Water for Agriculture in Zimbabwe

Policy and Management Options for the Smallholder Sector

Edited by
mmanuel Manzungu, Aidan Senzanje and Pieter van der Zaag

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September 1998

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Part II

AGRICULTURAL ASPECTS

Introduction

In Zimbabwe agriculture uses the bulk of the country's water resources. The judicious use of water in this sector needs no emphasis. Part of the solution lies in the availability of technologies that can make this possible.

In dry areas where no irrigation is available, it is important that every drop of water is utilised for agricultural production. Nyamudeza in Chapter 4 reports on a technology developed by the Lowveld Research Stations aimed at increasing and stabilising rainfed crop production. The technology, which involves sowing crops in the furrow, has many facets such as plant spacing, sowing dates and selection of crop varieties. The technology is therefore quite involved. The author, after surveying extensive data on the technology, offers down-to-earth recommendations regarding exercising flexibility in the implementation. There is another dimension to this flexibility. While Nyamudeza emphasizes technical flexibility, Mazhangara *et al.*, in a following chapter touch on social and socio-economic-induced flexibility. They follow the technology to the farmers' fields looking at how it is adopted. They found that there was a differential uptake of the technology by different farmers for different reasons. The chapter casts doubts on the paradigm of linear development of technology i.e. from researchers to extensionists to farmers.

In Chapter 6 Lovell *et al.* explore how ground water resources can better be used in the rural areas of Zimbabwe, not just for agricultural production, but for domestic uses as well. There are technical issues to be resolved e.g. finding the right technology (the collector well) to increase water yields. However, that is only one side of the story. Social and institutional factors must also be taken into account. If these are not matched technical issues are no good. This is the thrust of Lovell *et al.*'s chapter. Rounding up the agricultural section is Manzungu's chapter on smallholder irrigation. He proposes that management of smallholder irrigation schemes needs to be rethought by documenting the dynamics of water distribution in one smallholder irrigation scheme.

CHAPTER 4

Agronomic practices for the low rainfall regions of Zimbabwe

P. NYAMUDEZA

The semi-arid Natural Region 5 (NR5) of Zimbabwe occupies about 30 per cent of the country. Twenty seven per cent of smallholder farming areas are found in this region (Whitlow, 1980).[1] The major constraint to crop production in Natural Region 5 is lack of adequate water during the crop growing season.

In the Agricultural Survey of Zimbabwe (Southern Rhodesia) Part I: Agro-Ecological Survey, Vincent and Thomas (1960) noted that the rainfall received in this region was too low for reliable production even of drought resistant fodder and grain crops. However, in Part II: Agro-Economic Survey, Staples (1962) said that the region was only suitable for cultivation of extremely drought resistant varieties of sorghum and pearl millet. These two rather contradictory statements were not really put to test. It would appear, however, that for reasons that had to do more with conventional wisdom than technical considerations, the recommendation by Vincent and Thomas (1960) prevailed. As a result, little crop research under rain-fed conditions was undertaken. It was only in 1982 when such work was started at Chiredzi and Chisumbanje Research Stations (which fall under the Lowveld Research Stations). Figure 4.1 shows the location of the research stations where research was conducted and the surrounding communal areas where similar work was undertaken.

Despite the lack of technical support, peasants in this region have been growing crops for ages. The major crop has been sorghum. Although sorghum is widely recognised as well adapted to semi-arid environments, it fails completely in some years. In most years the yields are very low under the present farming system. The best way to produce crops in this region is by irrigation (and indeed the south east lowveld has the biggest portion of NR5 under large and small scale irrigation schemes). But the high cost of setting up irrigation schemes means that the production of crops by small scale farmers will continue to depend on rain-fed production. This means that success in cropping depends on using agronomic techniques which conserve or use water sparingly to enable

