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Comparative Economics of Maize Production in Risky Environments in Zimbabwe[1]

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Summary

Planting strategies of smallholder farmers are examined in two contrasting study areas in Zimbabwe, Mangwende (sub-humid, natural region II) and Mudzi (semi-arid, natural region IV), to show that farmers regard maize as a viable alternative to other crops for late planting in Mangwende and early planting in Mudzi. Comparative economic analysis shows farmers' assessment to be justified economically on the criterion of average returns to key labour, working capital, and land resources. However evidence suggests that farmers adjust their economic decisions according to their assessments of relative risk. The analysis was therefore extended to evaluate relative returns assuming farmers were averse to risk. The results remained unchanged and suggest that in Zimbabwe maize competes well with current alternative crops for late planting in natural region II and early planting in natural region IV. The implications of these findings for maize research and extension are discussed briefly.

Introduction

Over recent years maize has been planted on ever larger proportions of the smallholder crop production area in Zimbabwe. This increase in maize area has led to growing concern that maize will replace sorghum and millet in semi-arid areas. The Scientific Council of Zimbabwe (Gore 1987) noted that the government, in a bid to halt this trend, has made it policy to discourage farmers from growing more maize and encourage them to grow tropical small grains (millet and sorghum) and oilseeds. Extension workers are discouraging the expansion of maize area in drought prone areas (Rohrbach 1988). Concern over maize has arisen since physiologically it is less suited than tropical small grains to low and unreliable rainfall areas.

Research into short season, drought tolerant crops has been given priority, reflecting the government's desire to increase the production of drought tolerant crops in semi-arid areas. Government research (Department of Research and Specialist Services, DRSS) and extension (AGRITEX) departments defined the following order of priorities for research in the main semi-arid smallholder cropping region, natural region IV (NR IV) (Vincent and Thomas 1965), where seasonal rainfall ranges from 450 to 560 mm (DRSS and AGRITEX 1987a):

1) Cereals
   a) White grain sorghum
   b) Pearl millet
   c) Maize (including open pollinated varieties to reduce production costs)

2) Oilseed crops:
   a) Groundnuts
   b) Sunflower
   c) Castor beans
   d) Cotton (on soils with high water holding capacity)

Yet farmers are concerned with more than physiological adaptation, and so the first aim of this study was to examine whether small grain cereals and oilseeds are more viable economically than maize under farmers' current management practices in NR IV.

The literature suggests that, even though maize is more suitable than small grains in the less risky sub-humid areas of Zimbabwe (NRs II and III), it has to be planted early in the season. Some of the earliest research results on the advantage of early planting are reported in Mundy (1921), supported by further reports from Spear (1968), Wilson and Williams

1 Work summarized here was undertaken for an M Phil degree in the Department of Agricultural Economics and Extension, University of Zimbabwe, by Maxwell Mudhara under supervision of Allan Low and Godfrey Mudimu.

(1974), Anon (1983), Shumba (1984), and Chiduza and Funnah (1984). Government research and extension in Zimbabwe have devoted substantial resources to seeking alternative crops to late planted maize, such as sunflower. However, farmers in NRs II and III still plant maize late for several reasons, including avoidance of a mid-season drought, false starts to rainy seasons, and shortages of labour and draught power for timely land preparation (Hukura and Shumba, personal communication 1988). Accordingly, a second aim of this study was to look at whether under current farmer practices sunflower is more economically viable than late planted maize in NR II.

Results presented in research reports tend to use biological yield as the major criterion in assessing the performance of different crops. Waddington and Kunjeku (1989) noted that most research to date has tended to evaluate technologies solely in terms of production per unit area of land and has not looked at other criteria, such as power or cash resources, that are also important to farmers. In this paper we go beyond using simple yield assessments to compare maize with alternative crops. We also employ comparisons of the economic returns to labour, land, and working capital and attempt to account for risk considerations.

Research Methods

Two surveys were conducted in both Mangwende and Mudzi communal areas over two cropping seasons, 1987/88 and 1988/89. For the 1987/88 survey, 55 farmers were randomly selected from three villages in Mangwende and 40 farmers from four villages in Mudzi. Sixty farmers from each area participated in the 1988/89 survey.

In the 1987/88 survey, demographic data were collected using single-visit structured questionnaires. Input and output data were obtained for each field planted to maize, sunflower, or pearl millet through weekly visits. On each visit, a farmer was asked to detail all the activities carried out and amounts of inputs used in a specified field since the time of the previous visit. Just after crop maturity, land area and total grain yield were measured from each of the monitored fields.

The 1988/89 survey was also conducted over several visits. Additional demographic data were collected and farmers' cropping intentions for the season recorded. The farmers' operations were then monitored once a fortnight. At fortnightly intervals farmers were also asked to estimate the expected yield from fields that year and the proportion of years over a 10-year period when better or poorer yields were anticipated. The area of each field was measured again after crop maturity. Grain yields obtained in 1988/89 were given by the farmer in units of bags per field and converted to metric tonnes per hectare (t/ha).

Climate in Zimbabwe

Zimbabwe has a diverse climate. Vincent and Thomas (1965) classified Zimbabwe into five natural regions (NRs) on the basis of soil type and rainfall and other climatic factors. The potential of these regions for intensive crop production decreases from NR I to NR V with the progressive decrease in annual rainfall and an accompanying deterioration in soil fertility. Farmers in NRs IV and V represent 75% of the communal farmers in the country (CSO 1987). Risk in crop production increases from NR I to NR V.

