

Constraints and varietal trait preferences of sorghum producers in South Africa

M.A. Mofokeng^{*1,2}, H. Shimelis¹, P. Tongoona³ and M.D. Laing¹

¹African Centre for Crop Improvement, School of Agriculture, Earth and Environmental Sciences, University of KwaZulu-Natal; ²Agricultural Research Council, Grain Crops Institute, Potchefstroom, South Africa; ³West African Centre for Crop Improvement, College of Basic and Applied Sciences, University of Ghana

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Abstract

The objective of this study was to determine sorghum production constraints and preferred traits of sorghum varieties ideal for the smallholder farming systems of Limpopo Province in South Africa. The study was conducted in four Municipalities within two selected districts known for their sorghum production. Data were collected through semi-structured questionnaires, group discussions, key-informants, pairwise ranking and transect walks involving 311 farmers. Results indicated that the most important sorghum production constraints were bird damage, parasitic weeds, drought stress and postharvest insect pests. The traits of sorghum varieties preferred by farmers were good taste, high yield, resistance to bird damage, insect pests (weevils), and diseases, early maturity and drought tolerance. The study serves as the basis for formulating research and development strategies for sustainable sorghum production and productivity by resource poor farmers in these and similar environments.

Keywords: Farmers' preferred traits, Ideal variety, Limpopo Province, Production constraints.

Introduction

Sorghum (*Sorghum bicolor* [L.] Moench) is one of the major food security crops serving some 300 million people in the sub-Saharan Africa, and the fourth most important crop in Africa. In South Africa, sorghum remains one of the most important grain crops grown for food, and feed. It grows in various Provinces with the Free State Province being the main producer (DAFF, 2010). It has an ability to grow in marginal environments even where other cereal crops such as maize fail to grow. Although the production varies widely among Provinces, sorghum remains an important food constituent in the diet of rural households in the country.

Information obtained through participatory rural appraisal studies may assist plant breeders to define their breeding goals and objectives in order to

address farmer's needs. Local varieties are important in plant breeding programmes because they carry selected traits preferred by farmers. Gebretsadik et al. (2014) used the PRA approach to identify sorghum farming systems and production constraints focusing on breeding priorities on *Striga* infestations and the farmers' coping mechanisms in Ethiopia. Farmers in the Lake Zone of Tanzania preferred sorghum varieties on the basis of the color and taste of 'ugali', a porridge prepared from sorghum (Mafuru, 2007). Nkongolo (2008) studied farmers' preferences in sorghum landraces and reported that farmer characterization of sorghum varieties had allowed selection of superior landraces from which to develop modern varieties. Makanda (2009) conducted PRA studies in Zimbabwe and South Africa on sweet stem sorghum and reported that farmers preferred high yielding and early to intermediate sorghum varieties with high stem sugar content. Gebretsadik et al. (2014) reported farmer's

*Author for correspondences: Phone: +2718 299 6398, Email: MofokengA@arc.agric.za

preferred traits including drought resistance, early maturity, resistance to *Striga* infestation, and grain quality in Ethiopia. The authors also reported sorghum production constraints that included bird damage, drought, *Striga* infestation, declining soil fertility, lack of access to improved varieties and other production inputs. Farmers in north Wello of Ethiopia preferred *tef* and sorghum varieties with wider environmental adaptation and yield stability (Sinafikesh, 2010). In South Africa sorghum is grown by both small- and large-scale commercial farmers. However, there is no report that systematically documented sorghum production constraints and varieties preferred by smallholder farmers for sustainable sorghum production under resource poor farmers conditions. Therefore, the objective of this study was to determine sorghum production constraints, farmers' preferred traits and the profile of ideal sorghum varieties under smallholders farming systems in Limpopo Province of South Africa.

Materials and Methods

Description of the study sites and sampling method

The PRA was conducted during 2013 and 2014 in Sekhukhune and Waterberg Districts of the Limpopo Province in South Africa. These Districts are the major sorghum producing areas under smallholder farming systems in the Limpopo Province. Three Municipalities, Fetakgomo,

Makhuduthamaga, and Tubatse, in Sekhukhune and Lephalale Municipality in Waterberg Districts were selected for the PRA study based on their relatively large scale of sorghum production. A purposive sampling method was used to select districts, municipalities, villages and farmers. The villages were selected in collaboration with the extension officers and municipal managers of the Department of Agriculture, Forestry and Fisheries in the selected Districts. Makhuduthamaga and Fetakgomo municipalities represent the Lowveld areas, whereas Lephalale and Greater Tubatse are situated in the Highveld.

