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On-Farm Evaluation of Short-Season Sorghum and Fertilizer for Smallholder Farmers in a Semi-Arid Region of Zimbabwe

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Abstract

Three on-farm experiments were conducted during 1984-85, 1985-86, and 1986-87 in Siabuwa, Zimbabwe to test 1) earlier maturing food sorghums with pearly white grain and 2) fertilizer application as possible solutions to production problems faced by smallholder farmers growing sorghum.

Replacement of current long-season sorghums by improved short-season white grain open pollinated varieties, such as SV-2 and 321CR, consistently increased grain yield (by an average of 62%) in the three seasons at farmers' levels of inputs and management. Farmer evaluation of the taste of porridge from sorghum grain showed a high preference for the pearly white short-season varieties compared to the long-season local, Balala.

Fertilizer (50 kg N ha^{-1}, 12 kg P ha^{-1}) significantly raised the grain yield of the long-season local sorghum and shorter season varieties on vertisols, siallitic clays, and sandy loam soils in average and above average rainfall years (1984-85 by 37% and 1985-86 by 60%) but not in 1986-87, a very dry year. Use of fertilizer was not economic in any of the seasons.

Pearly white grain, short-season food sorghums are useful additions to the portfolio of sorghum varieties available to farmers in Siabuwa. These varieties should help increase the productivity of the important sorghum enterprise without requiring any major modification of current production practices and without the use of fertilizer in the short term.

Introduction

Based on diagnostic studies conducted during 1984 with smallholder farmers in Siabuwa Communal Area, northwestern Zimbabwe, an experimental agenda was developed to address several production problems identified in sorghum (*Sorghum bicolor* L., Moench), the dominant staple food crop. These problems were described in Chiduza et al. (1992).

In this paper we describe the high priority on-farm experiments implemented starting in 1984-85 to examine early maturing varieties and fertilizer as solutions to sorghum production problems. The experiments were accompanied by porridge taste tests.

Materials and Methods

Variety x fertilizer trial—The sorghum variety x fertilizer trial was planted to assess grain yields possible with the new short-season sorghums and to compare their potential with yields obtained from current long-season local sorghum. This trial was planted in Siabuwa at six sites in the 1984-85 and 1985-86 seasons. A randomized complete block design (RCBD) with a factorial combination of five varieties and two fertilizer levels was used, replicated three times at each site. The five varieties were: the farmer's local long-season variety (Balala); two intermediate maturity improved varieties, i.e., Serena (red grain) and M36172 (white grain); and two short-season improved varieties, i.e., SV-2 (white grain) and 321CR (white grain). Fertilizer levels were: no fertilizer; and 50 kg N ha^{-1}, 12 kg P ha^{-1}, and 8 kg K ha^{-1}. All of the P and K, and 15.5 kg N ha^{-1}, were applied as an initial dressing of compound fertilizer at planting. The remaining 34.5 kg N ha^{-1} was applied as an ammonium nitrate top dressing six weeks after planting. The plot size was 5 m x 4.5 m with 1 m between plots. Row width was 75 cm, with one plant per 20 cm of row.

Soil fertility levels in Siabuwa are known to vary greatly with soil type (Hungwe 1985), and so sites were selected to cover the three main soil types in the area, the vertisols, the siallitic clays, and the sandy loams. The trial was established at two sites of each soil type during both seasons. The same six sites were used in the two seasons, but a different location within the same field was selected during the second season. At two sites land was prepared using a tractor-drawn mouldboard plough; the other four sites were not ploughed.

The trial was dry planted (reflecting farmers' practice) at all sites on 16 November during 1984-85 and on 28 November during 1985-86. The researcher was responsible for planting, thinning, applying the fertilizer treatments, and harvesting. Other non-experimental inputs and practices were at the farmer level and managed by the farmer. In particular, host farmers were responsible for weeding (generally two hoe weedings) and scaring birds.

At harvest two crop rows were discarded on each side of an individual plot and a 50-cm length of plants was removed from both ends of the plot. The number of plants, number of panicles, and fresh weight of panicles were recorded for the remaining 4 m x 1.5 m nett plot.