While climatic factors, particularly rainfall, determine the risk of crop production in each region, the characteristics of the farm household, particularly those related to household food security, also influence farmers' perceptions toward risk.

Lineham (1972) calculated the frequencies of rainy pentads over 30 years for 30 stations to examine the occurrence of a mid-season break in the rains in NRs II, III, and IV (Figure 1). Figure 1 shows a higher frequency of rainy pentads earlier in the season and during the season as we move from region IV to II, indicating that on average the length of the season is longer for NR II than for NR IV. The probability of a mid-season drought, characterised by a fall in the frequency of rainy pentads around late January, is greater as we move from NR II to NR IV.

Thus, Mangwende (NR II) usually receives more rain and experiences lower mean temperatures than Mudzi (NR IV). See Figure 2 for the rainfall in 1988/89, an average season.

Farmers' Planting Strategies in Mangwende and Mudzi

The yields of most crops, especially maize, fall as the date of planting is delayed after the onset of effective rains (Mundy 1921). Farmers facing risk in crop production (especially in Mudzi) have limited resources with which to produce their crops, and must make difficult decisions on where to plant, when to plant, and how much land to allocate for each crop. The amount and reliability of rainfall, the type of soil in

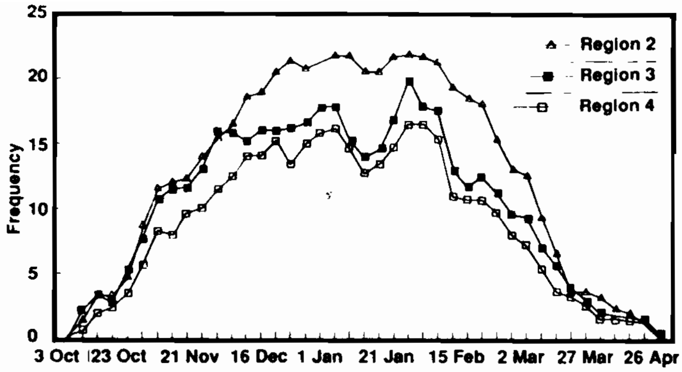

Figure 1. Frequency of rainy pentad by Natural Region in Zimbabwe (mean of 10 stations over 30 years).
Source: Lineham (1972)

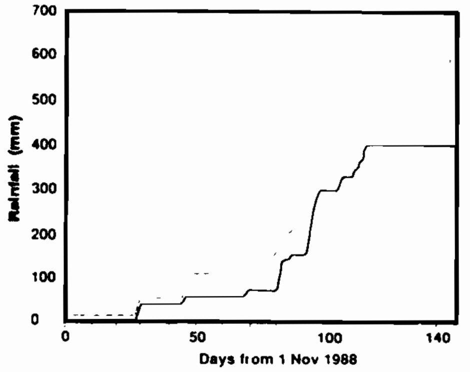

Figure 2. Cumulative rainfall in Mangwende and Mudzi, 1988/89.

a field, the distance of the field from the homestead, cash and labour available, and the objectives and priorities of the farmer are some of the factors determining planting decisions (Mudhara 1990). Here we focus on the relative timing of maize plantings versus plantings of other crops.

Figure 3 shows the cumulative percentages of the area planted to different crops after 1 November 1988 in Mangwende and Mudzi. To show the effect of rainfall on the cropping calendar, the 1988/89 rainfall distribution is plotted as well.

Responses in the surveys clearly indicated that farmers in both Mudzi and Mangwende regard maize as a crop to be planted before sunflower. But in Mangwende both maize and sunflower are considered relatively suitable for later planting. By the end of December in Mangwende, only maize and sunflower remained to be planted. By that same date in Mudzi, the maize plantings had been completed but sunflower remained to be planted. By 15 January only about 20% of sunflower had still to be planted in Mangwende, compared to more than 50% of the sunflower crop, about 40% of the pearl millet crop, and 30% of the sorghum crop which remained to be planted in Mudzi. Farmers in Mudzi recognise a high risk from planting maize in January and so have switched to planting drought tolerant crops late. However farmers appear to regard maize as unsuitable (relative to other crops) *only* for the late plantings in Mudzi. Farmers find maize productive when planted early.

This information contrasts with research and extension departments' (DRSS, AGRITEX) and other authorities' perceptions, which are that maize is relatively unsuitable compared to other crops for all plantings in NR IV and for late plantings in NR II. One reason for these contrary views may be that farmers are strongly influenced by economic returns whereas DRSS and AGRITEX evaluations are based largely on technical potential. The next sections of this paper compare the average economic returns achieved by maize and alternative crops at different planting dates in Mangwende and Mudzi.

Comparative Economics of Maize Production versus Other Crops

Returns to farmers' resources--Farmers allocate resources to different crops to get good returns to their inputs. Three basic kinds of inputs are under farmers' control:

- Labour, which comes from household members;
- Working capital, which is used to purchase fertiliser and seed, to prepare land, etc.; and
- Land.

Input and output data were collected from selected fields. Only inputs used before harvesting were recorded. Standard input values for harvesting have been calculated by AGRITEX and were used here. This was done with the conviction that harvesting depends more on the quantity of yield already in the field than on the farmer's present decisions. The following variables were calculated for each field:

- **Total working capital invested (TCI):** obtained by adding the cash used by the farmers, per hectare per crop, for purchasing fertiliser, seed, and other inputs such as herbicide and insecticide, as well as for hiring labour and/or oxen used before harvesting.