Data collection and analysis

In each section/ village 1 to 60 farmers were randomly selected. This provided a total of 311 farmers for semi structured interviews (Table 1). Further 21 focus groups were established with 15 farmers for focus group discussions. Each focus group had farmers selected by the village leaders and agricultural extension officers in each section. Participants for group discussions were selected to represent the spectrum of sorghum growers in the study areas taking into account gender balance. Established participatory rural appraisal tools were employed for data collection. A semi-structured questionnaire was used in the survey to collect information related to the importance and production constraints of sorghum, characteristics of good sorghum varieties and a farmer perceived

Table 1. Districts, municipalities, villages and the number of male and female sorghum farmers sampled for the study.

District	Municipality	Section/village	Gender		No. of participants
			Female	Male	
Waterberg	Lephalale	North	15	45	60
		South	16	11	27
		Central	8	18	26
Sekhukhune	Makhuduthamaga	Mashite	49	30	79
		Manganeng	45	9	54
		Mothibeng	17	7	24
	Fetakgomo	Malekaskraal	14	7	21
		Lerajane	9	0	9
	Greater Tubatse	Ga-Matokomane	1	10	11
Total			169	142	311

ideal sorghum variety. Different PRA approaches such as matrix and pairwise ranking, focus group discussion, key informants and transect walks were applied to identify farmers' preferences, and the most serious constraints affecting sorghum production. Pairwise ranking was used to identify the importance of sorghum as a food security crop and as an income generation crop. It was also used to rank farmers' preferences, constraints of production, characteristics of good sorghum varieties and the role of gender in sorghum production under small-scale farmers' conditions. Participants listed the best criteria and data were organized on flipcharts followed by ranking using a fixed number of votes. After votes were given by participants, percentage values of each parameter were calculated. The data collected from the farmers were coded, entered and analysed using SPSS version 22.0 computer package (SPSS, 2013). The cross tabulations were performed for data summary and contingency chi-square analysis performed to test significant differences among variables.

Results and Discussion

Description of households

The total numbers of respondents were 113 in Waterberg and 198 in Sekhukhune. The number of female respondents was higher than the males (Table 1). Females represented 54.3%, whereas males were at 45.7%. Many studies reported gender as a factor affecting technology adoption since the head of the household is the primary decision maker and men have more access to and control over vital

production resources than women due to socio-cultural values and norms (Mignouna et al., 2011). The contingency chi-square analysis revealed highly significant differences for education levels across Municipalities. Most respondents (46.3%) did not have basic primary school education (Table 2). Twenty six percent of the participants attended primary school, 18.3% had secondary school education and 0.32% had studied at a tertiary level. Most sorghum growers had limited level of education, which may impact on sustainable sorghum production and the adoption of new production technology. Affiliation with farming cooperatives, farmer support groups and networking with extension officers may enhance the farmers' knowledge of production of sorghum (Nkgodi, 2005). Reports indicate that in other countries like Ethiopia and Ghana, most farmers had low level of education (Melkam et al., 2014).

The chi-square analysis revealed highly significant differences for the age of farmer respondents across the municipalities. The ages of participants ranged from 21 to above 70 years old (Table 3). Respondent farmers were largely represented within age category of 51-60 years (27.6%), followed by 61-70 (22.6%), 41-50 (21.5%), > 70 (12.9%), and 31-40 (9.9%). The youth category (21-30) was the least numerous of respondent farmers. In general, the study found a low level of involvement of the youth in agricultural activities in the study areas. Adults and elderly were the dominant sorghum growers across the municipalities (Table 3). These results are in accordance with the study of Mmbengeni and

Table 2. Education level of the respondent farmers across the four sampled municipalities in Limpopo Province.

Municipality	Education level				Total
	none	primary	secondary	tertiary	
Lephalale	56	25	15	0	96
Makhuduthamaga	68	48	21	1	138
Fetakgomo	12	3	17	0	32
Tubatse	8	5	4	0	17
Total	144	81	57	1	283
Percentage	50.9	28.6	20.1	0.4	100

Pearson X^2 value, $df=9 =29.557$, Asymp. Sig. =0.001

Table 3. Cross tabulation of age group of respondent farmers' across four municipalities in Limpopo Province.

