JASSA

Journal of Applied Science in Southern Africa
The Journal of the University of Zimbabwe

Volume 4, Number 2, 1998 ISSN 1019–7788

CONTENTS

EDITORIAL

The seven articles in this issue Volume 4(2) ,consist of three research papers from physics, two research papers from the agricultural sciences, one inaugural lecture and one book review. The current issue has a very good balance of the physical and biological sciences. This is important and in line with the policy of JASSA, that is, the publication of papers on applied sciences. Previously there has been a preponderance of papers from the agricultural sciences. In this issue, the three submissions from the discipline of physics has, for the moment ended that tradition. This is a welcome development as this widens our latitude of papers on applied sciences. The two agro-based papers present particularly interesting findings because of their relevance to the Southern African regional context, in as far as the economic importance of sugar production, both for export and local consumption, and the significance of semi-arid agriculture in the region.

The paper on sugar cane establishes that induction of mild stress, in the form of restriction of water to levels that do not fall below crop factor 0.85, increases sucrose yield. The second agricultural based paper establishes poor crop establishment as a major factor affecting crop production in the semi-arid areas of Zimbabwe. Agriculturalists in semi-arid areas will find this paper interesting. 'A pedestrian route to Gleason's theorem' is the creative title of one of the physics papers. The author here offers what he calls an elementary proof of the 'theorem' and one which is different from those previously offered and it is interesting.

The inaugural lecture is this issue: 'New Directions for Pesticide Use' is the first in this series. This lecture is an intellectual plea for the serious consideration of 'the middle road' approach to Integrated Pest Management from a prominent crop scientist. It is argued that the misconception that pests can be eradicated rather controlled has subsequently led to the pesticide treadmill and that the proper use of pesticides should involve a thorough understanding of pest population dynamics and how this is influenced by the pesticidal control and the infestation/yield loss relationship and the economics of pesticide use. The Integrate Pest Management approach is argued for, convincingly.

Finally the review of the book *Lecture Notes on Pharmacodynamics* represents almost exclusively the first review ever in the JASSA of an article from the medical sciences. This is a welcome development, even more so for the fact that this is a text book for students of the medical sciences.

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Vol. 4, No. 2, 1998
ISSN 1019–7788

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Published by University of Zimbabwe Publications
P.O. Box MP203, Mount Pleasant, Harare, Zimbabwe

Typeset by University of Zimbabwe Publications
Printed by Mazongororo Paper Converters

Agronomic practices, major crops and farmers' perceptions of the importance of good stand establishment in Musikavanhu Communal Area, Zimbabwe.

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Surveys were conducted of rainfed crops growing in farmers' fields in the Musikavanhu Communal Area in Natural Region V of Zimbabwe during and after the 1995/96 cropping season. The major crops were sorghum, maize and sunflower grown by 94.36 and 15 per cent of the farmers, respectively, and occupied 82.12 and seven per cent of the land. Eleven sorghum cultivars were grown in the area during the 1995/96 season, although only four were grown by more than 10 per cent of the farmers. The most popular maize variety was grown by 28 per cent of farmers on 10 per cent of the land, but had been distributed as part of a drought relief package. Stand establishment was identified as a major crop production constraint in this area. More than 50 per cent of the farmers gap-filled at least once and there was a good correlation (R^2 = 0.73) between frequency of re-sowing of sorghum and the number of varieties present in fields because seed of the initial, preferred variety was not available for later sowings. On-farm seed priming was fairly common in maize and transplanting, using thinnings, was almost universal in sorghum.

Keywords: semi-arid Zimbabwe, farmer survey, crop establishment, sorghum, maize, sunflower, seed priming, transplanting.

Introduction

Zimbabwe is classified into five Natural Regions (NR I to V) according to Vincent and Thomas (1960). The agricultural potential of the country declines from NR I which represents the high altitude wet areas to NR V which receives low and erratic rainfall averaging 500 mm or less per annum. Natural Region V covers 27 per cent of the geographical area of Zimbabwe and 29 per cent of that area is settled by communal farmers (Whitlow, 1980; Anderson *et al*, 1993). According to Beets (1990), communal farmers are smallholders with small farms (0.5 to 5.0 ha) operated by one or a few households. The head of the farm is usually the head of the household and is sometimes the owner of the farm but is in most cases a tenant because there are no title deeds. Most of the smallholders (communal farmers) in Zimbabwe operate under rainfed conditions.

Sorghum, pearl millet and maize are major rainfed crops in NR V and crop failures are common in all crops (Chiduza, 1987; 1993; Chivasa, 1995). Some parts of NR V are very remote and seed is often in short supply, which can result in reductions in area planted and consequently to shortfalls in food supply at household level (Chiduza, *et al*, 1994). FSRU (1994) found, for example, that in Chivi communal area sorghum hectarage was reduced to just two per cent due to a lack of seeds. Farmers have difficulties in sourcing seed due to persistent droughts and low yields. Whatever grain is harvested has to be eaten and there are few chances to retain seed for planting (van Oosterhout, 1996a).