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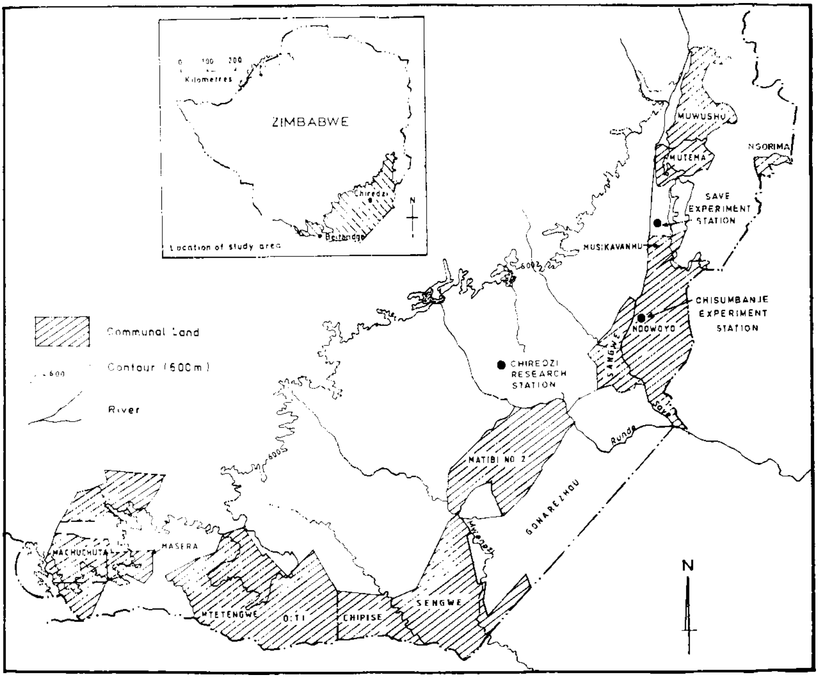
[1]Natural regions are a classification of the agricultural potential of the country; Natural Region 1 represents the high altitude wet areas while Natural Region 5 receives low and erratic rainfall averaging about 500 mm per annum (Vincent and Thomas, 1960).

Figure 4.1: Location of research stations and the surrounding communal areas



the crop to survive under the low rainfall conditions and to go through the long dry spells common in the area.

This chapter focuses on such management or agronomic techniques. These include water conservation using furrows of tied ridges, row spacing and population, crop varieties, sowing dates and fertility management. The discussion is based on experiments done in the south east lowveld on four soil types, vertisols, paragnesis, alluvial and granite derived sandy soils.

WATER CONSERVATION

According to Moss (1968), the best means of enhancing productivity of crops in semi-arid regions is by ensuring that maximum use is made of every drop of rain that falls to the ground. This could be achieved by adopting appropriate management techniques which increase the infiltration rate of water into the soil profile and minimise the effects of drought. NR5 of Zimbabwe is the worst in terms of amount and distribution of rainfall and probably has the most need for water conservation techniques.

Experiments were carried out from 1983/84 to 1990/91 on water conservation using tied ridges. The use of ridges is an old practise in some parts of Africa (Rounce and Thornton, 1939; and Dunham, 1983). The unique feature about tied ridges tested in NR5 of Zimbabwe is that crops were sown in furrows of tied ridges. Because sowing was in furrows the technique was called tied furrows to differentiate it from tied ridges when crops are sown on ridges.

The use of ridges and tied ridges has been tested by several people who have reported failures and successes. Successes, that is tied ridging improving crop performance, have been reported by Lawes (1961), Dagg and Macartney (1968), Honisch (1974), Hulugalle (1987), Nagy *et. al.* (1990) and Wright *et. al.* (1991). Vogel (1993) reported no advantage on granite sands of Zimbabwe and Walton (1962) found conflicting results in Uganda. Little has been reported on sowing crops in furrows of tied ridges.

Table 4.1 shows the effect of sowing crops in tied furrows and on flat over a period of six seasons at Chiredzi. In 1984/85 sowing in furrows of wide ridges, 1.5 and 2.0 m apart, reduced yield compared to the traditional system of sowing on the flat. Furrows of 1.0 m ridges increased yield by 29 per cent, which translates to 860 kg/ha more grain than the traditional system. The 1984/85 season had occasional heavy rain storms and the total rainfall was above average. This could have caused temporary waterlogging in the big furrows which concentrated more water than the 1.0 m tied furrows. Another possible reason for lower yields from the big furrows could be due to reduced soil fertility in furrows because more top soil is used to construct the ridges.