A sub-sample of 10% of the nett plot fresh weight was collected from each plot and dried to constant weight at 80°C for 72 h and then threshed. Grain yield per hectare was calculated from these sub-samples, and reported at 12.5% moisture.

An analysis of variance was first done for each site in each year, then across sites and across years, and was followed by means separation tests. A partial budget analysis (CIMMYT 1988) was done for the local sorghum, SV-2, and 321CR, with and without fertilizer. The latter two varieties are short-season sorghums which taste tests have shown to produce acceptable-tasting porridge. The sorghum grain yields from the trial plots were reduced by 20% in the partial budget to reflect yields that farmers would expect to get in their fields (CIMMYT 1988). The 1986 Grain Marketing Board price of Z$ 180/t was used to value sorghum grain and farm gate costs of fertilizer and labour for applying the fertilizer and harvesting the extra yield were used. These were Z$ 356.00/t for compound D fertilizer and Z$ 406.00/t for ammonium nitrate fertilizer. Labour costs were Z$ 4.50/ha for applying both compound D and ammonium nitrate fertilizer, and Z$ 3.60/ha for harvesting the extra grain yield.

Fertilizer levels trial—The fertilizer levels trial was established in 1985-86 and 1986-87 to examine the response of the short-season sorghum, SV-2, to a range of low levels of inorganic fertilizer. The experimental design was a split plot. Levels of initial dressing of compound fertilizer comprised the main plots, and levels of top dressing of ammonium nitrate the sub-plots. There were three replicates. A total of 16 experimental treatments were included as a factorial of the following: 1) initial fertilizer at 0:0:0, 10:7.3:4.6, 20:14.6:9.2, and 30:21.9:13.8 kg NPK ha^{-1}; and 2) topdress fertilizer at 0, 28, 56, and 84 kg N ha^{-1}. Gross plot sizes were 20 m x 3 m for the main plot and 5 m x 3 m for the subplot.

Three sites, one on each of the three main soil types, were selected for 1985-86 and for 1986-87, but different farms were used each year. The trial was planted on 30 November during 1985-86. In 1986-87 two sites were planted on 28 November and the third site on 10 December. Management of this trial, including planting, thinning, weeding, and harvesting, was by the researcher. Harvest methods and data gathered were similar to those described above.

Data for the 1985-86 season were available from only one site (crops at two sites were destroyed by drought); data for the 1986-87 season were available from all three sites. A grouping of sites by soil type resulted in homogeneous variances for data from sites located on sandy loam soils and for sites on clay or sandy clay loam soils. An analysis of variance was then carried out on the two sets of data.

As previously described, partial budgets were calculated from the combined data from the sandy loam sites. No economic analysis was done for sites on the clays and sandy clay loams because fertilizer effects on grain yields were not significant with those soils.

Variety trial—This trial examined whether shorter season food sorghums have yield advantages over other types currently grown by farmers in Siabuwa.

The experimental design was a RCBD replicated three times. Ten sorghum varieties were used: MR730, SV-1, SV-2, Segaolane, Chisumbanje, MR748, MR726, MR703, Serena, and the farmers' local variety (Balala).

The trial was planted during 1986-87 at seven sites across all soil types in Siabuwa. Plot size and management responsibilities were similar to those in the variety x fertilizer trial. Since most farmers do not use fertilizer on sorghum, fertilizer was not applied in this trial. The data gathered and methods used at harvest were also similar to those in the variety x fertilizer trial.

Farmer and site selection for the experiments—In 1984-85 farmers had to be selected largely for their willingness to co-operate, but many farmers offered land for the next season of trials, and so it was possible to choose farmers with representative resource levels and soil types for the 1985-86 and 1986-87 seasons.

Several farmers could not provide a sufficiently large piece of land with a similar cropping history on which to place a trial. Where necessary, trials were blocked such that each owner managed one replicate.

Some difficulties were experienced as the trial programme was implemented. Trials at several sites showed high coefficients of variation. Results from those sites have been reported because they reflect variations that occurred in farmers' fields. Some of the varieties tested, especially M36172 and to a lesser extent 321CR and SV-2, had approximately 77% of the numbers of plants/m² that were present for the long-season local and another variety, Serena. Plant population density was in part reduced by birds, particularly partridges (*Perdix perdix*), which dug up seeds and seedlings.