Crop stand establishment is a major constraint affecting smallholder food production in the semi-arid areas of Zimbabwe. Olver (1988) indicated that one of the major constraints of smallholder maize production in semi-arid areas is the establishment of optimum, even plant populations. Work by Chiduza et al (1995) in the semi-arid Siabuwa communal area confirmed erratic crop establishment as plant population densities in sorghum ranged from 22 000 to 160 000 plants per ha with a mean of 58 700. Yet farmers planted 1 200 000 to 1 800 000 seeds per ha, implying only two to nine per cent germination and emergence. Landsberg (1964) recommended a plant population of around 100 000 plants per ha for sorghum for parts of Zimbabwe with rainfall similar to Siabuwa. In the semi-arid south-east lowveld where rainfall is slightly lower than that in Siabuwa in the north-west, recommendations of up to 66 000 and 22 000 plants per ha for sorghum and maize, respectively, were made by Nyamudeza (1993, 1996). Poor crop establishment has also been recorded in the south-east lowveld (Chivasa, 1995). Thus, the problem of poor crop establishment is widespread in Zimbabwe's semi-arid smallholder sector.

Previous work by Harris (1992, 1996) in semi-arid Botswana showed that crop stand establishment was poor in about 40 per cent of sowings. Other authors have noted a similar frequency of need to replant in Zimbabwe, with consequent increased labour costs and exhaustion of seed supplies (Chiduza, 1987, 1993, Chiduza et al, 1995; Chivasa, 1995; van Oosterhout, 1996b). In terms of growth and yield, the consequences of poor crop establishment are not confined to wastage of resources because of sub-optimal plant population densities or heterogenous distribution of plants within fields. Surviving plants in a poorly-established stand seldom get off to a good start (Okonwo and Vanderlip, 1985; Harris, 1996).

Two surveys were conducted in four villages in Musikavanhu Communal Area during and after the 1995/96 cropping season. The objectives of the two surveys were: to quantify the various crops that farmers were growing; to test the hypothesis that poor crop establishment was a major constraint on yield; and to gather data on indigenous methods of improving stand establishment. In the first survey the characteristics of the major crops grown in the area were identified and reasons for farmers' choices were recorded, together with information on sowing practices.

The second survey looked in more detail at farmers' views on, and knowledge of, interventions to improve stand establishment. Improving agronomic management will improve food security of smallholder farmers in marginal areas.

Materials and Methods

Both surveys were conducted in four villages (Kondo, Maronga, Musa-pingura and Mwacheta) in Musika-vanhu communal area, Chipinge district in the south east lowveld of Zimbabwe (Lat. 20° 25' S, Long. 32° 20' E). Mean maximum and minimum temperatures of the area are shown in figure 1a. Long-term averages of monthly rainfall and potential evapotranspiration (PET) clearly show the marginal status of the area for crop production as PET is greater than rainfall in all months (Figure 1b).

Survey 1

Ninety-four farmers (55 men and 39 women) were sampled at random using a list of farmers compiled by the Agritex (Department of Agricultural Technical and Extension Services, Ministry of Agriculture) extension workers who were closely involved with this study. The fields of the sampled farmers were visited and information on standing crop characteristics was recorded by direct observation and by interview. The research instrument used was a semi-structured questionnaire which was designed to collect among others, the following information: types of crops and crop varieties growing in the farmers' fields, morphological and agronomic characteristics of varieties grown, size of land occupied by each crop/crop variety, methods of planting (e.g. broadcast/row, sole/mixed), source of seed, reasons for farmers' variety preferences (including gender differences), plant population densities, crop spacing, crop establishment and frequency of replanting.

Length of season a crop takes to maturity was defined as short (up to 100 days), medium (up to 120 days) and long season (up to 150 days) in sorghum and short (up to 140 days), medium (up to 150 days) and long (greater than 150 days) in maize. Plant height was defined as short (less than 150 cm), medium (up to 180 cm) and tall (greater than 180 cm) in sorghum and short (less than 250 cm), medium (up to 300 cm) and tall (greater than 300 cm) in maize. Particle size was defined as small (15 cm), medium (20 cm) and large (30 cm).