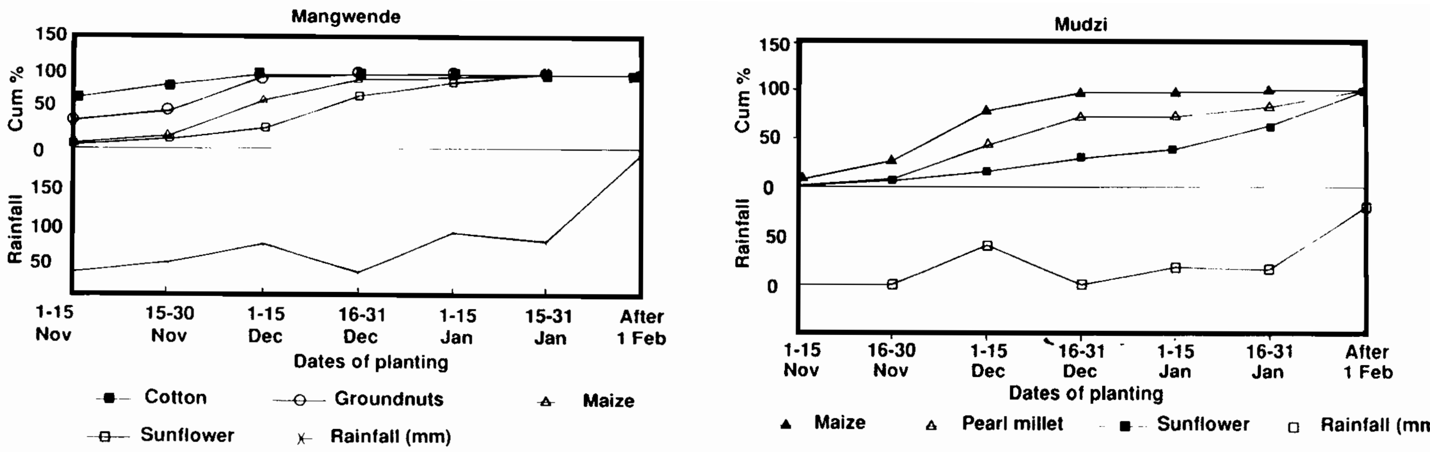

Figure 3. Cumulative percentage of area planted to different crops after 1 November, Mangwende and Mudzi, 1988/89.

- **Total family labour hours invested per hectare (TFL):** obtained by adding up all the family labour used per hectare before harvesting started.

- **Value of output per hectare:**

$$VOUT = Y \times (P - T)$$

where:

VOUT = Value of output per hectare (Z$/ha);
Y = Yield per hectare (t/ha);
P = The average price received by farmers in the sample for a commodity (Z$/t); and
T = The average transport and handling charges per tonne incurred by the farmers to take their crop to the marketing board.

- **Gross margin (GM) (i.e., return to land)**

$$GM = VOUT - TCI$$

- **Return to working capital (RTC):**

$$RTC = VOUT/TCI$$

- **Return per family labour hour (RTF):**

$$RTF = GM/TFL$$

To include a time component in the analysis, the variables listed above are presented and examined on the basis of the four categories given in Table 1.

The categories in Table 1 were selected to capture the 20 December cut-off point, a date commonly used in Zimbabwe to mark the beginning of 'late planting' of maize (Shumba, personal communication 1988). Since we are concerned with early planting in Mudzi and late planting in Mangwende, only results of plantings in these categories are reported in Tables 2 and 3. The hypothesis explored here is that maize planted late in NR II and early in NR IV does not give significantly worse economic returns than the alternative crops.

Table 1. Planting date categories used for maize in this study

Category	Maize planted:
1	Up to 10 Dec. 1987
2	11-20 Dec. 1987
3	21-30 Dec. 1987
4	31 Dec. 1987 and later

In no case did maize give significantly lower returns than sunflower in Mangwende for the late plantings (Table 2). Maize obtained significantly greater gross margins than sunflower for plantings between 21-30 December, 1987.

In Mudzi, pearl millet or sunflower did not show significantly higher returns than maize. Maize gave higher returns to land and per family labour hour than pearl millet (Table 3).

The only criterion for which alternative crops showed a consistent (though in most cases not significant) advantage over maize was returns to cash. One reason for this result is that average cash inputs into maize production are much higher than for alternative crops. With alternative crops, marginal returns to cash fall rapidly after moderate cash investments, whereas maize continues to give acceptable marginal returns at higher cash input levels.

Economics of delaying planting in Mangwende--Mundy (1921) and Anon. (1983) observed that grain yields from maize fell with increases in the duration between the date of the first effective rains and actual planting date. A regression of planting date against value of output, input costs, and quantity of family labour for maize (Table 4) shows that farmers respond to the decrease in yields (that is, to the increased risk of crop failure) with progressive cuts in their investment in maize production. Since the value of output from maize and the level of cash investment move in the same direction with time, the returns to cash investment nearly remain constant. Similarly the returns to labour are not appreciably different between the planting time categories (see Figure 4).