Farmer evaluation of sorghum porridge—Two tests to evaluate the taste of stiff porridge (the main food prepared from sorghum grain), a multiple comparison preference test and a hedonic (or degree of liking) test (Larmond 1982), were administered during the 1986 season to 21 panelists randomly selected from a gathering of farmers. Hot porridge made from four sorghum varieties (Balala, SV-2, 321CR, and M36172) was served to farmers. Balala, the local variety most commonly grown by farmers, was used as the standard. The detailed conduct of these tests followed the guidelines given by Larmond (1982).

In the preference test, farmers were asked to decide whether each coded sample of SV-2, 321CR, and M36172 had a better taste than, was comparable to, or was poorer than the standard, Balala. Farmers were then asked the amount of difference that existed between each of the coded samples and the standard. Scores were assigned to the responses: a score of 9 indicated a very high preference and a score of 1 an extreme dislike.

The multiple comparison preference test can only tell if one sample is preferred to another and cannot show whether two samples are highly preferred or not. Accordingly, the hedonic test was carried out to ascertain how much people really liked the samples. The standard and test varieties were recoded for this test. Again a scale of 1 ('dislike extremely') to 9 ('like extremely') was used for the responses.

An analysis of variance of results from the tests was carried out and Tukeys test used to determine which varieties were significantly different from each other.

Results

Rainfall during the three seasons of on-farm trials in Siabuwa was 775 mm in 1984-85, 720 mm in 1985-86, and 355 mm in 1986-87. A graph comparing monthly rainfall for the three seasons with 34 years of rainfall data from the Siabuwa meteorological station is shown in Figure 1. The first two seasons,

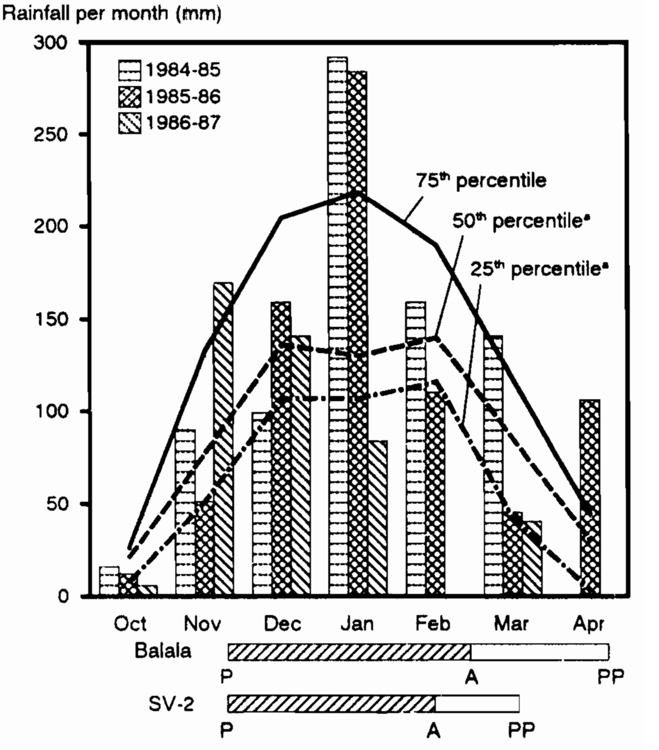

Figure 1. Relationship between the development cycle of Balala and SV-2 sorghum and rainfall per month for the 1984-85, 1985-86, and 1986-87 growing seasons in Siabuwa, northwestern Zimbabwe. P = planting, A = 50% anthesis, and PP = physiological maturity.

* Calculated from 1951-52 to 1986-87 data.

1984-85 and 1985-86, were among the 47% of years in which rainfall was above the mean of 676 mm, whilst 1986-87 had the third lowest rainfall total in the 34-year record. Responses to experimental treatments, particularly fertilizer, in the trials very much depended on the pattern and amount of rainfall in each season.

Variety x fertilizer trial—Variety x season (p = 0.01), variety x location (soil) (p = 0.05), and fertilizer x season x location (soil) (p = 0.05) interactions for grain yield were significant and are examined separately.

