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Farmers' desired traits and selection criteria for maize varieties and their implications for maize breeding: A case study from KwaZulu-Natal Province, South Africa

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Abstract

Adoption of hybrids and improved varieties has remained low in the smallholder farming sector of South Africa, despite maize being the staple food crop for the majority of households. The objective of this study was to establish preferred maize characteristics by farmers which can be used as selection criteria by maize breeders in crop improvement. Data were collected from three villages of a selected smallholder farming area in South Africa using a survey covering 300 households and participatory rural appraisal methodology. Results indicated a limited selection of maize varieties grown by farmers in the area compared to other communities in Africa. More than 97 % of the farmers grew a local landrace called *Natal-8-row* or *IsiZulu*. Hybrids and improved open pollinated varieties were planted by less than 40 % of the farmers. The *Natal-8-row* landrace had characteristics similar to landraces from eastern and southern Africa and closely resembled Hickory King, a landrace still popular in Southern Africa. The local landrace was preferred for its taste, recycled seed, tolerance to abiotic stresses and yield stability. Preferred characteristics of maize varieties were high yield and prolificacy, disease resistance, early maturity, white grain colour, and drying and shelling qualities. Farmers were willing to grow hybrids if the cost of seed and other inputs were affordable and their preferences were considered. Our results show that breeding opportunities exist for improving the farmers' local varieties and maize breeders can take advantage of these preferred traits and incorporate them into existing high yielding varieties.

Keywords: hybrid, landrace, open-pollinated variety, preferred traits, smallholder farmers

1 Introduction

Production of maize in Sub Saharan Africa (SSA) is dominated by small-scale farmers who have land holdings ranging from 0.5 to 3.0 ha (Byerlee & Heisey, 1997). Although improved, superior varieties have been developed in most of the countries in SSA including South Africa, the majority of the smallholder farmers still rely on unimproved, open-pollinated varieties (OPVs) for their plantings (Aquino *et al.*, 2001; FAO & CIMMYT, 1997). This is partly because the OPVs are easy to multiply and therefore cheap and readily available (FAO & CIMMYT, 1997). In addition, most of the breeders of improved varieties have focused more on raising yields under optimal, agronomically well-managed conditions (Reeves & Cassaday, 2002) and farmers either perceive little advantage in growing them because they are not designed for their

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needs (Banziger & Diallo, 2002). Consequently, maize yields in these areas have remained low, averaging below 1.2 t ha^{-1} against a potential of 7.0 t ha^{-1} (Pingali & Pandey, 2001).

Breeders have often been accused of failing to consider the special preferences of farmers especially those in marginal areas (Banziger & Cooper, 2001; Toomey, 1999), possibly because they are unaware of them. Therefore, for effective breeding, farmers' preferences for varieties should be clearly identified through researcher-farmer interaction and collaboration. Farmer participatory research, which involves farmers and scientists collaborating in research and product development, is therefore important (Bentley, 1994). Participatory methods are preferred as they recognize the value of farmers' local knowledge, their interests and ability to experiment and innovate, and their active exchange of information and technologies (Bellon, 2001).

In addition, Bellon (2001) also reports that farmers are not a uniform group; they differ in their preferences and priorities which should be taken into account in future breeding programmes. For example, farmers in Eastern Kenya indicated a preference for early maturity ahead of yield followed by yield-related traits namely cob size, grain size and drought tolerance (De Groote *et al.*, 2002). In some communities of Southern Africa, Banziger & de Meyer (2002) reported that apart from yield related traits, farmers frequently mentioned early maturing varieties, hard endosperm (flint) types and good husk cover for the maize varieties they would prefer. A study conducted in the Guinea savannas of Nigeria also indicated differences by farmers in their preferred choice of maize varieties (Kamara *et al.*, 2006). For example, farmers from the relatively market-driven production systems in the communities of Borno State, Nigeria preferred the early-maturing and high-yielding drought-tolerant varieties (Kamara *et al.*, 2006). In contrast, farmers from the relatively resource-poor sorghum-based production systems in Kano State, Nigeria preferred extra-early maturing varieties to provide food security during the period of food scarcity rather than high yielding varieties (Kamara *et al.*, 2006). It is, therefore, important to determine from farmers their preferred traits in crop varieties or include the farmers in a variety selection process. This enhances the potential for adoption of the varieties in the respective communities where studies are conducted. The objectives of this study were to identify maize varieties currently being cultivated by smallholder farmers in selected villages of KwaZulu-Natal Province, South Africa, and to establish the factors that influenced farmers classifications and choices of maize varieties.

2 Materials and methods

2.1 Description of study area, sampling procedures and participants

The study was conducted in three villages of Obonjaneni, Busingatha and Okhombe in Amazizi Tribal Authority (29°22'E, 28°44'S) in the Northern Drankensberg of KwaZulu-Natal (KZN) Province between 2007–2009. The area has an average annual rainfall between 700–800 mm, with frequent thunderstorms and intermittent dry spells a common occurrence and the rainy season normally lasting from September/October to March (Ngubane & Mudhara, 2009). The area is classified as having above average agricultural potential. However, major drawbacks are a short growing season, cold winters and acidic soils which tend to reduce the agricultural potential (Krone, 2006).