The survey was carried out in March 1996 when all varieties had passed the soft dough stage which made identification easier. In fields with intercrop/mixed varieties, population densities were recorded noting the separate and combined plant population. Size of each field was estimated by the farmer and the researcher. However, farmers' estimation of farm size is known to be unreliable, not because they wish to deceive but because they simply do not know. Therefore, proxy variables such as seeding rates, time taken for ploughing, planting, thinning, transplanting and weeding were used to estimate farm size. Visual assessment of stand establishment was done by the interviewer, supplemented by plant population density per unit area derived from quadrat sampling. A one square metre quadrat

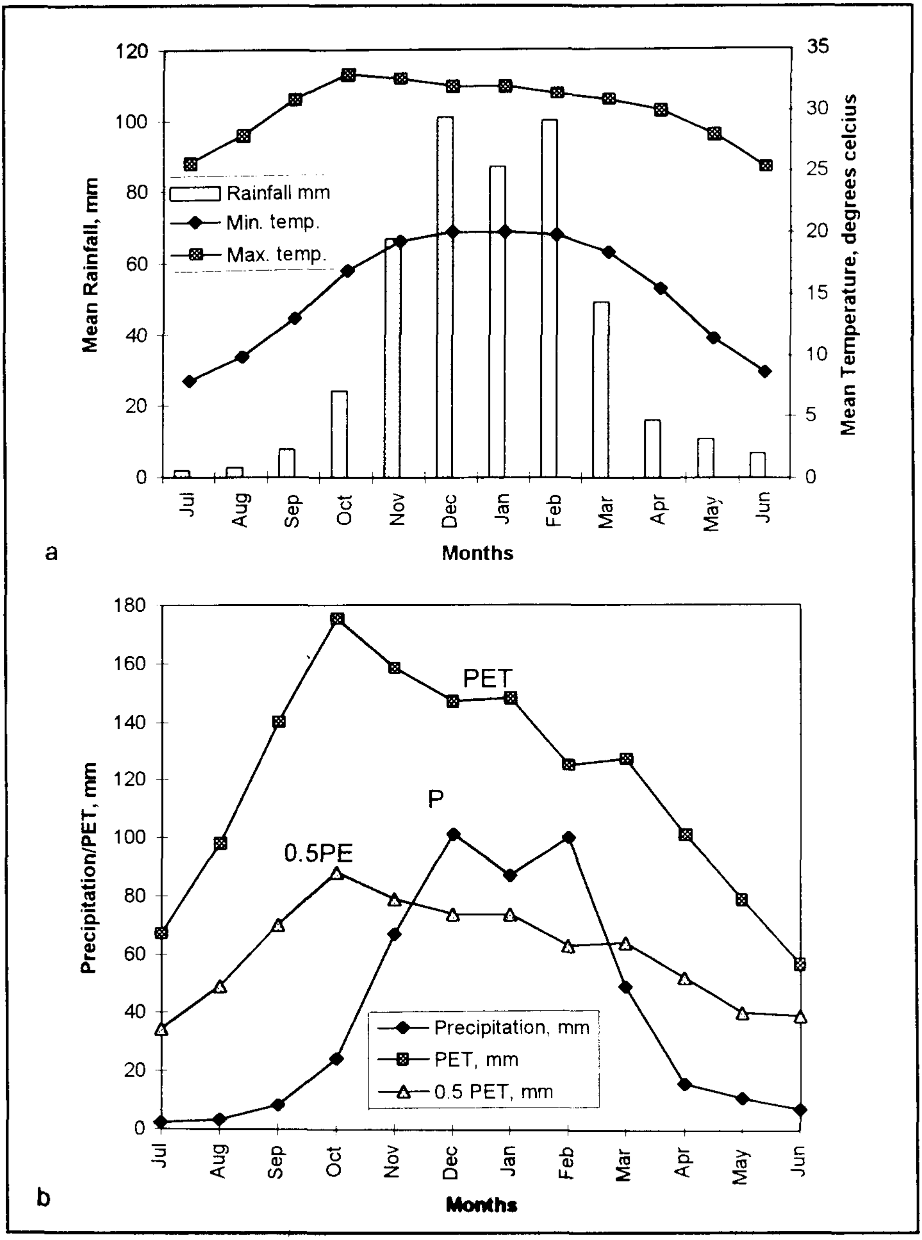

Figure 1: Mean monthly temperature and rainfall (a), and rainfall and potential evapotranspiration (PET) (b) for Middle Save, Zimbabwe, 1954 to 1984.

was used. Ten quadrats per field were sampled at random and the number of plants within the quadrat was counted and expressed per ha.

Survey 2

A subset of 60 farmers (15 from each of the four villages; 37 men and 23 women) was sampled at random (using the same list of farmers used in the first survey obtained from extension staff) and asked to provide information on farming practices likely to affect crop establish-ment. The research instrument used again was a questionnaire which was designed to collect data on farmers' agronomic practices and stand establishment problems. Information on farmers' practices collected included the following: crops grown, time of sowing, method of planting (e.g. sole or mixed), operation methods (farmers were asked whether they plough their fields before hand, broadcast/plough, dig/plant or plough/plant in rows), seeding rates, spacing, number of seeds per planting station, depth of planting, crop establishment problems, whether farmers soak their seed or transplant their seedlings, major pests affecting crop establishment and methods of storage of seed for next season. In the first survey, it was found out that the majority of the farmers used traditional unimproved varieties. In this survey the researchers were keen to find out how farmers handle their seed for planting in the next season since poorly stored seed can have an effect on germination per cent, hence crop establishment.