The grain yield of all varieties was lower during 1985-86 compared to 1984-85 (Table 1), but in both seasons all the introduced shorter season varieties yielded better than the local long-season variety, Balala.

Response of variety with season depended on the cropping season's rainfall pattern and the number of days needed for a particular variety to reach physiological maturity. Although rainfall totals for both 1984-85 and 1985-86 were above the 34-year average (775 mm and 720 mm respectively) the distribution of rainfall in relation to planting date favoured the 1984-85 season. In particular, in 1985-86 there was less rainfall shortly after planting and in March (during grain filling) (Figure 1). The low numbers of shoots and panicles per hectare achieved by all varieties in 1985-86 (Table 1) are attributable to the low rainfall received just before and soon after planting. The interaction arose because the two intermediate maturity materials (Serena and M36172: 126 and 121 days to physiological maturity, respectively) and the long-season local (around 131 days to physiological maturity) experienced a longer period of water deficit during grain filling than did 321CR and SV-2 (106 and 94 days to physiological maturity, respectively) in 1985-86 and consequently achieved much lower grain yields (Table 1, Figure 1).

Relative performance of varieties did differ by site but there was no consistent link with either the type of soil at a site or with whether the site was ploughed (Figure 2). For example, at the two sites on the sandy clay loam soil, variety SV-2 shifted from being the highest yielding at one site to being the lowest yielding at the other. Except for one site on the clay soil, Serena (intermediate type) was consistently the best or equally best yielding variety at all sites. The varieties 321CR and M36172 also yielded consistently higher than the local, whereas SV-2 was

Table 1. Grain yield, number of shoots ha^{-1}, and number of panicles ha^{-1} at maturity for five varieties of sorghum, averaged over two fertilizer regimes, Siabuwa, northwestern Zimbabwe, 1984-85 and 1985-86

Season and variety	Grain yield (kg ha^{-1})	Number of shoots ha^{-1}	Number of panicles ha^{-1}
1984-85			
M36172	2,583	128,600	127,400
321CR	2,499	125,700	131,500
SV-2	2,511	100,400	108,600
Serena	3,640	160,300	132,800
Long-season local[a]	2,223	160,000	141,800
1985-86			
M36172	892	49,000	41,100
321CR	1,636	73,800	69,000
SV-2	1,824	69,100	66,700
Serena	1,244	77,400	70,200
Long-season local[a]	702	77,400	70,200
SED (season x variety)	123	6,420	7,770

a Balala.

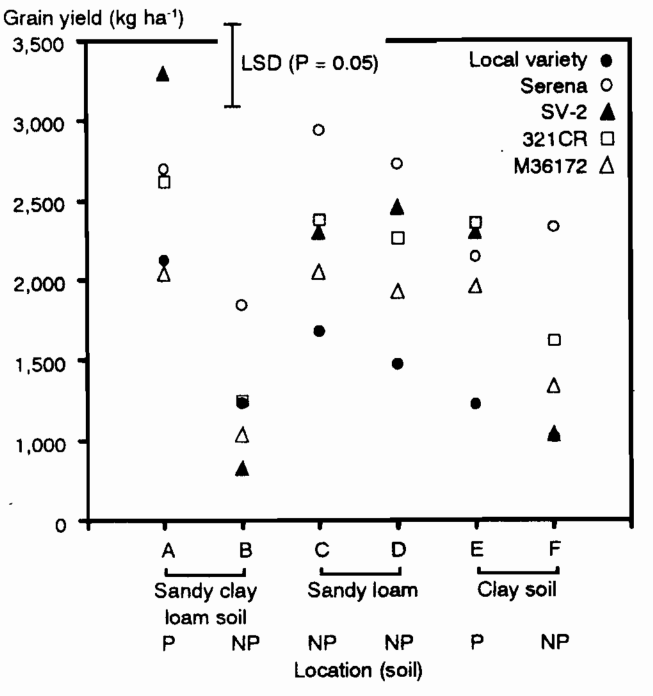

Figure 2. Response of five varieties of sorghum grown under ploughed or unploughed conditions on three soil types in Siabuwa, northwestern Zimbabwe, 1984-86: variety x fertilizer trial. P = ploughed, NP = not ploughed.

less consistent but generally yielded more than the local. Ploughing appeared important for high yield among the new short-season varieties at sites where the soil can cap (sandy clay loam) and on the clay soils (Figure 2).