Table 2. Crop production input/output variables per period, Mangwende, 1987/88

Variable and crop	Category[a] 3	4
Returns to land (Z$/ha)		
Maize	412.6	151.6
Sunflower	127.5	78.1
Significance	**	ns
Returns per family labour hour (Z$/h)		
Maize	2.2	1.8
Sunflower	1.9	1.0
Significance	ns	ns
Returns to working capital		
Maize	3.0	3.1=
Sunflower	8.5	6.1
Significance	ns	ns

Note:** = significant at the 5% level; ns = not significant.
a Number of fields making up a mean for category 3: maize = 22, sunflower = 5; for category 4: maize = 13, sunflower = 13.

Table 3. Crop production input/output variables per period, Mudzi, 1987/88

Variable and crop	Category[a] 1	2
Returns to land (Z$/ha)		
Maize	155.2	111.8
Pearl millet	32.5	17.1
Significance	***	*
Maize	155.2	111.8
Sunflower	136.4	34.5
Significance	ns	ns
Returns per family labour hour (Z$/h)		
Maize	0.6	0.7
Pearl millet	0.1	0.1
Significance	*	*
Maize	0.6	0.7
Sunflower	1.4	0.3
Significance	ns	ns
Returns to working capital		
Maize	3.0	2.1
Pearl millet	6.7	4.7
Significance	ns	ns
Maize	3.0	2.1
Sunflower	9.0	4.0
Significance	*	ns

Note: * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level; and ns = not significant.
a Number of fields making up a mean for category 1: maize = 32, sunflower = 5, pearl millet = 31; for category 2: maize = 13, sunflower = 9, pearl millet = 15.

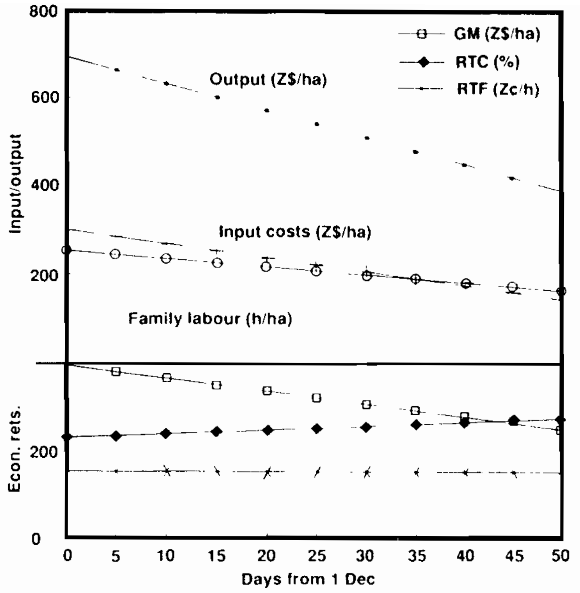

Figure 4. Changes in maize outputs, inputs, and economic returns as planting date is delayed, Mangwende, 1987/88.

Results support the hypothesis that, even though the value of output per hectare decreases as planting is delayed, there are also accompanying decreases in the labour and cash inputs into maize production. Thus later plantings end up being competitive with the early plantings in terms of economic returns to cash and family labour.

Results of the regression equations for sunflower's output versus gross margins and returns to labour are given in Table 5.

The comparison of returns to maize and sunflower as planting is delayed is presented in Figure 5. The gross margins from maize are consistently higher than those from sunflower. However, the returns per family labour hour are initially lower for maize but become greater as the season progresses, whereas labour and cash input levels decrease. With sunflower, low labour and cash inputs give little room for adjustment through the season and reduced yields for later plantings are thus reflected in reduced returns to labour. This result suggests that, contrary to conventional wisdom, maize does not become less attractive relative to sunflower as planting is delayed.

Risk Assessment

A comparison of average returns to maize and to alternative crops suggests that maize is competitive as a late planted crop in NR II and as an early planted crop in NR IV. However, one argument in favor of alternative crops is the increased risk supposed to be associated with growing maize versus sunflower and small grains. This increased riskiness is associated with greater variability in maize yields compared with yields of alternative crops. In the next part of this paper we ask:

- Do farmers perceive maize as a risky crop, especially in lower rainfall situations?
- Assuming that farmers are averse to risk, does maize still compete with the alternatives?

Farmers' perceptions of risk in maize production

Mudhara (1990) shows that farmers give preference to maize through field selection, especially in Mudzi. Maize is planted on the soils least prone to drought and on fields closer to the homestead, where better management and protection are possible. Farmers also use higher levels of cash in maize production. However, as we have seen, this cash input declines for later plantings in Mangwende. Here we focus on returns to cash in Mangwende versus Mudzi, to see whether farmers' decisions on cash inputs are influenced by their perceptions of risk.

Table 4. Maize regression coefficients

	Value of output (Z$/ha)	Cash costs (Z$/ha)	Labour (h/ha)
Constant	695.00	302.00	255.00
Coefficient	-6.11 *	-3.18 *	-1.83 ns

Note: * = significant at the 10% level; ns = not significant.

Table 5. Sunflower regression coefficients

	Gross margin (Z$/ha)	Returns to labour (Z$/h)
Constant	228	2.96
β -Coefficient	-3.41 *	-0.04 *

Note: * = significant at the 10% level.