Results

Survey 1

The main crops grown in the study area were sorghum, maize and sunflower by 94.36 and 15 per cent of the respondents, respectively (Table 1). There was no pearl millet grown in the area during the survey season. Minor crops were intercropped with both maize and sorghum. Eighty-three per cent of the farmers grew cucumbers, 70 per cent grew watermelons, 35 per cent grew cowpeas and 14 per cent grew gourds in intercrop with sorghum. Maize was intercropped with cucumbers, watermelons, cowpeas and gourds by 85, 65, 33 and 12 per cent of the farmers, respectively.

Table 1: Main crops grown by a sample of 94 farmers during the 1995/96 season in Musikavanhu Communal Area, Zimbabwe.

			Land devoted to crop (ha)			
Crop	No of fields	% of farmers growing crop	Total	Mean farmer^{-1} crop^{-1}	SD	% of total
Sorghum	88	94	230	1.5	1.0	82
Maize	34	36	34	1.0	0.8	12
Sunflower	14	15	15	1.1	1.2	7
Total	136		279			100

Table 2: Sorghum, maize and sunflower cultivars grown by farmers in Musikavanhu Communal Area during the 1995/96 cropping season.

Variety	No. of fields	% of farmers	Land devoted to each variety Total (ha)	% of total land
Sorghum				
Short Mutode*	59	63	104	37.3
Chihumani*	36	38	56	20.1
Muchayeni*	24	26	33	11.8
Chimariya*	9	10	11	3.9
Tall Mutode	7	7	6	2.2
Chitichi	6	6	6	2.2
Red Swazi	5	5	5	1.8
Chidhomeni	3	3	1	0.4
Chichayeni	2	2	3	1.1
Chimhondo	1	1	2	0.7
Dehwe	1	1	3	1.1
Maize				
CG 4585*	26	28	29	10.4
R 201	3	3	2	0.7
PAN 473	3	3	2	0.7
CG 4141	1	1	0.5	0.2
Sunflower				
Local*	13	14	14	5.0
Msasa	1	1	1	0.4

* grown by 10 per cent or more of the 94 farmers sampled.

Eleven varieties of sorghum were found growing in farmers' fields, although only four were grown by more than 10 per cent of farmers (Table 2). There was little use of improved sorghum varieties in the area although Chihumani is a locally-maintained version of an improved variety, SV-2. Although farmers grew four varieties of maize, by far the most common genotype was CG 4585, seed of which had been distributed by Government as part of a drought relief package. Almost all sunflower was grown from farm-saved seed of unknown identity. Morphological and agronomic characteristics of the varieties grown by farmers during 1995/96 season are listed in Table 3.

The reasons for farmers' variety preferences are listed in Table 4. Early maturity was very important to farmers because shorter duration varieties often avoided drought conditions. Good taste in sorghum was usually associated with longer duration and white varieties like Muchayeni and Chichayeni. The early-maturing and tasty Chihumani was an exception. Short Mutode and Chimariya

Table 3: Morphological and agronomic characteristics of the cultivars grown by farmers during the 1995/96 cropping season in Musikavanhu Communal Area, Zimbabwe.

Variety	Grain colour	Particle size	Morphological & agronomic characteristics		
			Season length	Plant height	Main use
Sorghum					
Short Mutode	red brown	large compact	short	short	beer
Chihumani	cream white	large compact	short	short	sadza
Muchayeni	chalky white	large lax	long	tall	sadza
Chimariya	light brown	large compact	short	medium	sadza
Tall Mutode	dark red brown	med. compact	medium	tall	beer
Chitichi	chalkly white	med.compact	short	short	sadza
Red Swazi	light brown	med.compact	short	short	beer
Chidhomeni	pale white	large compact	short	short	sadza
Chichayeni	pale white	med. compact	short	short	sadza
Chimhondo	light brown	med. compact	medium	tall	sadza
Dehwe	chalky white	small compact	medium	tall	sadza
Maize		*grain size*			
CG 4585	white	medium flat	short	medium	sadza
R 201	white	large flat	short	medium	sadza
PAN 473	white	medium flat	short	short	sadza
CG 4141	white	small flat	short	medium	sadza
Sunflower					
Local	black	large	short	medium	sale
Msasa	black	large	short	medium	sale

(both red varieties high in tannins) were popular with male farmers because they were early maturing, were suitable for brewing beer and were not susceptible to attack by birds. Women, however, were influenced more by taste, storage and food preparation characteristics.