All varieties, including the local, responded to fertilizer, but the level of response depended on the crop season (rainfall distribution) and the location (soil type) (Figure 3). Grain yield of local with fertilizer was generally less than the yield of the improved varieties without fertilizer, especially in 1985-86 when the long-season local was affected by a water deficit during grain filling and so could not benefit from the fertilizer applied (Figure 3). In 1985-86 there was a consistently higher grain yield (approximately 60% increase) with fertilizer across all soil types compared to approximately 37% in 1984-85. For the new varieties fertilizer effects on the sandy clay loams and sandy loams tended to be greater at sites that had been ploughed (Figure 3). Response to fertilizer did not differ greatly with the different soil types in the two years (Figure 3), which reflects the similar N and P status of the soils (Chiduza et al. 1992).

Variety trial—As noted earlier, rainfall during 1986-87 was the third lowest rainfall in the 34-year record. Little rain fell in January and none in February (Figure 1), and the resulting grain yields of the varieties examined was low (Table 2). Farmers did not harvest any grain from most of their longer season sorghum crops in Siabuwa in 1986-87. In the trial Serena (intermediate) and two later maturing varieties, Chisumbanje and Balala (the farmers' local), did not reach physiological maturity because the growing season ended early. These three varieties yielded no grain at almost all sites. However, the earlier maturing varieties (SV-1, SV-2, Segaolane, MR748, MR703, MR730, and MR726) yielded some grain. Days to 50% anthesis explain well the grain yields obtained. Serena, Chisumbanje, and Balala are 10-18 days later to anthesis compared to the other varieties (Table 2), and this meant that the early part of the grain filling phase coincided with the period of low rainfall (Figure 1).

Segaolane produced above average yields at all sites while SV-1 was above average at six of the seven sites. The varieties MR730 and MR748 had above average yields at some sites but yielded below average at others. Variety SV-2, which yielded well in the previous cropping seasons, again yielded well above average (at six of the seven sites) (Table 2).

Fertilizer levels trial—There was no effect on grain yield of either the initial dressing or the topdressing of fertilizer on either the sandy clay loam or the clay soils in 1985-86 and 1986-87. Relatively high levels of NPK present in these soils and insufficient moisture (especially in 1986-87) explain the low response to fertilizer.

The response to fertilizer during 1986-87 at the two sites with sandy loam soils was inconsistent (Table 3). Site 2 showed significant yield increases with increasing levels of both topdressing and the initial