Table 4.1: Effect of Cultivation System on Grain Yield (kg/ha) for the Six Seasons at Chiredzi

Cultivation system	Seasons						
	1984/85	1985/86	1986/87	1987/88	1989/90	1990/91	Mean
1.0 m Furrows	3 872	3 017	429	563	3 166	990	2 006
1.5 m Furrows	2 770	2 812	825	649	2 900	1 110	1 844
2.0 m Furrows	2 035	2 061	1 010	850	2 246	—	1 640
1.0 m Flat	3 015	2 022	213	0	1 546	369	1 194

In 1985/86 the 1.0 and 1.5 m tied furrows gave higher yields compared to the flat which gave a similar yield to the 2.0 m tied furrows. The season had less rainfall than 1984/85. In the following seasons, 1986/87 and 1987/88, the reverse occurred and all tied furrows which outyielded the flat and higher increases were from the 2.0 and 1.5 m tied furrows. The two seasons had very poorly distributed rainfall and the big tied furrows were more beneficial. In 1987/88 the flat gave zero yield (Table 4.1). In 1989/90 all tied furrows outyielded the flat but unlike 1986/87 and 1987/88 the 1.0 m tied furrows gave the highest yield as happened in 1984/85 and 1985/86. In the last season of the trial the 2.0 m tied furrows were dropped and in that season the 1.0 and 1.5 m tied furrows outyielded the flat by 168 and 201 per cent respectively.

Table 4.2 shows the effect of growing sorghum in tied furrows and on flat over six seasons at Chisumbanje. The soil at Chisumbanje is a vertisol with a high clay content and water holding capacity. The yield trends were generally similar to those observed at Chiredzi but the yield increases were not as high as at Chiredzi. The wide 2.0 m tied furrows reduced yield in three seasons and were dropped in the last two seasons of the experiment. The 1.5 m tied furrows reduced yield in two of the six seasons and the 1.0 m increased yield in all seasons.

Table 4.2: Effect of Cultivation System on Grain Yield (kg/ha) for the Six Seasons at Chisumbanje

Cultivation system	Seasons						Mean
	1984/85	1986/87	1987/88	1988/89	1989/90	1990/91	
1.0 m Furrows	4 501	1 918	4 357	1 368	2 441	2 334	2 819
1.5 m Furrows	3 758	2 108	3 462	1 509	2 266	1 779	2 480
2.0 m Furrows	3 115	2 098	2 848	799	—	—	2 215
1.0 m Flat	4 315	1 570	3 929	1 074	1 362	1 756	2 334

Table 4.3 shows the effect of tied furrows on yield on alluvial soils at three sites in different seasons. The yield trends are basically the same as on paragnesis soils (Chiredzi) and vertisols (Chisumbanje). On average the 1.0 and 1.5 m tied furrows gave similar yields and increased yield by about 50%.

Table 4.3: Effect of Cultivation System on Grain Yield (kg/ha) of Sorghum at Three Communal Area Sites on Alluvial Soil

Cultivation System	Site/Season					Mean
	Mutema			Rimbi	Malipati	
	1984/85	1986/87	1989/90	1984/85	1986/87	
1.0 m Furrows	1 676	635	3 654	3 527	602	2 019
1.5 m Furrows	2 505	959	3 013	3 097	565	2 028
1.0 m Flat	856	0	2 409	3 314	167	1 349

On sandy soils the tied furrows reduced yields at six sites over two seasons. After the two seasons the tied furrows were tested under different fertilizer levels for five seasons. As reported by Nyamudeza *et. al.* (1992), averaged over three fertility levels the 1.0 and 1.5 m tied furrows increased sorghum yield by 30 and 17% respectively over five seasons at three sites.

From these findings it is clear that each soil type differs in its response to tied furrows but the case for the technology seems broadly proved. The use of tied furrows does two things; first it holds all rain where it falls and increases soil water by reducing runoff (Nyamudeza and Jones, 1993) and second, it is a complete check to soil erosion. The first function has an immediate effect on yield in areas like NR5 where water is the limiting factor to crop growth in most seasons.

However, the use of tied furrows has some limitations. The construction of tied furrows is more laborious and time consuming than ordinary ridge cultivation and much more so than flat cultivation. A sound, though overstated, objection is that an unusually wet year may lead to water logging. It does, at least on certain soils, but the very wet year is rare enough to make the objection a minor one.