All sorghum and most sunflower was broadcast (Table 5) whereas most maize was row-planted with resultant population densities generally 35 per cent in excess of the 22 000 plants ha^{-1} recommended for the area by Nyamudeza (1996). Mean plant population densities measured by quadrat sampling and expressed per ha are shown in Table 6. All sorghum population means were below 66 000 plants per ha recommended by Nyamudeza (1993), except Red Swazi which was 16 per cent above the recommended population. Gap-filling in sorghum was very common, with farmers re-sowing up to four times. Figure 2 shows that of the fields with mixed sorghum varieties only 3.4 per cent were initially sown with more than one variety and there was a linear relation ($y = 0.579 + 1.08x$, $R^2 = 0.73$; $n = 119$) between frequency of re-sowing and the

Table 4: Main reasons for choosing sorghum and maize cultivars.

	*Reasons for farmers' preferences (percentage of farmers)														
Variety	1	2	3	4	5	6	1 &2	1&3	1&6	1,3&4	2&3	3&4	3&5	4&5	4&6
Sorghum															
Short Mutode[a]	—	—	50	5	5	13	2	4	2	2	2	8	2	3	2
Chihumani[a]	—	—	30	22	3	3	3	—	—	—	3	36	—	—	—
Muchayeni[a]	5	—	—	63	8	8	8	—	—	—	—	—	—	8	—
Chimariya[a]	—	—	56	—	—	44	—	—	—	—	—	—	—	—	—
Tall Mutode	—	—	—	—	58	42	—	—	—	—	—	—	—	—	
Chitichi	—	—	16	17	—	50	—	—	—	—	—	—	—	—	—
Red Swazi	—	—	60	20	—	20	—	—	—	—	—	—	—	—	—
Chidhomeni	—	33	—	34	—	—	—	—	—	—	—	—	—	33	—
Chichayeni	—	—	—	100	—	—	—	—	—	—	—	—	—	—	—
Chimhondo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dehwe	—	—	—	—	100	—	—	—	—	—	—	—	—	—	—
Maize															
CG 4585[a]	—	—	69	27	—	—	—	—	—	—	—	4	—	—	—
R 201	—	—	67	—	—	—	—	—	—	—	—	33	—	—	—
PAN 473	33	33	—	—	—	—	—	—	—	34	—	—	—	—	—
CG 4141	—	—	100	—	—	—	—	—	—	—	—	—	—	—	—

* 1 = good establishment; 2 = good keeping quality; 3 = early maturity; 4 = good taste for *sadza*; 5 = pest resistance; 6 = beer brewing.
[a] grown by 10 per cent or more of the 94 farmers sampled.

Table 5: Planting method and final plant spacings of crops grown by farmers during the 1995/6 cropping season in Musikavanhu Communal Area, Zimbabwe.

	Planting method (Percent of farmers)		Mean plant spacing (row crops only)			
Variety	B/cast	Row	Inter—row (cm)	SD	In—row (cm)	SD
Sorghum						
All varieties	100	0	—	—	—	—
Maize						
CG 4585	38	62	65	15.2	55	16.0
R 201	100	0	—	—	—	—
PAN 473	0	100	82	23.0	59	30.3
CG 4141	33	67	77	0.6	52	7.8
Sunflower						
Local	85	15	81	27.0	45	4.4
Msasa	0	100	—	—	—	—

Table 6: Mean plant population densities per hectare in sole crops during the 1995/96 cropping season in Musikavanhu Communol Area, Zimbabwe.

				Mean plant population (ha)		
Variety	Mean	SD	n	Maximum	Median	Minimum
Short Mutode	56 504	41 951	390	130 000	45 000	26 000
Chihumani	48 056	28 463	60	66 000	43 500	33 000
Muchayeni	46 333	20 664	60	66 000	43 500	33 000
Tall Mutode	54 500	31 431	60	88 000	52 500	32 000
Red Swazi	76 803	49 875	50	124 00	67 000	28 000
Chimariya	39 750	14 049	49	50 000	37 000	35 000
Chitichi	49 500	24 810	20	56 000	49 500	43 000
Chimhondo	35 000	21 731	10	1 field only	—	—
Maize						
CG 4585	38 312	14 989	260	59 000	38 000	24 000
R 201	37 750	10 833	30	46 000	35 000	32 000
PAN 473	35 969	11 246	30	37 000	36 000	35 000
CG 4141	39 000	12 867	10	1 field only	—	—
Sunflower						
Local	53 483	27 966	130	93 000	50 000	32 000
Msasa	59 000	20 790	10	1 field only	—	—