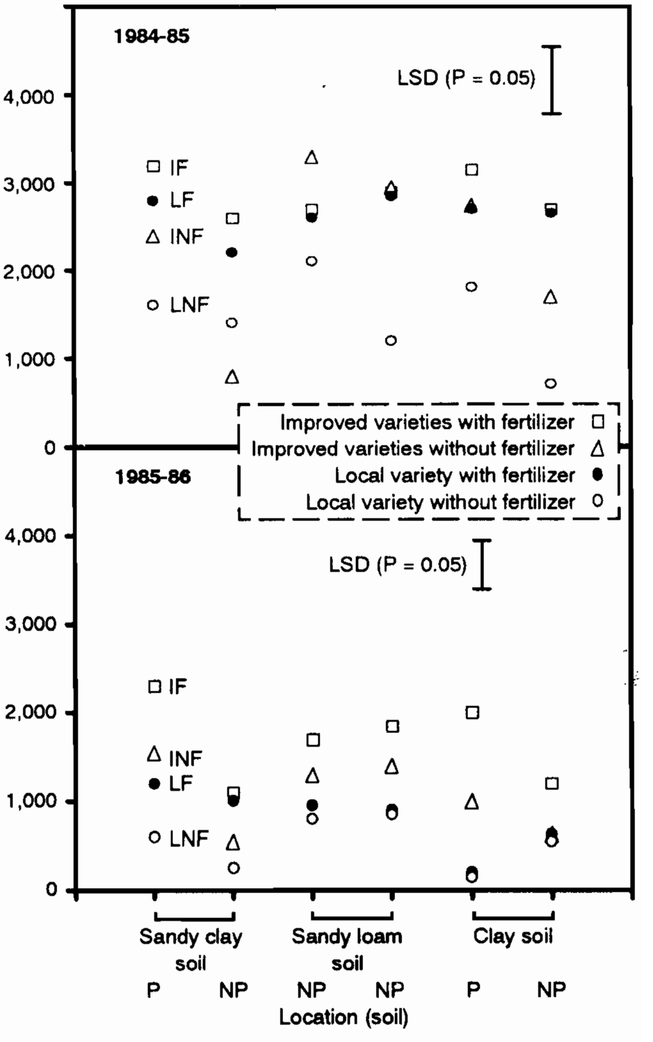

Figure 3. Response to applied fertilizer of local and improved varieties of sorghum grown on three soil types in Siabuwa, northwestern Zimbabwe, 1984-86: variety x fertilizer trial. P = ploughed, NP = not ploughed.

dressing up to 20:15:9 kg NPK ha^{-1} basal and 56 kg N ha^{-1} topdress, but little response was seen at the other site.

The different response to fertilizer at the two sandy loam sites was probably due to the differences in planting date and rainfall distribution following establishment of the trial at the two sites. A prolonged dry spell was experienced soon after establishment at the non-responsive site and resulted in little effect of fertilizer on grain yield.

Farmer evaluation of taste of porridge from sorghum grain—The multiple comparison preference test showed that farmers preferred the taste of thick porridge prepared from the grain of the early maturing varieties SV-2, 321CR, and M36172 significantly more (p = 0.05) than the taste of the farmers' current variety, Balala. Farmers had the highest preference for 321CR, followed by SV-2 and then M36172, compared to Balala.

In the hedonic test there were significant differences (P=0.01) in how much thick porridge prepared from the varieties SV-2, 321CR, M36172, and Balala was liked. Preferences agreed with those from the multiple comparison test. Porridge made from variety 321CR was liked the most, receiving a score of 8.3 out of 9 (thus it was 'liked very much'). SV-2 was also 'liked very much' (score 7.8), whereas farmers had a 'moderate preference' for M36172 (score 7.2). Balala received a neutral score of 5.0 from farmers, meaning that it was neither liked nor disliked. The preference for variety M36172, the least preferred of the three introduced sorghum varieties, was nevertheless significantly higher (p = 0.05) than that of Balala. Thus all three new white early maturing sorghums were preferred more or equally to varieties currently grown by the farmers for thick porridge.

Table 3. Effect of initial and topdress fertilizer on sorghum grain yield (kg ha^{-1}) for sandy loam soils, Siabuwa, northwestern Zimbabwe, 1986-87

	Site 1	Site 2
Initial dress, NPK (kg ha^{-1})		
0:0:0	732	1,253
10:7:5	553	1,709
20:15:9	574	2,651
30:22:14	532	2,427
SE	124	220
Topdress, N (kg ha_{-1})		
0	427	1,478
28	617	1,722
56	670	2,313
84	677	2,528
SE	105	151

Table 2. Grain yield of 10 sorghum varieties at seven sites, Siabuwa, northwestern Zimbabwe, 1986-87, and number of days from emergence to 50% anthesis and to physiological maturity for the same varieties grown under irrigation at Chiredzi, southern Zimbabwe (a location with temperatures similar to those in Siabuwa)

	Grain yield (kg ha^{-1})								Days from emergence to:	
	Site							Variety mean over	50%	Physiological
Variety	1	2	3	4	5	6	7	sites	anthesis	maturity[a]
MR730	825	859	523	741	333	288	327	557	76	112
SV-2	1,313	1,763	1,626	1,276	755	150	684	1,081	67	109
Segaolane	1,031	1,444	769	718	774	768	359	838	67	107
SV-1	1,077	1,195	839	789	822	213	908	835	75	111
MR703	947	939	946	645	360	224	294	622	73	121
MR726	517	728	120	323	0	324	268	326	75	122
MR748	731	731	305	646	780	115	522	547	74	123
Serena	0	0	0	0	0	19	0	3	84	126
Chisumbanje	0	0	0	0	0	9	0	1	84	128
Local[b]	444	0	0	0	0	156	0	86	90	131
SE	63.4	99.8	354.0	216.1	202.7	221.4	187.5	90.2	na	na

a Physiological maturity determined by appearance of dark hilum.
b Balala.
na = not applicable.

