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118

THE ECONOMICS OF SMALL-SCALE WHEAT PRODUCTION TECHNOLOGIES FOR KENYA

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Abstract

The economics of alternative wheat production technologies for Kenya are analyzed in this paper. A wide range of technologies were considered, from the current mechanized methods to highly labor-intensive methods. The costs of the main operations within the wheat growing calendar were budgeted for different scales of technology (mechanized through labor intensive). These budgets were prepared for various field sizes on farms (from 0.4 ha up to 40 ha). On very small fields, wide mechanical equipment (combine harvesters and mechanical sprayers) became highly inefficient, combines taking 160% more time to complete a given area than when working on very large fields. Narrower equipment incurs much smaller efficiency losses on small fields, for example, only 28% for three-disc plows. Costs of alternative technologies were based upon information from research in Kenya and from other countries. Generally, the labor-intensive technologies were more profitable for farmers only on very small fields, and labor-intensive wheat was no more profitable than maize, the main alternative crop. For large fields, mechanized wheat was more profitable than labor-intensive wheat. The study suggests that if Kenyan wheat researchers are to further promote small-scale technologies, they should concentrate their efforts on spraying and harvesting.

Introduction

Kenya is a net importer of wheat and is projected to remain so to the end of this century. Wheat is grown in Kenya using mechanized production methods that differ little from what might be observed in many industrialized countries. These methods contrast markedly with wheat-growing methods in many parts of the Third World where more labor-intensive practices are followed.

In Kenya, wheat is not traditionally a small-holder crop, although it is grown on small farms. Maize is the traditional staple food crop on many small farms of Kenya. As a consequence, when wheat land has been settled by small-holders in Kenya, they have switched from wheat to maize and, to a lesser extent, dairying. Since Kenya is largely self-sufficient in maize production, policy makers and researchers are seeking to promote small-scale, labor-intensive wheat technologies. This decision is based partly on the need to promote employment and income in the rural sector. Given Kenya's high population growth rate and comparatively low wage rates, substituting labor for capital in agriculture has been a central feature of post-Independence land settlement programs. With rural wages of Kenya no higher than in many countries where small-scale wheat technologies prevail, there is considerable interest in knowing if such technologies would be profitable for Kenyan farmers.

Wheat occupied about 100-120,000 ha of Kenya's arable land in the 1980s. However, this was only some 2-3% of the total area of crops and pastures (5). Data from previous studies suggested that the area of small-holder wheat in Kenya might be around 15% of the total wheat area. However, in considering the potential for small-holder wheat in Kenya, current area is probably less important than an assessment of potential area. Considerable potential would exist to expand wheat on small holdings, if it was profitable for farmers compared with alternative crops and dairying.

This paper presents an economic analysis of small-holder wheat technologies for Kenya. The analysis is reported in much more detail in Longmire and Lugogo (4). Since small-scale wheat technologies are not used in Kenya, technical information was superimposed from other countries, particularly Pakistan, where such technologies are well established. The analysis involved costing alternative operations of different wheat and maize technologies for different sizes of fields. The time required for operations to be done 1) by machinery of different sizes, 2) by bullocks, and 3) by manual labor with hoes, sickles, or by hand was specified. This provided the basis for costing alternative operations and hence technologies having widely differing degrees of labor intensity for wheat.

In addition to costing technologies with budgetary analysis, the profitability of alternative wheat and maize technologies was analyzed. This was done using 1987 prices of inputs and outputs for the Nakuru district. Besides the analysis of farmer profitability, the national profitability (social profitability) was assessed. National profitability provides a measure of comparative advantage of alternative technologies for wheat and maize in Kenya. Some key parameters were varied to analyze the sensitivity of the results to underlying assumptions.

Yield Losses and Timeliness

A survey of 45 small-holder wheat farmers in the districts of Nakuru and Eldoret during May and June 1986 suggested that lack of timeliness in performing certain operations was a key factor affecting wheat yields (4). Average yields reported by the small farmers was 2.6 t/ha, in 1985, about 20% below the averages reported for all farmers in these districts. Some 76% of small farmers assessed that they suffered yield losses because operations were not done on time and the average loss (as estimated by farmers) was 22%, or some 580 kg/ha wheat. Such a loss translates into a reduction in profit of over 1600 Ksh/ha (at the exchange rate prevailing, almost US$100).