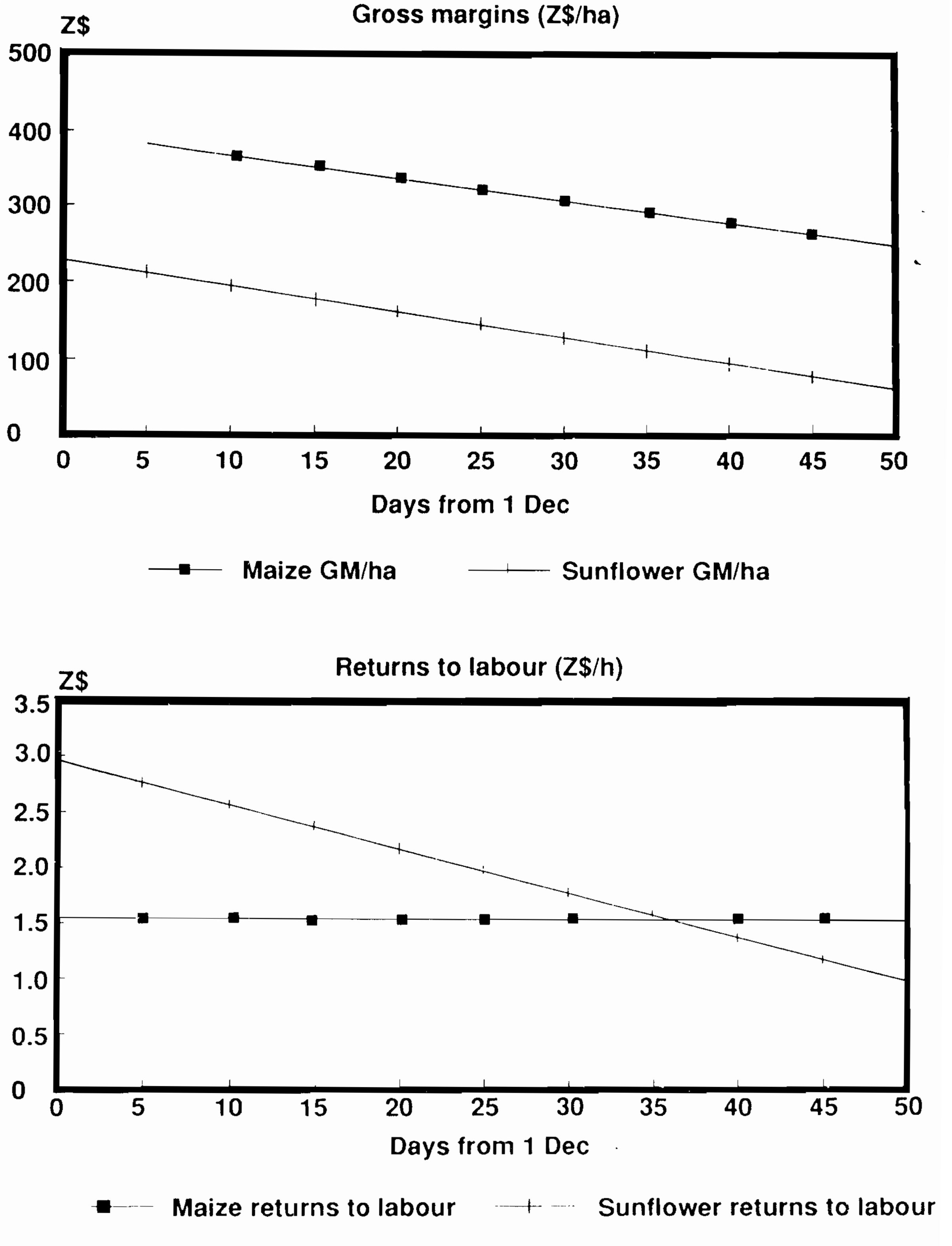

Figure 5. Returns to maize and sunflower as planting is delayed, Mangwende.

The aversion to risk has been observed to cause farmers to apply lower levels of resources than would have been desirable for maximising profits. Inefficiencies in resource allocation can be examined in terms of the marginal returns to mean input levels. Comparing marginal returns obtained by farmers across crops or regions that diverge to different degrees from optimum resource allocation gives evidence of different levels of risk perception.

Multiple regression equations relating maize yields to land 'abour, and cash inputs in Mangwende and Mudzi are given in Table 6. The marginal value products per dollar (Z$) of cash invested in Mangwende and Mudzi are given in Table 7. The coefficients in the equations represent the marginal contribution to output (in tonnes) to a unit change in the level of the factor, after the effects of the other factors have been taken into account. Labour inputs are measured in hours, cash inputs in dollars, and output in tonnes. Multiplication of the marginal contribution to output by the field price of the output gives a measure of the marginal value product per dollar invested in maize in the two areas (Table 7).

Much higher marginal returns to cash are obtained in Mudzi than in Mangwende. At the average levels of use, farmers in Mudzi would gain Z$ 2.96 for the next dollar of cash they put into maize, whereas farmers in Mangwende would only get back Z$ 0.85 for each dollar that they invest. The immediate suggestion is that average levels of cash input into maize in Mudzi are lower than they might be. If we look at the returns to cash inputs for maize in Mudzi assuming that the average levels of inputs increase to the levels used in Mangwende, then the marginal return falls to Z$ 0.94 per dollar invested.

It is likely that the greater riskiness attached to cash investments in Mudzi compared to Mangwende has induced farmers to reduce their inputs below the theoretical, no risk, optimum. Another contributing factor could be the lower credit availability in Mudzi compared to Mangwende. Indeed the seeming over-investment in Mangwende might be related to credit packages that encourage higher than optimum use of fertiliser (Mataruka et al. 1990).