Some of the questions which many people have asked about the tied furrows are: (1) will the usefulness of tied furrows be confined to NR5 or (2) will soil type rather than climate set the limits and (3) will continued tied furrows lead to undue leaching? Sowing in furrows could be limited to NR5 whilst sowing on the ridge could be practised in the other natural regions. The technology works best on soils with a reasonable clay content say 20% and above. On light soils there is a definite need for organic or inorganic fertilizers. There is probably a need to change the position of the furrow every year or once in two years to ensure complete burying of crop residues and improve the organic matter of the soil.

In conclusion, I recommend the use of 1.0 m tied furrows due to its yield superiority when averaged over a number of seasons although the 1.5 m does better in the very dry seasons. A slight disadvantage of 1.0 m tied furrows compared to 1.5 m is that they have to be reconstructed more often. However, they are easier to construct than the 1.5 m tied furrows and farmers can construct them using an ox-drawn plough or ridger. On sandy soils it is necessary to apply some manure or inorganic fertilizers for maximum response.

PLANT POPULATIONS AND ROW SPACING

A cheap practical method open to a farmer for optimising the use of soil water is to change plant population or row width. Gregory (1984) reported that if the supply of soil water is limited and a crop is sown densely, then the supply of water may be used too rapidly and the crop will fail. Thomas *et al.*, (1981), Azam-Ali *et al.*, (1984), Jones (1987) and Steiner (1987) also reported the importance of using low populations where water is limiting.

The advantages of wide rows in dry areas have been reported by Bond *et al.* (1964), Blum and Naveh (1976) and Thomas *et al.* (1981). The recommendations for plant population density and row width in NR5 have been extrapolations from work done in higher rainfall areas. Therefore, there was a need to study a range of row widths and populations for sorghum, maize and cotton under NR5 conditions.

Experiments done at Chiredzi (Nyamudeza, 1993) showed no significant yield difference between 33, 66 and 99 thousand plants of sorghum per hectare but the highest population gave slightly lower yields over a period of five seasons. This trend was more pronounced in drier seasons. It was concluded that a population range of 33 to 66 thousand plants per hectare is most suitable for NR5 because higher populations carry a greater risk of crop failure. In Botswana, DLFRS (1985) showed that a population of 30 to 70 thousand plants per hectare gave the highest yields over a rainfall range of 200 to 700 mm and this is in general agreement with the findings reported by Nyamudeza (1993).

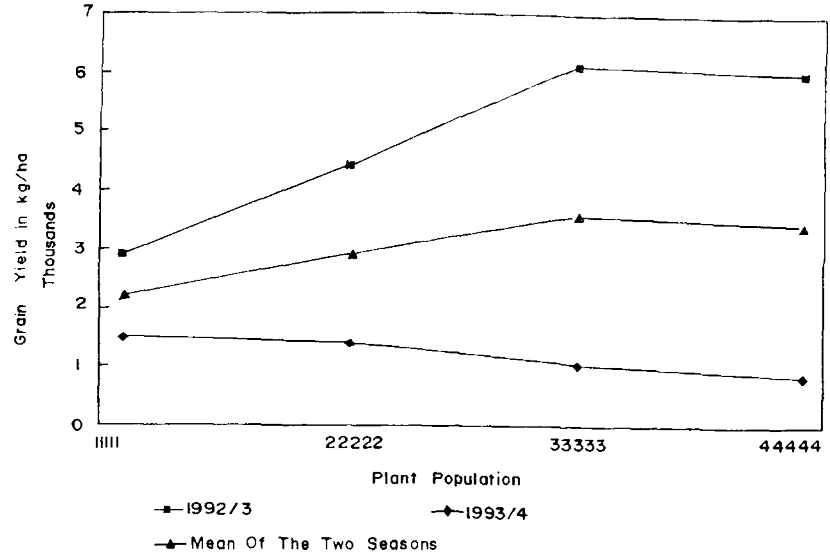
For five seasons three row widths for sorghum were compared at Chiredzi on both the flat and in tied furrows. The row widths were 1.0, 1.5, and 2.0 m. On the flat, averaged over five seasons, the 1.5 m outyielded the 1.0 and 2.0 m by 16 and 15 per cent respectively. In average and above average rainfall seasons the 1.5 m gave similar yields to the 1.0 m but in below average seasons it significantly yielded more than the 1.0 m row width. In furrows the 1.0 m (one row per tied furrow) gave the highest yield averaged over five seasons. The findings for the row width on flat agree with the findings by Bond *et al.* (1964), Blum and Naveh (1976) and Thomas *et al.* (1981).