Three hundred randomly selected households were included in the structured survey. More females than males from each village participated in the structured survey. Overall, across the villages, 59 % of the respondents were females. In addition there were five focus group discussions of about 10 key informants that included individuals who had great knowledge about the villages, the farms, crops and local conditions and problems in the district. Selection of this group was done in consultation with the facilitator who resided in the area and had knowledge of the farmers around. The farmers selected were a mixed group of males and females, farmers who planted many crop varieties, farmers who had a reputation for good workmanship, young and old farmers, and farmers with large or small land holdings. Overall, 45 farmers participated in the focus group discussions (53 % males and 47 % females).

2.2 Data collection and analysis

Primary data were collected through a structured survey to obtain characteristics of the farmers in the districts and through participatory methodologies. The structured survey served as a control for checking or comparing information obtained through participatory methods. Information was gathered through a questionnaire administered to the farmers by the facilitators. Number and types of maize varieties, seed sources, important variety characteristics, characteristics of farm and farmer, and general information on crop production were obtained from this survey.

To learn about the farmers' classifications and choices, PRA methodologies involving focused group discussions (with semi-structured questions), matrix scoring and pair-wise ranking were used. The farmers listed the varieties they grew, ranked them, and identified traits they preferred in maize, giving reasons for the

varieties they liked to continue growing. The facilitators used pictures and cards that had drawings representing various traits to assist the farmers during the discussions. For pair-wise ranking, traits of interest were compared pair by pair; groups were asked which of the two they preferred, and why. In matrix scoring, the farmers compared three locally grown varieties against the characteristics they had listed during the focus group discussions. The criteria were placed in rows in a matrix and the varieties in columns. The farmers were asked to complete the boxes row by row, giving a score for each of the characteristics. The scores used were 1 = very poor to 5 = excellent. The scores for each variety were added and the mean calculated and used to rank the maize varieties.

Statistical analyses were performed in SPSS (Release 15.0) computer package, Genstat 12th edition (Payne *et al.*, 2009) and PROC GLM procedure in SAS 9.2 (SAS Institute, 2002). Relationships were explored through frequencies, descriptive statistics and analysis of variance (ANOVA) for data collected in each village followed by mean comparisons between villages. Data were transformed where necessary, before subjecting to ANOVA.

3 Results

3.1 General crop production aspects and uses of maize

There were significant differences amongst the three villages in the household characteristics with the exception of farming experience years (Table 1). The average household size ranged from six to eight family members with an average of seven members. The male to female ratio in the households were 1:1 in Busingatha and Obonjaneni and almost 2:3 in Okhombe. Between 31–37 % of the people in each household attended school, while 13–15 % had jobs off the farm, leaving less than half of the members per household to work on the fields. Less money was spent on labour cost, with a maximum of *R* 341.21 (US$ 42.60 at US$ 1 = *R* 8) per growing season. About 62 % of the farmers were above 45 years and only 1 % below 25 years old. Twenty-five percent of the farmers did not have any formal education. There were significant differences in the highest education grade attained amongst the three villages. The average grade across the villages was five.

Table 1: *Household characteristics of the farmers in Amazizi district.*

Characteristic	*Village*			*Overall mean*	*P-value**
	Obonjaneni	*Busingatha*	*Okhombe*		
Household size	6.69	8.33	6.98	7.33	0.004
Males in household	3.38	4.01	3.04	3.48	0.023
Females in household	3.31	4.32	3.94	3.86	0.015
Children in school	2.44	3.13	2.19	2.59	0.001
Number with off-farm jobs	0.9	1.28	0.94	1.04	0.03
Labour available on farm	2.79	2.86	2.41	2.68	0.021
Labour cost (*R*)	341.21	105.76	316.06	254.34	0.001
Farming experience (years)	21.96	21.29	22.42	21.9	0.656
Age category (% responding)					
18–25 years	1	2	1	1.3	
26–35 years	10	3	2	5.0	
36–45 years	32	27	36	31.7	
>45 years	57	68	60	61.7	
Education					
Able to read and write (% responding)					
Yes	88	67	69	74.7	
No	12	33	29	24.7	
Not indicated	0	0	2	0.7	
Highest grade attained	6.45	3.92	3.88	4.76	0.001
Education level (% responding)					
No formal education	12	33.7	28.6	24.7	
Gr. 1–4	20	20.4	26.5	22.3	
Gr. 5–7	33	34.7	35.7	34.5	
Gr. 8–10	13	8.2	7.1	9.4	
>Gr. 10	22	3.1	2.0	9.0	

* Probability values based on one-way ANOVA.