*n = total number of quadrats sampled

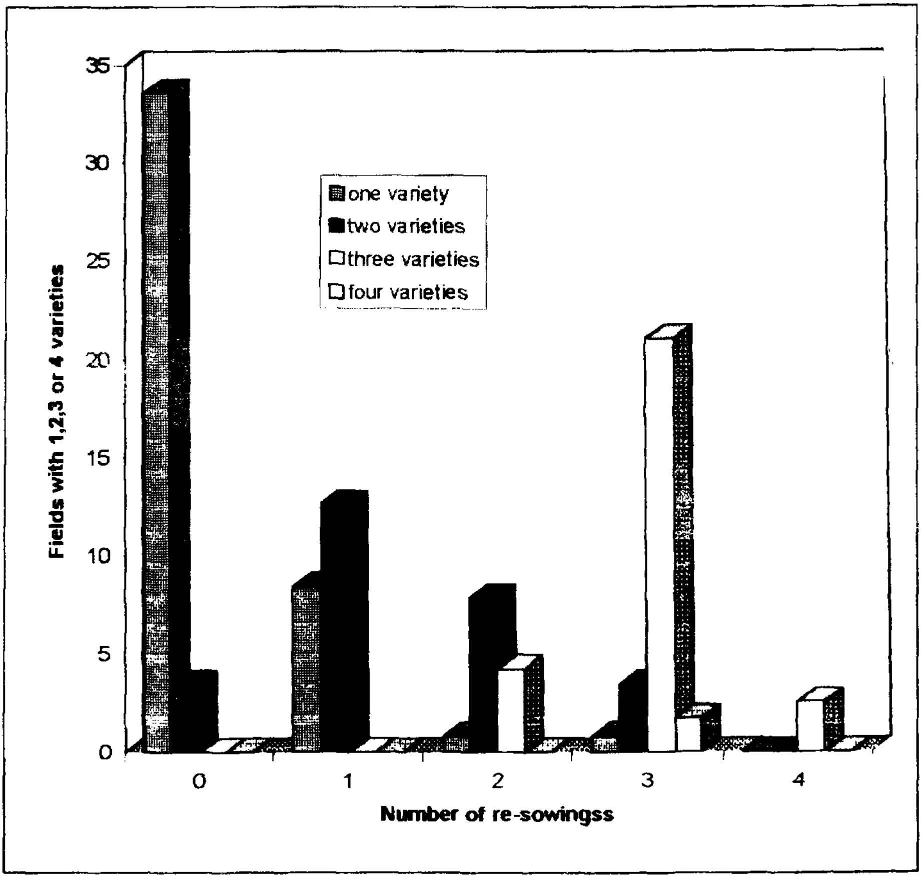

Figure 2: Relation between the number of sorghum varieties field^{-1} and the number of times the field was re-sown. Total sample was 119 fields with either Short Mutode, Chihumani or Muchayeni as the initial variety sown (see Table 2).

eventual number of varieties grown. Farmers in the study area reported that they mixed sorghum varieties because they were unable to obtain replacement seed of their preferred cultivars if they failed to establish and other, less preferred cultivars had to be used. However, even in fields where varieties were mixed, combined plant populations ranged from 26 000 to 94 000 plants/ha with a mean of 47 000 plants/ha well below the recommended optimum of 66 000 plants/ha.

Although farmers replant more than once (Table 7 and Figure 2), most of them did not achieve a reasonable plant stand as plant population ranged from as low as 26 000 to 130 000 plants per hectare (Table 6) in sorghum.

Table 7: Percentage of farmers who replant between 0 and 4 times during the 1995—96 cropping season in Musikavanhu Communal Area, Zimbabwe.

	Percentage Farmers who replant				
Number of times:	0	1	2	3	4
Sorghum					
Short Mutode	34	25	10	28	3
Chihumani	43	14	14	29	0
Muchayeni	33	21	17	25	4
Chimariya	22	30	6	31	11
Tall Mutode	60	0	20	0	20
Chitichi	67	33	0	0	0
Red Swazi	50	50	0	0	0
Chidhomeni	0	100	0	0	0
Chichayeni	22	0	22	44	12
Chimhondo	17	16	0	50	17
Dehwe	0	100	0	0	0
Maize					
CG 4585	35	31	19	15	0
R 201	100	0	0	0	0
PAN 473	67 0	33	0	0	
CG 4141	0	0	100	0	0
Sunflower					
Local	0	0	0	100	0
Msasa	69	15	8	0	0

Survey 2

Some of the common land preparation and planting methods used by farmers in Musikavanhu Communal Area are shown in Table 8. All farmers practised both dry planting and wet planting (i.e. planting after the rains) in sorghum whereas maize and sunflower were planted after the rains. Comparison of Table 5 and 8 shows that farmers in the second survey indicated that they sometimes plant their sorghum in rows, but observations in the field indicated that, in 1996, all sorghum was broadcast. Farmers use a combination of planting methods according to their individual circumstances and those who used hoes (to dig planting holes) indicated shortage of draught power.