Municipality	Age (years)						Total
	21-30	31-40	41-50	51-60	61-70	>70	
Lephalale	7	20	33	21	16	6	103
Makhuduthamaga	1	3	21	50	41	24	140
Fetakgomo	8	5	7	6	4	4	34
Tubatse	0	1	2	4	5	4	16
Total	16	29	63	81	66	38	293
Percentage	5.5	9.9	21.5	27.6	22.6	12.9	

Pearson X^2 value, $df=15=76.598$, Asymp. Sig.=0.000

Table 4. Farm sizes of respondent farmers across four municipalities in Limpopo Province

Municipality	Farm size (ha)						Total
	1-2	3-4	5-6	7-8	9-10	>10	
Lephalale	19	16	7	1	0	0	43
Makhuduthamaga	57	27	4	9	1	3	101
Fetakgomo	8	9	8	1	2	1	29
Tubatse	11	5	1	0	1	0	18
Total	95	57	20	11	4	4	191
Percentage	49.7	29.8	10.5	5.8	2.1	2.1	100

Pearson X^2 value, $df=15=31.198$ Asymp. Sig.=0.008

Table 5. Areas allocated to sorghum production by respondent farmers in four selected municipalities of Limpopo Province

Municipality	Area allocated to sorghum production (ha)				Total
	1-2	3-4	5-6	9-10	
Lephalale	40	3	0	0	43
Makhuduthamaga	69	29	3	0	101
Fetakgomo	7	10	9	1	27
Tubatse	14	0	1	0	15
Total	130	42	13	1	186
Percentage	69.9	22.6	7.0	0.5	100

Pearson X^2 value, $df=9=62.2260$, Asymp. Sig.=0.000

Mokoka (2002) who reported a low level of involvement of the youth in agriculture in the Limpopo Province. It is therefore important for policy makers and development agents to create incentives for young farmers to involve in farming activities. As such it is necessary to identify preferences of this age group for effective intervention of policies.

Major crops grown and area of production

There were highly significant differences among the municipalities in farm sizes of respondents (Table 4). The farm sizes ranged from 1 to > 10 hectares

(ha). Most respondents had farm sizes of 1-2 ha (49.7%), followed by 3-4 ha (29.8%), 5-6 ha (10.5%) and 7-8 ha (5.8%). The numbers of farmers owning farms of 9-10 ha and >10 ha were very small both at 2.1%. This shows that the municipalities are dominated by smallholder farmers mainly growing sorghum for subsistence purposes. Makhuduthamaga Municipality had the largest number (60%) of farmers owning small farms of 1-2 ha, followed by Lephalale (20%) and Tubatse (11.6%). In general, farmers in the Fetakgomo Municipality had bigger farms ranging between 1 and 6 ha. Farmers in Fetakgomo and Tubatse

Table 6. List and order of importance of major crops grown by respondent famers in four municipalities of Limpopo Province.

Municipality and crops grown			
Lephalale	Makhuduthamaga	Fetakgomo	Tubatse
Sorghum	Sorghum	Maize	Sorghum
Pearl Millet	Maize	Sorghum	Pearl Millet
Bambara groundnut	Dry bean	Cowpea	Watermelon
Dry bean	Pumpkin	Pumpkin	Pumpkin
Watermelon	Melon	Vegetables	Dry beans
Maize	Sugar cane	Sugarcane	Maize
Sunflower	Watermelon	Groundnut	
Melon	Pearl Millet	Watermelon	
	Groundnut		
	Cowpea		

Municipalities owned relatively smaller landholdings.

The total area allocated for sorghum production showed significant differences between Municipalities (Table 5). Most farmers (69.9%) cultivated sorghum in 1-2 ha of land in all sampled Municipalities except in Fetakgomo municipality where most farmers grow sorghum using 3 to 6 ha of land (Table 5). In Tubatse, most farmers grew sorghum with farm areas measuring 1-2 ha. Most farmers in Makhuduthamaga Municipality cultivated sorghum using 1-2 ha of land followed by 3-4 ha, while few used 5-6 ha of cultivated lands. The landholdings recorded in this study are comparable to the report of Byerlee and Heisey (1997) who indicated that smallholder farmers in sub-Saharan Africa (SSA) had landholdings ranging from 0.5 to 3.0 ha. The results are also in accordance with a report by Shargie (2015) that the sorghum production in Limpopo Province is mainly produced by smallholder farmers