Late harvesting was considered to be the main source of yield loss on small-holder wheat farms, with 55% of farmers ranking this as the main source of yield loss. Another 33% reported planting delays to be the main source of yield loss, while only 8% felt that delays in plowing caused the greatest loss. The importance of timeliness of operations on wheat yields is supported by agronomic studies conducted by wheat researchers in Kenya, Tanzania, and Ethiopia (see other papers in these proceedings and earlier reports).

Farm contractors in Kenya generally charge similar rates for their services, irrespective of the size of the field in which their operations are undertaken. As a consequence, contractors greatly prefer jobs on large farms because they are more profitable and incur less contractor overheads and financial risk per area completed. Jobs on small farms receive low priority and are usually the last, or near to last, to be done in any area. It is for this reason that small-scale wheat farmers have problems completing some operations on time, especially harvesting.

Costing Operations by Field Size

The time required for machinery to complete the main operations on fields of different sizes was calculated using spreadsheet analysis. Information was obtained from machinery contractors in Kenya on average working speed, working width, road speed, distances travelled from field to field, time to set up in a field, time to service machinery and daily work hours. Some key results are

presented in Table 1. Generally, the smaller the field, the more machinery time is required to finish a given area. Compared to large fields, more time is lost in a working day in small fields in turning, headland overlap, setting up machinery in each field, and in moving from field to field.

The analysis suggests that on very small fields of 0.4 ha, 28% more time was required to plow a given area compared with plowing the same area on very large fields. For combine harvesting, 160% more time was required. In contrast to heavily mechanized operations, labor-intensive operations on small fields require very little, if any, extra time to complete a particular area. The diseconomies of size with machinery on small fields suggests that on small holdings labor-intensive wheat technologies might be more economic than the mechanized technologies currently used.

Using information from Gardezi et al. (1), ICRISAT (2), Longmire et al. (3), Smale (6), and Tanner and Ransom (7), the time required to complete a particular area was estimated for all scales of technology (from most machinery-intensive to most labor-intensive). From these, the costs per hectare of alternative operations were calculated for different field sizes. The results are presented in Table 2. Apart from using bullocks for certain operations, labor-intensive methods of plowing, cultivating, and planting were generally no cheaper than using a tractor, except for very small fields (1 ha or less). In contrast, labor-intensive harvesting technologies became cheaper than the full costs of combine harvesting at a field size of just under 4 ha, and was less than half the cost for the smallest field size.

Although labor-intensive harvesting of small fields was cheaper than the cost of combine harvesting, it was estimated to cost more than the prevailing charges of contractors of 500 Ks/ha. Hand cutting and threshing with a large mechanical thresher was estimated to cost about 25% more than the current contractor rate. For this reason, small-holder wheat farmers in Kenya would find labor-intensive wheat technologies attractive only if the technologies sizably reduced losses caused by harvest delays from having to wait for contractors.

Profitability of Alternative Technologies

An analysis of the profitability of a range of wheat and maize technologies using 1987 prices was undertaken. The technologies for wheat were:

- Oxen/manual: land preparation by oxen, broadcasting, harrowing in with oxen, manual weeding, manual harvesting and threshing.

- Small motorized: land preparation by small 7 hp two-wheeled tractor, manual broadcasting, harrowing in by small digger, knapsack spraying, cutting with reaper attachment, threshing with small motorized thresher.

- South Asian: land preparation by large tractor, broadcasting, harrowing in by offset disc, knapsack spraying, cutting manually, large mechanical thresher.

- Fully mechanized: as currently used.

Similar technologies for maize were also analyzed.