The second survey revealed that farmers plant their sorghum, maize and sunflower at an average depth of 8, 11 and 7 cm with standard deviations of 4, 5 and 4, respectively. Farmers who plant their sorghum, maize and sunflower per station indicated seeding rates of 10-30, 1-3 and 3-5 seeds per planting station with means of 17, 1 and 4 and standard deviations of 11, 0.6 and 4, respectively.

Table 8: Common land preparation and planting methods used by farmers in Musikavanhu Communal Area, Zimbabwe.

	Percentage Positive Respondents		
Practices	Maize	Sorghum	Sunflower
Plough before hand	26	23	24
Broadcast plough	15	55	28
Plough plant (rows)	72	30	56
Dig planting hole	37	42	36
Broadcast and weed	7	27	4
Thinning	64	100	92
Dry planting	0	100	0

Table 9: a) Incidence of poor stand establishment, b) reasons for it, c) use of methods for improving it.

	Percentage of Respondents		
Question	Maize	Sorghum	Sunflower
a) *Poor stands?*	93	95	87
b) Reasons?			
Low moisture	65	73	74
Bad seed	13	18	22
Pests (*Hodotermis* spp.)	50	42	17
c) Use improvemetns?			
Seed Soaking	37	2	4
Transplanting	15	97	13

Poor stand establishment was reported by 93, 95 and 87 per cent of farmers in maize, sorghum and sunflower, respectively (Table 9). The major reasons cited for this in all three crops were low soil moisture at sowing time, pests (especially Hodotermis mosambicus L.) and poor seed quality. Thirty-seven per cent of farmers reported soaking maize seed sometimes overnight before sowing, although this was more usually only done if sowing was delayed following a planting rain. Only one farmer reported soaking sorghum seed, while two said that they had tried soaking sunflower. In contrast, 97 per cent of farmers reported trans-planting sorghum using thinnings whereas only 15 per cent and 13 per cent transplanted maize and sunflower, respectively.

Most farmers (90 per cent) select seed after harvesting for planting next season but only 52 per cent reported dressing their sorghum seeds with chemicals. Seed for planting next season is prone to damage by pests, reducing their quality and germination per cent which can adversely affect stand establishment.

Discussion

Sorghum, maize and sunflower were the most important crops in the study area. Minor crops like cowpeas, pumpkins, watermelons, cucumbers and gourds were commonly intercropped with sorghum and maize. They are clearly important to farmers and are eaten green either as vegetables, as desserts or when farmers are working in the fields. The role of these minor crops in semi-arid areas of Zimbabwe has been described elsewhere (Mazvimavi *et al.*, 1994) and discussion here is confined to the three main crops. It is somewhat surprising that no pearl millet was grown in the study area as this crop can be observed in fields in the Tanganda area to the north. When questioned, farmers attributed the absence of pearl millet in the area to traditional beliefs reinforced by the views of local chiefs. The chiefs do not allow their people to grow pearl millet because the ancestral spirits 'guiding' the chiefs do not tolerate pearl millet. It is alleged that if these chiefs eat any pearl millet product they become ill. These socio-cultural constraints are at odds with views on the agro-ecological suitability of pearl millet for the area. The crop is considered to be more drought tolerant than either maize or sorghum (Kassam and Kowal, 1975)

Eleven varieties of sorghum were recorded with most farmers growing more than one variety in the same field. Sometimes mixing of early and late maturing varieties was planned but usually mixtures resulted from the need to re-plant or fill gaps in a patchy stand. The first gap filling was usually done with the same variety but in subsequent gap fillings the farmers resorted to other sorghum varieties because of lack of seed. Not only does inappropriate plant population lead to low yields but to food insecurity at household level.

Only four of the sorghum varieties were grown by more than 10 per cent of the farmers and only Chihumani was an improved variety, and then not in a pure form. This is in general agreement with Oosterhout van (1992) who found out that, of the sorghum varieties grown in her study sites (Musikavanhu, Gokwe and Siabuwa), about half were grown by only a small proportion, often less than 10 per cent, of the farmers. Either improved sorghum germplasm is not deemed suitable by farmers or it is not reaching them on a regular basis. Certainly the reasons for choosing varieties cited in this study do not include yield-related characteristics and early maturity seems to be particularly important. Mazvimavi *et al*, (1994) have also reported that 36 per cent of the respondents in their survey in Chiredzi district, an area with similar climate, preferred early maturing varieties. It is interesting to speculate on the consequences for crop diversity in the area if stand establishment were to be improved substantially. Data in Figure 2 and Table 7 suggest that reducing the frequency of re-sowing might reduce the number of varieties grown together in the same field, although differences in preference between farmers could maintain diversity in the area as a whole.