During focus group discussion farmers listed crops being grown in the surveyed Municipalities. Across the four Municipalities sorghum was the most important crop followed by pearl millet and maize. (Table 6). Respondent farmers planted sorghum with other grain, legume and vegetable crops in the study areas (Table 6). Other crops being grown included

millet (*Pennisetum glaucum* (L.) R. Br.), maize (*Zea mays* L.), watermelon (*Citrullus lanatus* (Thunb.)), pumpkin (*Cucurbita pepo* L.), beans (*Phaseolus vulgaris* L.), cowpea (*Vigna unguiculata* [L.] Walp.), sugarcane (*Sacharum officinarum* L.), bambara groundnut (*Vigna subterranean* (L.) Verdc.), sunflower (*Helianthus annuus* L.), groundnut (*Arachis hypogaea* L.), sweetpotato (*Ipomoea batatas* (L.) Lam.) and various vegetable crops. The list of common crops grown across the villages corresponds with the report of WOMIWU Rural Development (2005). Overall, farmers in the study areas preferred to grow improved sorghum varieties although they will still continue to plant their local varieties for their adaptation to harsh growing conditions and quality attributes to prepare various food products. Like most farmers in sub-Saharan Africa, farmers in the study areas keep seeds from the previous harvest for planting in the next season.

Farmers' preferences of sorghum varieties

There were highly significant differences between the sorghum varieties preferred by the farmers of the study areas (Table 7). Farmers preferred the improved variety Macia as their number one choice followed by their local variety Sefubetswane, Mapinkana and Maseka-aswere, respectively. The least preferred local variety was Khunamang. This is because Macia yields high, matures early and has a good taste good for preparing porridge or 'ugali'

Table 7. Names of sorghum varieties grown and percentage of farmers growing these in four municipalities of Limpopo Province.

Variety	Municipality and % preference				Type	Mean ¹	Rank
	Lephalale	Makhuduthamaga	Fetakgomo	Tubatse			
Macia	32.00	41.00	45.00	56.00	Improved	43.50 ^d	1
Sefubetswana	38.00	24.00	34.00	21.00	Local	29.25 ^c	2
Mapinkana	15.90	18.00	13.00	0.60	Local	11.88 ^b	3
Maseka-a-swere	7.00	12.00	10.00	6.30	Local	8.83 ^{ab}	4
Manthate	11.00	6.00	3.00	15.00	Local	8.75 ^{ab}	4
Mahubedu	9.00	4.00	9.00	8.00	Local	7.50 ^{ab}	4
Khunamang	4.00	3.00	1.00	10.20	Local	4.55 ^a	5
Mean	16.70	15.43	16.43	16.73		16.32	

P-value < .001, LSD (0.05) 8.50, CV (%) 38.90

in sub-Saharan Africa. In Botswana, the farmers preferred to grow sorghum varieties like 'Segaolane', 'Phofu', and 'Town' on the bases of early maturity. The levels of knowledge, age, labour, land holding, and resource availability are very important in determining the farmers' choice of varieties and enterprise mix. Studies revealed that generally, farmers have their own way of selecting a variety for their localities, although in some cases the farmers' preferences coincide with the breeders' selection.

¹Means followed by the same letter do not differ significantly according to Fischer's least significant difference test ($P > 0.05$)

Farmers' perception of traits of an ideal sorghum variety

There were significant differences among the traits that the farmers preferred across Municipalities (Table 8). The most important farmer preferred traits were high yield and good taste. This was followed by early maturity, insect and disease resistance, heat and drought tolerance, and the ability to grow with low production inputs. Furthermore farmers did not appear to experience problems with acidic soils. The farmers' preferences concur with the study by Nkgodi (2005) where farmers in Sekhukhune District of the Limpopo Province preferred sorghum varieties with characteristics of early maturity,

Table 8. Traits of sorghum varieties preferred by farmers in four municipalities of Limpopo Province.

Preferred Traits	Municipality and trait preference (%)				Mean ¹	Rank
	Lephalale	Makhuduthamaga	Fetakgomo	Tubatse		
High yield	52.00	43.00	61.30	56.00	53.075 ^a	1
Good Taste	56.00	44.00	51.00	49.20	50.05 ^a	1
Early Maturity	41.00	37.00	34.00	28.00	35.0 ^b	2
Insect resistance	36.00	43.00	36.00	26.00	35.25 ^b	2
Disease resistance	32.00	28.00	25.00	38.00	30.75 ^b	2
Drought tolerance	23.20	25.00	26.70	24.00	24.73 ^c	3
Heat tolerance	24.30	23.10	25.00	24.00	24.1 ^c	3
Low input for growing	25.60	22.10	23.20	24.90	23.95 ^c	3
All purpose type	18.10	16.30	18.00	17.00	17.35 ^d	4
Tolerant to acid soils	5.60	6.10	4.50	4.20	5.1 ^c	5
Mean	31.38	28.76	30.47	29.13	29.95	

P-value < .001, LSD (0.05) 6.04, CV (%) 15.7

¹Means followed by the same letter do not differ significantly according to Fischer's least significant difference test ($P > 0.05$).

Table 9. Various traits of sorghum varieties listed and preferred by farmers across four municipalities of Limpopo Province.