Table 7. Marginal value product per Zimbabwe dollar of cash invested in maize at mean levels of investment

Maize field price = Z$ 142.1/t		
Variable	Mangwende	Mudzi
Mean input (Z$/ha)	101	30
MVP per Z$ (at mean)	0.85	2.96

Table 6. Regression equations for maize planted in Mudzi and Mangwende, 1987/88

	Mangwende (R^2 = 0.75, n = 112)			Mudzi (R^2 = 0.72, n = 55)		
Variable[a]	β	t	sig	β	t	sig
Cult	0.0777	3.10	.003	--	--	--
Prep	0.0181	1.63	.097	--	--	--
Weed	0.0044	1.80	.074	0.0026	2.89	.006
Cash	0.0060	4.25	.000	0.0269	4.34	.000
Cashsq	--	--	--	-0.0001	3.90	.000
Plant	-0.0287	3.00	.004	-0.0284	2.30	.026
Plantsq	--	--	--	0.0003	1.41	.165
Area	3.3305	7.60	.000	1.1460	4.30	.000
Constant	-0.3240	1.66	.100	-0.0711	0.49	.630

a Cult = number of family labour hours used for cultivation; Prep = adult family labour hours used for land preparation; Weed= adult family labour hours used for weeding; Cash = cash used for purchasing inputs and the hiring of labour; Plant = adult family labour hours used during planting.

These results provide some evidence that farmers perceive maize to be more risky in Mudzi than Mangwende, and that they adjust their economic decisions accordingly.

Farmers' assessments of yield variability-- An attempt was made to assess farmers' relative perceptions of risk for producing maize, sunflower, and pearl millet. Farmers were asked whether they thought the 1988/89 season was good, average, or bad and asked how they would expect yields to differ from these expectations over a 10-year period (Table 8). Farmers in Mangwende regarded most of the season as between good and average. Those in Mudzi, on the other hand, regarded the start of the season as between average and bad, and average to good after 1 January.

To measure farmers' perceptions of relative yield variability, farmers were asked to give the number of years, out of 10 years, they would expect to get a yield:

- Equal to the one currently expected;
- 50% greater than the yield currently expected; and
- 50% less than the yield currently expected.

Table 9 gives the results for the years out of 10 that farmers expect 50% less than the current yield estimation made before and after planting. These estimates suggest that farmers tend to see the chances of obtaining low yields of maize as no higher than for alternative crops. Maize is only given a significantly higher score in the case of the estimate after planting in comparison with sunflower in Mudzi.

Table 8. Farmers' assessment of the 1988/89 season with time

Dates of assessment	Average scores: Mangwende	Mudzi
1 - 20 Nov	1.87	2.00
20 Nov - 10 Dec	1.88	2.10
10 - 30 Dec	2.21	2.64
1 Jan and after	1.73	1.74

Note: Good = 1; average = 2; bad = 3.

Crop selection assuming risk averseness-- We have some evidence that farmers' economic behaviour reflects a concern about risk in maize production but little evidence that farmers see maize as having a higher yield variability than alternative crops. Nevertheless in assessing the relative advantage of maize over alternative crops we should take account of the variability around mean estimates of economic performance. It is possible that higher mean performance may also be accompanied by higher variability of performance around the mean for maize than with the alternative crops. Given the assumption that most communal farmers are risk averse, this might cause farmers to discount a mean performance with high variability more than those with less variability.

Table 9. Farmers' assessment of low yield probability

	Number of years in which yield will be 50% less than current expected yields			
	Mangwende		Mudzi	
	At planting	After planting	At planting	After planting
Maize	1.7	2.6	2.7	2.9
Sunflower	1.5	na	3.1	2.4
Pearl millet	na	na	2.5	2.9

Note: na = not available.

The analysis was therefore extended to examine whether:

- Maize has more variable returns than the alternative crops; and
- Higher variability of returns in maize changes the conclusions of our simple means analysis, assuming risk averse behaviour on the part of communal farmers.

Mean-variance analysis. Variability in the mean, a measure of the risk attached to a crop's returns, was measured using the index of variability. The index, which allows for comparisons across means of different magnitude, is calculated by dividing the standard deviation of a variable by its mean and multiplying by 100. As a proxy of risk, the greater the index of variability, the greater the risk attached to the crop in respect of the variable.

Where higher returns are accompanied by lower variabilities, the higher yielding alternative would be preferred. Similarly, where no difference in average yields is apparent the alternative with the lower variability would be preferred. However where higher average returns are accompanied by higher variability there would be no clear preference for either alternative.

Tables 10, 11, and 12 summarise the returns to land, labour, and working capital and the accompanying variability indices for maize and the alternative crops. The preferable crop, chosen on the basis of higher return and/or lower variability, is indicated.

Maize emerged superior to sunflower and pearl millet on many scores on the basis of both mean performance and the variability index. In both Mudzi and Mangwende, sunflower performed better than maize in terms of returns to working capital.

Stochastic dominance analysis. An alternative approach is to compare the probability distributions of the returns in the alternative crops.

Crop (*a*) will be preferred over crop (*b*) if its returns are higher at all probability levels. The cumulative distribution functions of returns to working capital are plotted for maize and pearl millet in Figure 6. Neither crop dominates in this case since the cumulative distribution functions cross. In the first degree stochastic dominance curve (FSD), pearl millet has a higher mean but a higher variation around this mean.