Maize varieties grown during the 1995/96 season were obtained from the government as part of the drought recovery programme and, in this respect, this season (1996/97) may be atypical. Maize has become a preferred food staple in Zimbabwe even in low rainfall areas like Musikavanhu. Farmers seem to be willing to buy and sow hybrid maize seed, even in this high risk, semi-arid environment, and the high perceived value of maize is evident in the care taken to plant a large proportion of it in rows in contrast to sorghum which is entirely broadcast. Mbwanda and Rohrbach (1989) suggest that the increase in smallholder maize production is due to institutional and technological interventions introduced by the government. Much debate has surrounded the widespread shift from more drought tolerant small grains to maize in semi-arid cropping systems, a development made possible by the availability of relatively short-season maize hybrids, for example R 200, R 201 (Mazvimavi *et al.*, 1994). Several authors (for example Rukovo and Gwitira, 1994; van Oosterhout, 1996) have suggested the distribution of small grains instead of maize in drought-susceptible areas, and it is interesting to note that in the study area sorghum still occupied most of the crop land — perhaps a reflection of farmers' experience and pragmatism in a harsh environment.

Land preparation may have an effect on subsequent crop establishment and Chiduza *et al* (1995) have noted poor moisture infiltration due to localised and shallow land preparation using a hoe. Only planting stations are tilled when using a hoe and weeds are often present. Timeliness of land preparation can have important effects on soil moisture conservation, mineralisation of crop residues, weed growth, and most significantly on planting time and the success of crop establishment (Stroud, 1985; Rowland and Whiteman, 1993).

The diversity of farmer perceptions of poor stand establishment is emphasised by the data in Table 9 reinforced by observed data in Tables 6 and 7 and Figure 2. Not only are farmers acutely aware of the problem and understand the main reasons for it, they have also developed appropriate responses. Ninety-seven per cent of farmers reported transplanting sorghum, using thinnings from overcrowded parts of the field. Conditions for successful transplanting were well known — moist soil and plants of a particular size. Thinnings were used both to fill gaps and to plant extra areas, particularly if good early rains persisted into the middle of the season. The physiology of transplanting sorghum is not well understood, particularly its merits relative to re-sowing and the labour involved. In contrast to sorghum, farmers did not transplant maize or sunflower to any great extent. Of the three crops only sorghum readily produces tillers and has the developmental plasticity to respond succesfully to bare-root transplanting, although transplanting nursery-grown seedlings of maize has proved feasible on wetland soils, for example in Vietnam (Uy and Marathé, 1996).

The willingness of a significant proportion of farmers to soak maize seed is encouraging (Table 9) although closer questioning showed that this was only done to 'catch up' if a sowing opportunity had been missed. Farmers did not consider it worthwhile to soak maize seed before sowing under optimal conditions and they hardly considered soaking sorghum seed at all. This may be a missed opportunity because Harris (1996) has shown that a major factor influencing crop establishment in sorghum is the rate of germination and emergence and that soaking seed or 'on-farm priming' for 8 to 10 hours before all sowings can markedly improve establishment and early growth. Similar results were obtained after priming maize for up to 24 hours (Harris, unpublished data) although preliminary work with sunflower suggests that it does not respond well to seed priming. Research is under way to develop and evaluate this technology further in collaboration with Zimbabwean farmers.

Conclusion

Poor crop establishment is a major factor affecting crop production in the semi-arid areas of Zimbabwe. A large per centage of farmers cited the problem in this study and this conclusion is supported by population densities observed in farmers' fields. Sorghum diversity in the area is linked to the success or failure of early plantings and improved crop establishment might reduce diversity, at least within fields. The problem of stand establishment is not confined to the south east lowveld alone but has been reported by several authors from other semi-arid areas of Zimbabwe. Farmers have developed appropriate responses - soaking maize seed and transplanting young sorghum plants - in order to improve crop stands. There is need to develop further agronomic practices that will improve crop establishment in semi-arid areas of Zimbabwe and the best step towards a technology better suited to the majority of the smallholders is the use or improvement of existing indigenous technology. Seed priming (soaking) has been used elsewhere with other crops and locally by few farmers and can be used in maize and sorghum to improve crop establishment. Transplanting sorghum has never been explored by researchers locally to see its effects on establishment, growth and yield performance, yet the practice has been going on for a long time. Thus, current farming practices provide a point of departure for developing and refining technologies to address one of the major reasons for production shortfalls in the semi-arid smallholder sector.

ACKNOWLEDGEMENTS

The authors thank the AGRITEX extension staff of the respective villages, all farmers who cooperated in the study and all colleagues who assisted in data collection. This document is an output from a project (Plant Sciences Research Programme project R6395) funded by the UK Department for International Development (DFID) administered by the Centre for Arid Zone Studies (CAZS) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

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