When these row widths were tested in the communal areas, farmers resent the wide rows because they appear to waste land. The farmer sees the wide gaps as a waste of land so, to recommend 1.5 m row width on flat may fall on deaf ears. It is more appropriate to talk about 1.0 m but at the same time recommending the use of tied furrows.

Population studies on maize were carried out for two seasons, one season at Chiredzi and the second at Save Valley Experiment Station. Figure 4.2 shows the yield responses to the different populations in an above average season and an average season. In an above average season yield increased with increasing population up to 33 thousand and decreased at 44 thousand plants per hectare. In an average season yield decreased with increasing population. In a below average season maize usually yields nothing in NR5.

Based on the above results one would be tempted to recommend a plant population of 33 thousand plants per hectare. The two seasons data may not tell the whole story and the good seasons are rare in NR5 when rainfall distribution is taken into account. I would therefore recommend a population of 22 thousand plants per hectare for maize if one takes the risk of growing maize.

Figure 4.2: Effect of plant population on maize yield



CROP VARIETIES

It is a general opinion by many people that in dry regions short season varieties should be grown. The studies done in the south east lowveld of Zimbabwe actually show that there is room for short, medium and even long season sorghum varieties. As for maize, medium season varieties have also done well. Mentioning maize does not mean that I am fully recommending maize for NR5 because maize failed completely in two out of seven seasons at Chisumbanje and four out of seven seasons at Chiredzi. However, if a farmer puts part of his/her field to maize I will not discourage the farmer because although maize gives zero yields in more years than sorghum, the mean yield over a number of seasons is more than that of sorghum. When maize does well it gives double the yield of sorghum.

The work done at Chisumbanje and Chiredzi on maize varieties shows that medium season varieties do just as good as some short season varieties. Recommending short, medium and long season sorghum varieties reduces the risk of complete crop failure. The drought periods are very unpredictable and by having one's crop at different stages of growth, which would be the case if the different varieties are grown at the same time, reduces the risk of complete crop failure. This could also happen if one variety is sown at different times, but the problem is that there are not many sowing opportunities. Table 4.4 shows the yield and days to maturity of four sorghum varieties sown at different times at Chiredzi in 1992/93. The earliest maturing variety, 65D, was outyielded by the other varieties in all sowing dates except the last sowing date when it yielded more than SV2. In other years it is possible that the longer maturing varieties can be hit by drought when the early maturing one is at an advanced stage in which case the longer maturing varieties would suffer.

Table 4.4: Mean Number of Days to Maturity and the Effect of Sowing Date on the Grain Yield (kg/ha) of Four Sorghum Varieties in the 1992/93 Season at Chiredzi

			Sowing		
Variety	Days to maturity	25 Nov	11 Dec	6 Jan	29 Jan
Red Swazi	86	3 511	2 879	1 771	602
SV2	89	3 763	2 970	1 280	317
65 D	77	2 354	2 003	969	452
Mnondo	101	3 714	4 212	1 811	966

As for sorghum varieties, the local landraces should be encouraged hand in hand with improved varieties which have not been bred in NR5. The variety Mnondo in Table 4.4 is a local variety or landrace and it yielded very well. These local landraces have undergone a much more vigorous selection over a number years in NR5 than the present improved varieties.

SOWING DATES

The most common answer when farmers ask about when to sow their crops, is, sow early. Indeed all farmers would like to sow early but certain factors may prevent farmers from sowing early. Small scale farmers usually want to reduce the risk of crop failure by spreading their sowing dates. In some cases lack of draught power and labour prevents the farmers from sowing early. The most important and uncontrollable factor is the start of a reasonable planting rain. Sowing late is therefore unavoidable in most cases. Hence, what needs to be known is what agronomic practices need to be taken into consideration when rains are late in order to make efficient use of the rain and what yield levels should the farmers expect. It is also necessary to know the cut off point after which farmers should not bother to plant.