Yields and input levels were representative of wheat production in the Nakuru District. Yields, for example, were 2.8 t/ha for wheat and 3.5 t/ha for maize. The results are presented in Table 3. These suggest that fully mechanized wheat is the most profitable alternative on large fields. On very small fields, however, maize and labor-intensive wheat technology were approximately equal in profitability and superior to fully mechanized wheat. Labor-intensive wheat showed greater profitability than fully mechanized wheat on field sizes less than 4 ha.

Analysis of comparative advantage was also undertaken to assess which of the wheat technologies were most profitable from the national perspective. This "social profitability" analysis involved estimating the "opportunity" prices of all inputs and outputs (that is, prices that have been adjusted to be free of all government policy effects, and short-term commodity price fluctuations). The results for costs of operating a tractor and combine harvester under actual farmer prices and under opportunity prices are presented in Table 4. Generally, using the opportunity prices of inputs led to lower machinery costs than using farmer prices, because the lower costs of repairs and fuel tended to outweigh higher capital costs associated with higher interest rates and higher prices of imported machinery. Assuming opportunity wage rates equal to current levels, and with opportunity prices of outputs applicable equally to all scales of technology, the more-mechanized technologies were favoured slightly.

The results of the national profitability analysis are presented in Table 5. In this case, all except the most profitable technology show negative profits, since the opportunity cost of land in these is the profit foregone from the most profitable alternative. National profitability is positive for fully mechanized wheat technology on large fields, indicating that in Kenya a comparative advantage exists in producing wheat on large farms with machinery-intensive technologies. On small fields, labor-intensive wheat was more nationally profitable than fully mechanized wheat. However, producing maize with labor-intensive technology was slightly more profitable to Kenya than producing wheat with labor-intensive technology.

Sensitivity analysis was undertaken to assess how reliable these findings were under different price assumptions. It was found that labor-intensive wheat became more profitable than maize with a 4% increase in the opportunity price of wheat. This suggests that if policy makers strongly favour small-holder wheat over maize, and adopt a program to promote it, the efficiency cost of pursuing such a strategy would be comparatively small. A major factor in whether or not to promote labor-intensive technologies for wheat is the likely course of real wages and the availability of labor to do the tasks. With rapid population growth, there is a strong chance that the opportunity wage rate in the future will be below the current wage rate. However, by lowering real wages with sensitivity analysis, the national profitability of maize increased relative to that of labor-intensive wheat. This result occurred because maize is more labor-intensive than the potential labor-intensive wheat technology. The profitability of different scales of technology was also found to be comparatively insensitive to changes in the real interest rate.

Conclusions

Whether or not to devote more resources to small-scale wheat technologies in Kenya is a decision that will be based on a number of considerations, such as profitability, effects on employment, on distribution of income, and on foreign exchange as well as the likely uptake of the research results. Our analysis generally shows that, according to these criteria, small-holder wheat in the Nakuru district offers little or no advantage over maize, since maize grown with labor-intensive technology can offer employment, income for small farmers, and foreign exchange efficiency comparable to small-holder wheat. The economic advantage of maize production depends on the natural advantages that exist in different locations for the two crops on small holdings. Where conditions favor wheat production more than our analysis has assumed, small-holder wheat will offer greater profitability to farmers and to the nation than maize.

The potential for small-holder wheat also depends on two other key factors:

- The availability of a pool of casual labor to do the cutting, stacking, threshing, and other tasks involved.

• Farmers' preferences for one crop over another. Nevertheless, the low opportunity cost of labor suggests that the potential exists for labor-intensive wheat production, as occurs in neighboring Ethiopia.

The results of this study raise several issues for further research. First, more information is needed to assess sources of yield losses on small holdings. Additional data on sources of yield losses could be obtained by a more extensive survey of small-holders who grow wheat. That information might be supplemented by further on-farm analysis of the relationship between planting dates and wheat yields, and between harvest dates and yields. Second, information could be gathered on potential areas for small-holder wheat in Kenya, areas where wheat is currently grown on smallholdings, yields of wheat and competing crops in major production districts, and so on. Finally, analyses similar to this one might be conducted in other districts of Kenya to assess whether the natural advantages of wheat are sufficient to warrant promoting small-holder wheat technology.