However farmers who wish to avoid risk will be concerned that comparing two functions, (*a*) and (*b*), the accumulated expected value of losses over all output levels would be less than the accumulated expected value of gains.

To determine whether the gains outweigh the losses, a second-degree stochastic dominance (SSD) analysis can be performed. The SSD functions are

Table 10. Mangwende: maize vs sunflower (planted after 20 December 1987)

Variable	Crop	Mean	Index of variability	Crop choice
Gross margin (Z$/ha)	Maize Sunflower **	295.11 95.14	120.6 120.6	Maize
Returns to working capital	Maize Sunflower	3.04 6.81 *	184.0 116.7	Sunflower
Returns per family labour hour (Z$/h)	Maize Sunflower	2.13 1.34 ns	140.9 136.7	?

Note: * = significant at the 10% level; ** = significant at the 5% level; ns = not significant.

obtained by adding up the areas under the FSD curves. Figure 6 shows the SSD of returns to working capital for pearl millet and maize. Again there is no dominance, though maize seems clearly superior at the low levels of return.

A third degree function (TSD) can be obtained by accumulating the areas under the SSD. The criterion of dominance under TSD for selection of risk efficient alternatives is consistent with the assumption that aversion to risk decreases as wealth increases (Anderson et al. 1977). Figure 6 shows that maize dominates pearl millet under TSD and can therefore be deemed the risk efficient alternative under the assumption of risk aversion decreasing as wealth increases (Makenzie 1987). A summary of the results of the same analysis performed on the other comparisons is given in Table 13.

Using stochastic dominance to order alternatives assuming risk averseness indicates only one case in which an alternative crop would be preferred to maize: returns to cash for late planted sunflower in Mangwende. As noted earlier, per-hectare cash inputs are much lower for sunflower than for maize.

Table 11. Mudzi: maize vs sunflower (planted before 20 December 1987)

Variable	Crop	Mean	Index of variability	Crop choice
Gross margin (Z$/ha)	Maize	142.68	115.3	
	Sunflower	53.79 *	267.9	Maize
Returns to working capital	Maize	2.74	126.2	
	Sunflower	5.28 *	120.1	Sunflower
Returns per family labour hour (Z$/h)	Maize	0.64	140.4	
	Sunflower	0.62 ns	198.8	Maize

Note: * = significant at the 10% level; ns = not significant.

Table 12. Mudzi: Maize vs pearl millet (planted before 20 December 1987)

Variable	Crop	Mean	Index of variability	Crop choice
Gross margin (Z$/ha)	Maize	142.68	115.3	
	Pearl millet	27.47 ***	272.1	Maize
Returns to working capital	Maize	2.74	126.2	
	Pearl millet	8.08 ns	214.8	?
Returns per family labour hour (Z$/h)	Maize	0.64	140.4	
	Pearl millet	0.12 ***	311.0	Maize

Note: *** = significant at the 1% level; ns = not significant.