Discussion

Grain yield of short-season sorghum varieties—Introduced pearly white grain sorghum varieties with a short plant development cycle that better fits the available rainfall season yielded consistently better (by an average of 62% in three trials) than current local long-season varieties in the three years of experimentation. These sorghums sampled a good (greater than 700 mm of rainfall, well distributed during the growing season), an average, and a poor rainfall season in Siabuwa. Varieties such as SV-2 and 321CR performed well in all the seasons in which they were tested, while varieties such as M36172 showed greater potential to take advantage of a good rainfall season. Given the highly variable rainfall pattern in Siabuwa, the stability of the yield improvement offered by the new short-season sorghum varieties over the different types of season is important. Seasons with good rainfall occur only about one year in three in Siabuwa.

Serena, an intermediate maturing improved variety, yielded better than the short-season varieties SV-2 and 321CR in 1984-85 (when rainfall was good and well distributed), but in 1985-86 and 1986-87 most short-season varieties yielded better than Serena. Data from the variety trial conducted during 1986-87, which had a total of just 355 mm of rainfall, highlight the advantage that farmers can obtain by growing the short-season sorghum varieties. The long-season local (Balala) yielded 86 kg ha^{-1} compared with an average 828 kg ha^{-1} for introduced short-season varieties under farmer management in that extremely dry year (Table 2).

Thus in almost all seasons in Siabuwa, any of the three short-season improved varieties (SV-2, M36172, and 321CR) would be preferable to the current local longer season varieties under present farmer management, including no use of fertilizer.

Farmer food preference for short-season sorghum varieties—The priority for most farmers in Siabuwa is to meet their subsistence food requirements. The crops and varieties of those crops they produce are dictated by, amongst other things, food preferences. At the moment one of the main reasons why farmers grow long-season sorghum varieties is because they like the taste of porridge prepared from them. Taste preference has been shown elsewhere to be important in the adoption of sorghums by subsistence farmers, e.g., in West Africa (ICRISAT 1980-83). Results from the food evaluation tests indicated that farmers in Siabuwa preferred the taste of porridge from the new improved short-season sorghum varieties compared to the current long-season variety, Balala.

If data on grain yield only are considered, then in the wetter years the intermediate variety Serena had the best advantage over the long-season local compared to other varieties. However, no farmer was observed to grow Serena even though it had been available in Siabuwa since the early 1980s, while in 1985-86 and 1986-87 a few farmers grew three other improved shorter season sorghum varieties, SV-2, 321CR, and M36172, straight after their release. The difference between Serena and the other varieties, apart from maturity length, is grain colour and taste. Serena is a bitter red-grained brewing type of sorghum, whilst the other three are pearly white grained varieties specifically bred as food sorghums. Unsuitability for porridge may explain the low adoption of brewing sorghum varieties reported by Reid (1982) in Kariba District.

Adoption potential of short-season sorghum—The combination of higher, more stable grain yield with a preferred taste should quickly lead Siabuwa farmers to adopt the new short-season sorghums. The new short-season sorghums are open pollinated varieties, and seed was made available free to farmers who expressed interest in growing them during the 1987-88 and 1988-89 seasons. Thus little extra cost was associated with the use of these materials. Even if seed has to be purchased, the change of variety will be extremely economic given the estimated marginal rate of return of 1,232% in moving from the farmer's local to SV-2 (Table 4).

Nevertheless it is anticipated that for two main reasons farmers will continue to plant a proportion of their sorghum area to longer season sorghums, especially as ratoon crops on the vertisols. First, these experiments indicate that long- or intermediate-season sorghums with grain acceptable for making porridge and higher yield potential may have a role in the system to take full advantage of good rainfall years. However these materials have still to be developed. Second, a shortcoming of the new short-season sorghums appears to be their greater difficulty in establishing a good plant stand on the vertisols. This was observed at trial sites, especially in 1985-86 when rainfall was low just after planting, and the resulting yield reductions require further study in relation to tillage. Only Serena and the local achieved good stand establishment on all soil types, whether ploughed or not. It seems that the short-season varieties were more responsive to ploughing and may therefore establish themselves better as land preparation improves in Siabuwa.