If small-holder wheat technology is to be developed further in Kenya, this study suggests that focusing on harvesting technology is probably the most cost-effective strategy. A central element of the strategy with respect to labor-intensive wheat harvesting must be preventing losses by improving the timeliness of operations. If small-scale wheat farmers do not perceive gains in yield (from savings in crop losses) they will be unlikely to switch from their current technologies to others.

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Table 1. Estimated time required to complete 1 hectare for different machinery operations, by field size.

	Field size				
	0.4 ha hr/ha	1 ha hr/ha	4 ha hr/ha	10 ha hr/ha	40 ha hr/ha
Tractor with:					
3-disc plow	3.2	2.8	2.6	2.5	2.5
2-way disc harrows	1.6	1.2	0.9	0.9	0.8
seed drill	1.5	1.0	0.8	0.7	0.6
boom spray	1.2	0.7	0.4	0.3	0.3
Combine harvester	1.3	0.9	0.6	0.6	0.5

Table 2. Costs per hectare of selected operations for different field sizes.

	Field size				
	0.4 ha Ksh/ha	1 ha Ksh/ha	4 ha Ksh/ha	10 ha Ksh/ha	40 ha Ksh/ha
Plowing					
Tractor	643	564	517	504	496
[illegible] oxen	236	230	226	225	224
[illegible]nual	1080	1080	1080	1080	1080
P ing					
[illegible]or & drill	392	275	203	182	168
[illegible]adcast & oxen	270	264	259	258	257
Broadcast & manual	188	188	188	188	188
Spraying					
Tractor & boom	279	167	99	80	67
Hand sprayer	29	24	22	21	20
Hand weeding	150	150	150	150	150
Harvesting					
Combine harvester	1120	761	543	485	444
Reaper & thresher	737	688	657	648	641
Sickle & thresher	623	623	623	623	623
All manual	646	646	646	646	646

Table 3. Profit per hectare of alternative technologies, by different field sizes.

	Field size				
	0.4 ha	1 ha	4 ha	10 ha	40 ha
Maize					
Manual	2,303	2,303	2,303	2,303	2,303
- Oxen	3,639	3,652	3,661	3,664	3,667
- Tractor	2,527	2,858	3,062	3,118	3,158
Wheat					
- Oxen/manual	3,632	3,880	3,997	4,002	4,006
- Small motorized	2,926	3,148	3,171	3,204	3,230
- South Asian	2,885	3,332	3,625	3,703	3,758
- Reaper/ thresher	2,759	3,260	3,586	3,674	3,738
- Fully mechanized	2,705	3,672	4,286	4,450	4,566

Table 4. Breakdown of costs of tractor and combine harvester operations calculated using actual farmer prices and opportunity prices, 1987.

	Cost per hour for:			
	Tractor		Harvester	
	Actual prices Ksh/hr	Opportunity prices Ksh/hr	Actual prices Ksh/hr	Opportunity prices Ksh/hr
Depreciation	23.0	25.3	163.9	180.2
Capital cost	18.3	25.1	65.1	89.4
Fuel and oils	48.7	42.8	67.0	58.8
Repairs & maintenance	44.6	33.9	464.7	268.9
Operator labor	2.5	2.5	2.8	2.8
Contractor overheads	13.7	13.0	76.4	60.0
Total	151	143	840	660

Note: The purchase price for farmers of a new tractor was Ksh 343,000, and of a combine harvester, Ksh 1,223,000. Using opportunity pricing, a new tractor was estimated to cost Ksh 377,000 and a new harvester, Ksh 1,345,000. For more details see (4).

Table 5. National profitability of alternative wheat and maize technologies by different field sizes, 1987.

Wheat and maize technology	National profitability per ha Average field				
	0.4 ha	1 ha	4 ha	10 ha	40 ha
Wheat, labor intensive	-301	39	-544	-683	-781
Wheat, South Asian	-933	-622	-854	-924	-974
Wheat, fully mechanized	-774	-39	554	683	781
Maize	301	-114	-589	-730	-826