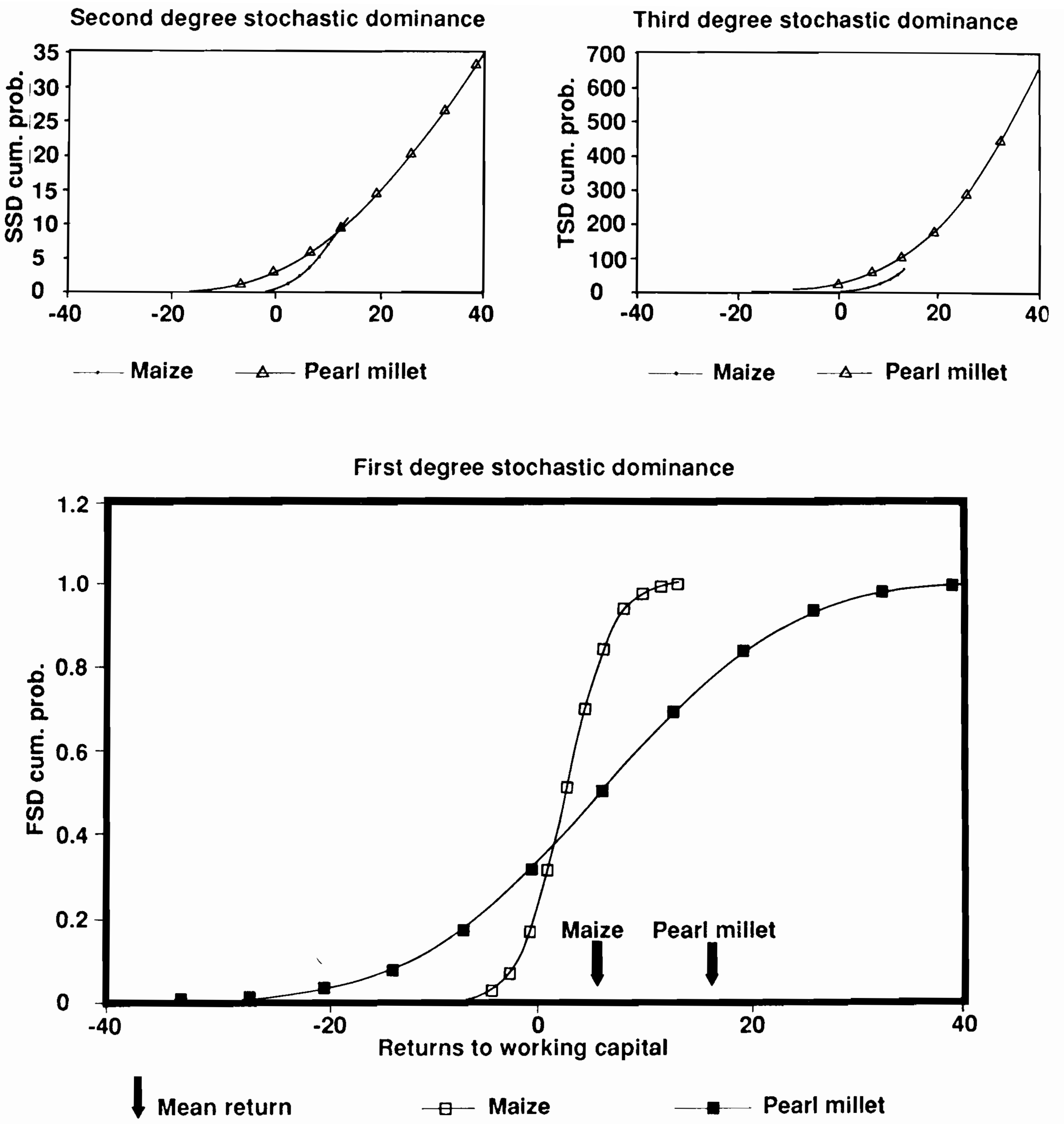

Figure 6. Stochastic dominance analysis of returns to working capital for maize and pearl millet (planted before 20 December 1987), Mudzi.

Table 13. Summary table: comparison of maize versus alternatives on the basis of stochastic dominance ordering

	Crop preferred (maize = M, alternative = A, neither = N)		
	Gross margin	Returns to cash	Returns to labour
		Mangwende - late planting	
Maize versus sunflower			
FSD (all)	M	N	N
SSD or TSD (averters)	M	A	N
		Mudzi - early planting	
Maize versus sunflower			
FSD (all)	M	N	N
SSD or TSD (averters)	M	N	M
		Mudzi - early planting	
Maize versus pearl millet			
FSD (all)	N	N	N
SSD or TSD (averters)	M	M	N

Note: FSD = first-degree stochastic dominance; SSD = second-degree stochastic dominance; TSD = third-degree stochastic dominance.

Thus the analysis suggests that, given the choice of applying low levels of cash inputs to sunflower or higher levels of cash inputs to maize, risk averse farmers in Mangwende would prefer the former option. In all other cases, risk averse farmers would either prefer maize or no clear advantage can be attached to maize or the alternative crop.

In three cases in Mudzi, maize becomes preferable under assumptions of risk averseness where maize showed no clear advantage under the more restrictive criterion of utility maximisation at all probability levels (FSD). This suggests that in Mudzi farmers who wish to avoid risk are as likely as risk neutral or risk taking farmers to select maize over alternative crops for early planting. The normal assumption that maize is less preferable than alternatives in NR IV, particularly for risk averse farmers, is brought into question by this analysis.

Conclusion

This analysis of returns to land, cash, and labour indicates that, for late planting in NR II and early planting in NR IV, average returns obtained to land and labour are no worse for maize than for the current alternative crops advocated by research and extension. Even when variability of output and farmer risk aversion are taken into account, maize seems to be clearly less preferable than an alternative crop only in the case of sunflower for late planting in Mangwende and only where returns to cash determine the farmer's choice.

The conclusion from this study is that farmers' current choice of maize over alternative crops for late planting in NR II and early planting in NR IV is economically rational. Farmers in NR IV even select maize over alternative crops recommended for late planting. For example, *The Herald* newspaper of 9 January, 1990 reported that farmers in Matebeleland 'were now replanting maize, against the advice of Agritex officers who urged them to grow drought-resistant crops such as sorghum, mhunga [pearl millet], and rapoko [finger millet].'

The findings from this study have implications for maize research and extension. Maize research has focussed on developing recommended practices for production under favourable conditions. Little work has been conducted on options for producing maize under unfavourable conditions. However, this study crops, large areas of maize will continue to be grown under unfavourable conditions in Zimbabwe (planted late in high rainfall areas and planted early in low rainfall areas).

Initial monitoring studies of farmers' practices on maize in NR II indicate that, compared with early planted maize, late planted maize receives less fertiliser and suffers more early weed competition, but plant spacing does not differ (S. Waddington and P. Kunjeku, personal communication, 1989). Farmers apply these management compromises in the absence of information from research about options for maize management under sub-optimal and risky conditions.

For the drier environments, maize research opportunities identified by Waddington and Kunjeku (1989) include:

- Breeding for drought avoidance and tolerance;
- Seed placement and timing for planting on drying seedbeds;
- Plant population densities for maximization of yield stability;
- Moisture conservation tillage systems; and
- Inorganic fertiliser management at low rates in relation to use of manure and crop residues.

Extension, following research, has recommended that farmers produce alternative crops to maize as production conditions become less favourable. Extension advice on alternative maize management strategies and the comparative economics of alternative crops under different climatic conditions is likely to be more helpful to farmers than directives to plant Crop X or Crop Y as an alternative to maize.

Farmers see a clear role for maize in the risky environments of Zimbabwe. Rather than dispute this viewpoint, research and extension should aim to help farmers better define maize's role in relation to the alternatives.

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