Trait	Variety						
	Mapinkana	Maseka-a-swere	Manthate	Macia	Khunamang	Sefubetswana	Mahubedu
Early maturity	44	68	23	38	14	56	34
Good taste	66	44	48	25	49	63	68
High yield	13	10	15	65	23	20	18
Resistance to pests and diseases	8	6		45	5	36	3
Other	14	12	5	-	-	28	-

drought tolerance and porridge making quality and good taste. Tesfamichael et al. (2013) found that the farmers choose the sorghum for seed to plant the following year based on panicle and seed size, grain color and maturity dates.

Respondent farmers rated good taste as a highly preferred trait found in the varieties Mapinkana, Manthate, Khunamang, Sefubetswane and a red seeded variety (Mahubedu) (Table 9). Early maturity was the most preferred trait in variety Maseka-a-swere and Sefubetswana. High yield was regarded as the most preferred in variety Macia with its resistance to diseases and insect pests. It is, therefore, important to determine farmers preferred traits in crop varieties or include farmers in variety design and selection processes to meet their demand.

This enhances the potential for adoption of the varieties in the respective communities for sustainable production and productivity.

Major constraints to sorghum production

The major challenges to sorghum production as perceived by farmers are indicated in Table 10. The stress factors varied across municipalities and are ranked in order of importance during focus group discussion (Table 10). Bird damage and weevils were rated as the most prevalent and serious problems in farmers' fields and during storage, respectively. Parasitic weeds (*Striga*), drought, and storage rot were the next most important constraints followed by stem borer, rust, anthracnose and heat stress. Downy mildew, northern leaf blight, and soil fertility were considered the least important stress

Table 10. Important biotic and abiotic constraints to sorghum production indicated by farmers across four municipalities of Limpopo Province.

Biotic/abiotic constraint	Municipality and farmers (%)				Mean ¹	Rank
	Lephalale	Makhuduthamaga	Fetakgomo	Tubatse		
Birds	52.00	43.00	61.30	56.00	53.08a	1
Weevils	56.00	44.00	51.00	49.20	50.05a	1
Parasitic weeds	41.00	37.00	34.00	28.00	35.00b	2
Drought	36.00	43.00	36.00	26.00	35.25b	2
Storage rots	32.00	28.00	25.00	38.00	30.75b	2
Stem borer	23.20	25.00	26.70	24.00	24.73c	3
Rust	24.30	23.10	25.00	24.00	24.10c	3
Anthracnose	25.60	22.10	23.20	24.90	23.95c	3
Heat	18.10	16.30	18.00	17.00	17.35d	4
Downy mildew	5.60	6.10	4.50	4.20	5.10e	5
Northern leaf blight	4.80	5.30	5.00	3.90	4.75e	5
Phaeosphaeria leaf spot	2.50	3.10	2.30	3.80	2.93e	5
Soil fertility	0.60	1.20	1.10	0.80	0.93e	5
Mean	24.75	22.86	24.08	23.06	23.69	

P-value < .001, LSD (0.05) 5.25, CV (%) 17.4

¹Means followed by the same letter do not differ significantly according to Fischer's least significant difference test (Pd^{0.05})

factors. The findings on production constraints in this study concur with other studies by Chikuta et al. (2014) and Gebretsadik (2014) who reported low yield, limited availability of improved sorghum varieties, poor access to improved seed, inconsistent grain market, and pests and diseases in Zambia and *Striga* spp. in Ethiopia. Mwadalu and Mwangi (2013) reported that the quelea birds were one of the production constraint of sorghum in farmers' fields in Kenya. The farmers in the present study areas indicated that they needed better sorghum varieties to increase production and to reduce pre- and post-harvest losses.

The present study determined sorghum production constraints, farmers' preferred traits and ideal sorghum varieties of sorghum in the smallholder subsistence farming system of four selected Municipalities of the Limpopo Province in South Africa. The study documented that sorghum was the principal crop grown by smallholder farmers across the study areas. Farmers preferred sorghum varieties were Macia, Sefubetswana, Mapinkana and Maseka-a-swere. Respondent farmers preferred to grow both improved varieties and local landraces to minimize production risks. The most important sorghum production constraints across the study areas were bird damage, parasitic weeds, drought stress and postharvest insect pests. Respondent farmers indicated that their ideal sorghum varieties should have good taste, high yields, resistance to bird damage, insect pests and diseases, early maturity and drought tolerance. The study may serve as the basis for formulating research and development strategies for sustainable sorghum production and productivity by resource poor farmers in these and similar environments in the country.

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