Some of the reasons for advocating early sowing are to ensure that the crop matures before the rains end and to avoid low temperatures in the case of summer crops. In the south east NR5 of Zimbabwe, temperatures at the beginning of winter are relatively good for most summer crops. So, if water is available even late sowing of maize, sorghum, cotton and sunflower could give good yields.

Table 4.5 shows the effect of sowing date on yields of cotton, maize, sorghum and sunflower at Chisumbanje and Chiredzi. In some years planting rains can start as late as end of December as happened at Chisumbanje in the 1992/93 season. During that season there were five possible planting opportunities stretching as late as end of February. The crop sown at the end of February still managed to produce a tonne of maize and slightly more than half a tonne of sorghum and sunflower. In the other natural regions, 1 to 4, sowing in late February would probably yield nothing due to the low temperatures in April and May. In fact farmers in the Chisumbanje area only get worried if there are no rains up to mid-January. The vertisol at Chisumbanje has a high water holding capacity of about 180 mm to a depth of 1.0 m and heavy falls in February can produce a crop. The highest yields are of course still obtained in the early sown crop and in 1992/93 for example (Table 4.5). The yield of all crops except sunflower were significantly reduced by late sowing. However, in some years, represented by 1993/94 in Table 4.5, sowing opportunities can be as little as two. In 1993/94 these were in late November and early December.

At Chiredzi planting is possible after receiving at least 20 mm, so in general there tends to be more planting opportunities at Chiredzi than Chisumbanje. A 20 mm rain on a dry vertisol would only wet the top 5 to 10 cm. The paragnesis soil at Chiredzi holds less water than vertisols, about 107 mm to 1.0 m depth and planting after mid-January can be more risky than at Chisumbanje. This would also apply on alluvial soils which cover a big area of NR5. As shown in Table 4.5 relatively high crop yields can be obtained by sowing as late as early January. During the 1992/93 season for example, planting in early January gave 2, 619 kg ha^{-1} of maize, 1, 458 kg ha^{-1} of sorghum and 1, 846 kg ha^{-1} of sunflower.

A close analysis of Table 4.5 shows that cotton can be sown up to late December. However, the yields may be too low to be economic. Maize, sorghum and sunflower can be sown up to early January at Chiredzi and early February at Chisumbanje.

FERTILIZER REQUIREMENTS

The main soil types found in NR5, in particular the south east lowveld are alluvial, vertisol, paragnesis and sandy soils derived from granite. The alluvial soil is mainly found along the Save Valley, vertisols in the Ndowoyo and Matibi 2 communal areas, paragnesis around Chiredzi and Triangle and sand soils in Matibi 1 communal area. One unique feature of crop production on vertisols and alluvial soils is that smallholder farmers do not apply fertilizers claiming that applying fertilizers would be detrimental to their crops. The vertisol has been described by Thompson and Purves (1978) as inherently fertile but for how long can farmers continue to crop these soils without depleting the soil of its fertility. On the other hand, due to the low and unpredictable nature of the

Table 4.5: Effect of Sowing Dates on the Yields of Cotton, Maize, Sorghum and Sunflower at (a) Chiredzi and (b) Chisumbanje

(a) Chiredzi

	Crop/Season							
	Cotton		Maize		Sorghum		Sunflower	
Sowing date	1992/93	1993/94	1992/93	1993/94	1992/93	1993/94	1992/93	1993/94
Early Nov.	*	1 338	*	*	*	1 219	*	1 448
Late Nov.	2 204	*	4 804	3 496	3 336	*	2 301	–
Early Dec.	1 633	1 534	5 532	2 192	3 016	853	2 432	1 266
Late Dec.	1 087	*	*	*	*	*	–	–
Early Jan.	645	616	2 699	0	1 458	0	1 845	567
Late Jan.	*	498	839	0	584	0	914	0