Fertilizer use—Because of the small number of sites and seasons sampled, the conclusions on fertilizer use are preliminary.

In very dry seasons similar to 1986-87, fertilizer generally does not increase yield and so an economic disadvantage would accrue from applying fertilizer. Similar dry seasons with less than 450 mm of rainfall, in which little or no response to fertilizer is likely, occur about one year in seven in Siabuwa.

During above average or average rainfall seasons, such as 1984-85 and 1985-86, use of 50 kg N, 12 kg P, and 8 kg K ha^{-1} fertilizer should show a yield increase of about 44% across all soil types, compared to no fertilizer. Although in these trials the local variety produced the highest percentage response to fertilizer, the absolute grain yield for the local with fertilizer was only slightly higher than that of the short-season improved varieties without fertilizer.

Table 4 shows net benefits and the marginal rate of return to cash for applying fertilizer to the farmers' local, 321CR, and SV-2 sorghum during 1984-85 and 1985-86, the years when fertilizer consistently raised grain yield. Marginal rates of return in moving from no fertilizer to 50 kg N, 16 kg P, and 7.6 kg K ha^{-1} were 75% for the farmers' local variety and 96% for SV-2. Farmers in Siabuwa are risk averse and not accustomed to purchasing high levels of inputs. As a general rule, in an environment like Siabuwa farmers will be unlikely to make an investment unless the average rate of return is at least 100% per crop per season (Perrin et al. 1976, CIMMYT 1988). Consequently the cash returns to fertilizer use are probably unattractive to farmers in Siabuwa even in seasons when rainfall is above average.

Thus, preliminary results show the application of fertilizer to either current long-season local or improved short-season sorghums in Siabuwa to be very risky and uneconomic. Fertilizers were not generally used by local farmers on sorghum at the time of the trials and these findings support current farmer practice. However the issue of fertilizer use x soil type x season interaction does need further investigation. Lower levels of N fertilizer (20-40 kg N ha^{-1}) applied as a cheaper straight N source shortly after emergence (rather than mixture of compound basal and straight N topdress) may be economic in years when rainfall is average or better than average, especially on ploughed land.

Table 4. Costs that vary and net benefits from the use of fertilizer (50 kg N, 16 kg P, and 8 kg K ha^{-1} split dressing) with farmer's local, 321CR, and SV-2 varieties, Siabuwa, northwestern Zimbabwe, 1984-85 and 1985-86

Treatment	Total costs that vary (Z$/ha)[a]	Net benefits (Z$/ha)[b]	Marginal rate of return (%)[c]	
Farmers' variety, no fertilizer	0.0	156.1		
321CR, no fertilizer	6.7	229.7	1,232% (farmers' variety to SV-2, no fertilizer)	75% (farmers' variety, no fertilizer to with fertilizer)
SV-2, no fertilizer	7.0	242.2		
Farmers' variety, with fertilizer	145.4	265.1		
321CR, with fertilizer	152.7	365.8	96% (SV-2, no fertilizer to with fertilizer)	
SV-2, with fertilizer	153.1	382.2		

a The cost of $0 given to the farmers' variety biases the marginal rate of return (MRR) in favour of this variety. If a seed cost were attached to the farmers' variety, the MRR in moving to the improved variety would be much higher.

b Yields reduced by 20% to approximate farmers' yields.

c The MRR is calculated only in moving to the best yielding improved variety, SV-2.

Conclusion

In conclusion, results from the experiments reported here indicate that:

- Use of improved white grain, open pollinated short-season sorghum varieties acceptable for porridge, such as SV-2 and 321CR, would increase grain yield per hectare (and yield stability) over almost all rainfall seasons under farmers' current management without use of fertilizer in the short term. Such short-season sorghums are useful additions to the portfolio of sorghum varieties available to farmers in Siabuwa.
- Use of fertilizer (at 50 kg N, 16 kg P, and 8 kg K ha^{-1}) is at present uneconomic for most seasons on all the main soil types in Siabuwa, either with current local long-season sorghums or the new short-season varieties. Lower rates of fertilizer need testing.

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