expected to be the moderation or elimination of harvest time price collapse in good rainfall years. This scenario was simulated assuming that the in good and very good states of nature, millet prices will reach their normal year levels. An increased millet price in good rainfall year will not only reduce price variability but also increase the expected profits from millet production. The total household income increase is 35% when elimination of good harvest price collapse (A) is combined with new technologies adoption (Table 2).

Reversing the low food price public policy

The current low food price policy stems mainly from government preoccupation to protect both urban consumers and some farmers, who are net food buyers. However, by depressing food price they are hindering intensification efforts because with low prices farmers make minimal to no profits and are discouraged from making the necessary investments to increase production.

The depressing effect on investments intensifying millet production is not only coming from the government but also from development projects and NGOs involved in food aid and other assistance programs. The unintended effect of those programs that bring in substituting products such as maize or wheat is to keep millet prices low. However, farmers need sufficiently higher output prices to justify the investments needed to increase production.

Expected millet price also increases with a reversing of the current low food price policy. In the model, the simulation on reversing the current low food price policy assumes a conservative increase of 40% in millet in adverse and very adverse years. Unlike the previous case, increase in millet price for adverse years will increase the expected price, but increase price variability and increase profitability of purchased inputs use.

Model results indicate that reversing the current low food price policy (B) will lead to a 48% income increase after new technologies are introduced (Table 1). The higher price of millet allows for harvest income requirement to be achieved with less grain, leaving a high portion of millet to be sold later in the year when prices have further recovered.

Implementing the warrantage

The inventory credit system also called *warrantage* is a program currently being implemented in some regions of Niger and other West African countries by development projects. The *warrantage* program is an inventory credit system where farmers borrow against their stock of cereals. The program helps farmers to have contact with financing agencies, which lend money to farmers through their co-op at harvest. Loan repayment is guaranteed by the farmer leaving a stock of his cereal in a warehouse under the supervision of a coordinating agency. The cereal stock is sold 5-6 months[3] later allowing farmers to repay their loans and profit from the price recovery. Farmers have been able to realize a profit even with the high interest rate of 21% for 5 months (République du Niger, 2000). The *warrantage* program thus allows farmers to take advantage of the price recovery later in the year. Farmers are able to achieve their harvest income goals without being forced to sell their cereals at the annual low point of cereal prices. So, the *warrantage* program eliminates the need for early sales thus allowing farmers to take advantage of the higher prices later in the year.

There are two expected effects from the *warrantage* program. First because farmers sell crops latter in the years, they receive higher prices. Second, by providing farmers with cash at harvest, it eliminates the need for harvest time sales. Without government intervention to drive the price of millet down with imports and, the relative price of millet is expected to increase by 30% from its current value[4]. This increase corresponds to an increase in the price of millet from 113 FCFA to 147 FCFA in a normal year. This level of increase is not unusual in Niger where price increases of 50% between harvest and the next planting season are common (République du Niger, 2000). The overall expected price for millet is increased, thus the price of millet is higher both at harvest and also at the price recovery period.

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[3] The actual sale date is set by the co-op after a majority of farmers agree that prices are high enough.

[4] The current expected relative price of millet to inorganic fertilizer (millet price/NPK price) is 0.52. It varies from 0.94 in very bad states to 0.19 in very good state.

The increase in expected farm income is more significant when it is compared to the expected farm income from the current system. The combined effect of introduction of new technologies and change in the policy would be a 49% increase in farm expected income compared to the current system. This is an important result, which has implications for policy makers and donor agencies. Activities geared toward accelerating the introduction of new technologies have a significant impact on farm expected income.

Table 2: Land allocation and Income effects of selected price policies, model results

	New technologies + No price collapse in good years (A)	New technologies + No government intervention in bad years (B)	New technologies + *Warrantage* (C)
1. Current practices (ha)			
No fertilizer	-	-	-
Small doses of fertilizer	-	-	-
2. New technologies (ha)			
Micro doses	3.61	2.46	3.96
Moderate doses	2.39	3.54	2.04
3. Household Income (FCFA)	455410	497420	502296
4. Percent change	35%	48%	49%

Source: Model results

Combining price strategies

Following the previous analysis where each price policy was considered alone, this section is concerned with combined effects of policies. The combinations are considered after new technologies introduction to analyze how their presence can enhance household income. The three policies analyzed in this paper are not mutually exclusive. Instead they can be combined to produce lager effects. Millet price could be increased in both bad and good rainfall years as explained above (A+B). Another simulation included here considers a reverse in the current low food price policy while implementing the inventory credit (*warrantage*) system (B+C). We could also consider a scenario with no millet price collapse in good years is combined with the *warrantage* (A+C). These price increasing policies can then be coupled with *warrantage* to eliminate harvest sales and allow farmers to take advantage of the price recovery latter in the year (A+B+C).

Table 3: Potential income effects of selected price policies, model results

	New technologies + No new policy	A+B	B+C	A+C	A+B+C
Household Income (FCFA)	435686	514698	534310	565589	610095
Percent change	-	18%	23%	30%	40%

Source: Model results

B = New technologies + No price collapse in good years, C = New technologies + No government intervention in bad years and D = New technologies + *Warrantage*

As expected combining the different price policies yield higher impacts on household income. Without the millet price collapse in good rainfall years and with the millet price allowed to increase in bad cropping season, household income is increased by 18% compared to the scenario with new technologies alone (Table 3). The model takes advantage of these price increases to satisfy harvest income and subsistence food constraints using a smaller portion of total production leaving more grain to be sold latter in the year when prices are higher. The largest impact of 40% compared to new technologies alone (Table 3), is achieved when the three policies are combined. In this scenario, elimination of harvest income constraint with the *warrantage* leads to a higher available marketable surplus when prices recover. With better millet prices now (no price collapse and government intervention), sales in all states of nature increase leading to a higher household income. Between the above two other combinations also lead to increases in household income.

Conclusions

In order to increase agricultural production and reduce the current trend of continuous soil mining without nutrient replacement, agricultural policy in Niger needs to focus on making sure that the economic environment is such that farmers can continue to profitably invest in inputs. Also for the intensification process to accelerate, farmers need to make higher profits on the investments they make. Eliminating the effect of price collapse would result in farmers using higher quality fertilizer technologies, which is necessary to reverse the current trend of soil mining.

Millet price collapses in good rainfall years due to inelastic demand and the higher supply from the increased production. Evolution of new markets for millet will moderate this price collapse. There are emerging markets for traditional cereals for both human food and feed. Good quality control in both production and processing of millet will determine the future of these emerging processed millet food industries. The institutional changes for farmers to produce a high-value, quality controlled millet that can be reliably delivered to a food processor or a feed mixer will require substantial organizational effort on the part of millet farmers.

It is imperative that government stops the policy of artificially maintaining prices of cereals low by driving down the millet prices with subsidized imports.. There are other instruments for addressing poverty issues besides food prices. Food prices need to give signals to farmers to increase current capital expenditures because intensification will be profitable for them. In the long term technological change enables falling per unit output costs so prices can fall moderately with both farmers and consumers still benefiting.

Most cereal producers feel strong pressures to sell their products at the post harvest price low. Then strategies such as warrantage will allow them to take better advantage of the increased marketable surplus from new technologies and increase their income. The higher income will ensure that farmers can continue to afford investing in the new technologies.

A critical factor for adoption of new technologies is improvements in rural infrastructures as they will allow farmers to have higher output prices and lower input price with the reduction in transportation and storage cost. Governments can also facilitate the evolution of input/output markets. Specifically developed input markets can ensure timely availability of inorganic fertilizer and improved seeds at the village level.

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