(b) Chisumbanje

	Crop/Season							
	Cotton		Maize		Sorghum		Sunflower	
Sowing date	1992/93	1993/94	1992/93	1993/94	1992/93	1993/94	1992/93	1993/94
Late Nov.	*	371	*	3 496	*	*	*	*
Early Dec.	*	342	*	2 192	*	*	*	*
Late Dec.	1 269	*	3 189	*	3 840	*	705	*
Early Jan.	394	*	*	*	*	*	*	*
Late Jan.	260	*	1 907	8	617	*	847	*
Early Feb.	*	*	1 428	*	567	*	847	*
Late Feb.	*	*	981	*	78	*	650	*

**No planting opportunity during the period in the season.*

rainfall, is it not sensible to say that applying manure or inorganic fertilizers results in a bigger crop which depletes the limited soil water faster than an unfertilized crop. Affholder (1995) reported that the application of manure to a millet crop raised crop water requirements without substantially increasing the water supply of the soil. He concluded that the use of manure under conditions of low rainfall increases the risks taken by the farmers.

The situation of NR5 will be discussed based on fertility experiments carried out from 1986/87 to 1990/91. Relatively low levels of nitrogen were tested on the assumption that accelerated water use through fertilization can be disastrous if the soil moisture supply is exhausted and rains come after long dry spells. Table 4.6 shows the response of sorghum to nitrogen at two sites on alluvial soils. The trials also had two levels of phosphorus but there were no interactions.

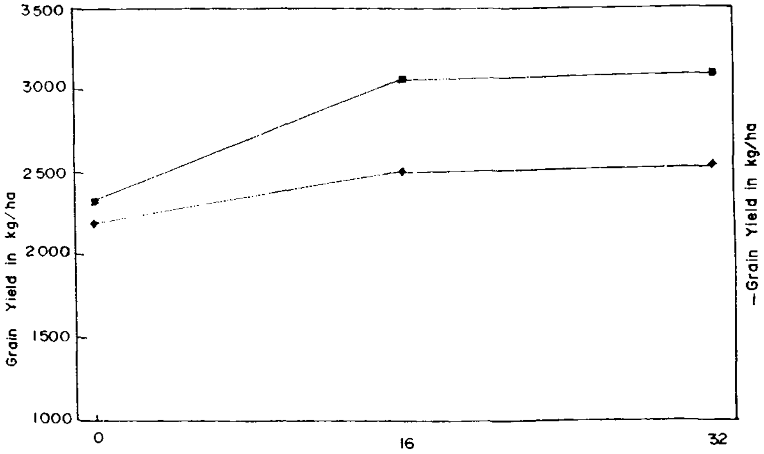
The yields shown in Table 4.6 are averaged over phosphorus levels. In two out of three seasons there were significant yield differences between the control (zero N) and the fertilized treatments at Mutema. There were no differences between 16 and 32 kg N ha-^{1}. At the second site, Rimbi, similar responses were observed but only one year in three had significant yield differences. Averaged over the three seasons 16 and 32 kg N ha^{-1} outyielded the control by 32 and 33 per cent respectively at Mutema which translates to about 750 kg ha^{-1} more than the control. At Rimbi 16 and 32 kg N ha^{-1} increased yield by 15 and 16 per cent respectively. Figure 4.3 shows the nitrogen response curves at the two sites. It is clear from these results that the response is positive but the amount of nitrogen required is very small.

Table 4.6: Sorghum Grain Yield (kg/ha) Response to Nitrogen at Two Sites on Alluvial Soil

	Site/Season					
	Mutema			Rimbi		
Nitrogen (kg/ha)	1987/88	1988/89	1989/90	1987/88	1988/89	1989/90
Control	2 506	1 888	2 586	3 428	1 446	1 707
16	3 060	2 220	3 910	3 757	1 566	2 225
32	2 966	1 983	4 338	3 936	1 479	2 239

Rainfall in mm.

Figure 4.3: Nitrogen response curve on alluvial soil at Mutema and Rimbi



Tables 4.7 and 4.8 show sorghum and maize responses to nitrogen over a number of years on sandy soils. The experiments which produced these results also compared three landforms i.e. sowing on the flat, and in 1.0 m and 1.5 m tied furrows. Therefore the yields are averaged over landforms. The nitrogen levels tested were, 25 and 50 kg N ha^{-1} after applying 150 kg ha^{-1} basal fertilizer (8:14:7, NPK). These were higher than those tested on alluvial soils because sandy soils are generally less fertile than the alluvial. The sorghum trials ran for five years and in each year the response was similar, 25 and 50 kg N ha^{-1} yielded more than the control. There was little difference between the two nitrogen levels and the five season means show that the 150 kg/ha basal fertiliser (8:14:7 NPK) plus 25 kg N ha^{-1} top dressing could be the most economic. Maize at Negari, Table 4.8, responded in a similar way to sorghum. The two nitrogen treatments outyielded the control by 35 and 28 per cent.

Table 4.7: Sorghum Grain Yield (kg/ha) Response to Nitrogen on Granite Derived Sandy Soil at Neshuro

	Season					
Nitrogen (kg/ha)	1986/87	1987/88	1988/89	1989/90	1990/91	Mean
Control	1 472	955	2 015	892	924	1 252
37	1 632	956	2 074	2 082	1 463	1 641
62	1 640	1 346	2 294	2 009	1 387	1 735

(1) This includes 12 kg/ha from the basal fertilizer

Table 4.8: Maize Grain Yield (kg/ha) Response to Nitrogen on Granite Derived Sandy Soil at Negara

	Season			
Nitrogen (kg/ha)	1988/89	1989/90	1990/91	Mean
Control	1 108	1 146	515	923
37	1 271	1 389	1 087	1 249
62	1 553	1 243	755	1 184

(1) This includes 12 kg/ha from the basal fertilizer

Table 4.9 shows responses of maize, sorghum and cotton to fertilizer on vertisols. In all seasons cotton and sorghum showed no significant response to fertilizer. Maize responded in the third season. The 16 and 32 kg N ha^{-1} outyielded the control by 13 and 17% respectively i.e. an additional 759 and 916 kg ha^{-1} of grain. Vertisols are the most fertile of all the soils in NR5. Given that the yields are relatively low in most years due to low rainfall and in some years farmers harvest nothing, it appears that farmers may continue not to apply

Table 4.9: Yield (kg/ha) Responses of Cotton, Maize and Sorghum to Nitrogen on Vertisols at Chisumbanje

	Crop/Season								
	Cotton				Maize			Sorghum	
Nitrogen (kg/ha)	85/86	86/87	87/88	89/90	85/87	86/87	89/90	85/86	89/90
Control	1 225	197	3 378	1 083	1 932	321	5 478	1 164	2 130
16	1 270	194	3 374	1 059	1 794	340	6 237	1 382	2 258
32	1 310	197	3 545	1 057	1 715	313	6 394	1 371	2 290

fertiliser on vertisols. Maize responded in a good rainfall season. It would be dangerous not to recommend anything on vertisols and the best advice would be to apply fertilizer depending on the quality of the season. Based on the present low yields, it will take a long time for farmers to apply fertilizers.

It is clear from the alluvial and sandy soil results that there is a definite positive response to nitrogen. However, the amounts required are small, 16 kg N ha^{-1} on alluvial and 37 kg N ha^{-1} (including 12 Kg N from the basal fertilizer). The response to nitrogen is definitely season dependent and the more rainy a season the better the response. People would tend to cast doubts on low levels of N arguing that yield would be compromised in the good years. Mckenzie (1987) reported that because of the potential losses that can occur in dry years, there is a tendency to recommend lower levels of fertilizer than would be needed for high productivity in an average year. For this reason Piha (1992) recommended the application of fertilizers based on the quality of the season so as to maximise productivity in average and above average rainfall years, whilst minimizing financial losses in dry years. This basically encourages the farmer not to follow a rigid extension recommendation but to change fertilizer rates depending on the quality of the season.

CONCLUSION

The overall conclusion as far as water in agriculture is concerned in Natural Region 5 is that apart from irrigation, some small scale farmers can survive by growing rain-fed crops. This can be enhanced by following appropriate agronomic practices which not only conserve water, but use it sparingly in order for the crop to survive the long dry spells. Recommendations should be based on research done in the area as opposed to the previous recommendations which were extrapolations from work done in better rainfall areas.

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