Significant differences amongst villages in terms of land holdings and area of land allocated to maize cultivation were observed (Table 2). The average land size across the villages was 1.4 ha and about 80–90 % of this was used for cultivation. Of the land cultivated, 94 to 98 % was allocated to maize production and the remainder to other crops. Across the villages, maize was grown by 100 % of the farmers who responded and ranked first by farmers from focus group discussions. The percentage of farmers growing other crops was less than 10 %. During focus group discussions, vegetables such as potatoes and beans were ranked second to maize for cultivation (Table 2). Maize was grown mainly for consumption; but some farmers also used maize for livestock feed and sold the surplus. The farmers made mealie-meal (maize flour) from maize, which was then used for the traditional meal, a thick porridge – *puthu* and *pap* consumed with vegetables and/or meat. Other uses were breakfast porridge (white and yellow maize), roasted or boiled green mealies (yellow and white maize) and samp (mealie-rice). Yellow maize was also used for the traditional beer *mtombo*. An average of 46 % of the farmers used yellow maize for livestock feed.

3.2 Maize varieties grown and sources of seed in Amazizi district

Different maize varieties which included hybrids, open-pollinated varieties (OPVs) and local landraces were grown by the farmers (Table 3). The majority of farmers (77–100 %) grew a local or indigenous variety (landrace) named *Natal-8-row* or *IsiZulu*. The name *Natal-8-row* was derived from the number of rows, which was eight in most of the cases. The variety, was open pollinated, had large kernels, eight rows, and was highly variable in kernel colour ranging from white (predominant), yellow, mixtures of white and yellow, and red and maroon mosaics. Most cobs of this landrace collected from the farmers were clean, with no cob rots and the grain texture ranged from flint to dent. In general the ear aspect (ears that are well-filled, uniform and free of rots) was good, although the cob size was variable. The other local variety called *Doylanda* (DL) grown by about 5 % of the farmers was a hybrid between *Natal-8-row* (NTL8) and PANNAR (PAN) hybrids that were grown in the area. *Doylanda* and PANNAR hybrids differed from NTL8 in that they had 10–12 rows, while NTL8 had eight rows.

Table 2: *Means for land holding (hectares), general crop production aspects, maize production and uses of maize in Amazizi district.*

Characteristic	*Village*			*Overall mean*	*P-value**
	Obonjaneni	*Busingatha*	*Okhombe*		
Land holding and crops grown (hectares)					
Size of landholding	1.1	1.0	2.1	1.4	0.001
Size of cultivated land	0.9	0.8	1.9	1.2	0.001
Land for maize	0.8	0.8	1.8	1.1	0.001
Land for other crops	0.1	0.01	0.2	0.1	0.008
Time of planting (%)					
October	3	2	2		
November	64	69	73		
December	32	29	25		
Crops grown (% farmers growing)					*Ranking*
Maize	100	100	100	100	1
Pumpkins	2	9	9	6.7	3
Vegetables †	17	10	13	13.3	2
Other crops ‡	3	2	2	2.3	3
Products made from maize (% farmers responding)					
Mealie meal	89	98	96	94.3	
Samp	68	82	72	74.0	
Green mealies (boiled or roasted)	87	58	67	70.7	
Mealie bread	49	41	40	43.3	
Porridge	80	90	82	84.0	
Livestock feed (yellow maize)	55	46	36	45.7	
Other maize products §	31	45	51	42.3	

* Probability values based on one-way ANOVA. † Vegetables included beans, potatoes, tomatoes cabbages and spinach. ‡ Other crops included mainly sorghum and fruits. § Other maize products were mostly Zulu traditional dishes given with Zulu names (not shown).

Table 3: *Varieties mentioned and percentage of farmers growing them in Amazizi district.*

Variety	*Formal Survey (% farmers growing variety)*			*Focus groups (% farmers growing variety)*			*Colour*	*Type*
	OBO [‡]	*BUS*	*OKH*	*OBO*	*BUS*	*OKH*		
IsiZulu (Natal-8-row) [*]	77	90	97	100	100	100	white, yellow, mixture	Local [§]
PAN 6479	8	7		33	27	39	white	Hybrid [¶]
PAN 6043				33		13	white	hybrid
PAN 6480	7	5	5	33	27	39	yellow	hybrid
PAN 6825						13	white	hybrid
PANNAR brand	18	5					white or yellow	hybrid
Doylanda [†]	6		5				white, yellow, mixture	local
R0413	4	4						OPV [‖]
Kalahari Early Pearl	4	4	6			22	white	OPV
Nelson's choice	4						white	OPV
Afric1			5				white	OPV

[*] *IsiZulu* or *Natal-8-row* – local or indigenous variety, [†] *Doylanda* – a variant from Natal-8-row, which was a hybrid between Natal-8-row and some PANNAR varieties that were grown in the area. [‡] OBO = Obonjaneni, BUS = Busingatha, OKH = Okhombe; [§] local – no specific name, but planted by the farmers in the community for many years, [¶] hybrid – name provided by the farmers of a known hybrid or a company that sells hybrids, [‖] OPV – name provided by the farmers of a known OPV whose seed was bought from the shop, then recycled over a number of seasons.

Table 4: *Farmers' source of maize seed (%)*

	Village								
	Obonjaneni			*Busingatha*			*Okhombe*		
	Local (n=78) [*]	*Hybrid s (n=38)* [†]	*OPVs (n=5)* [‡]	*Local (n=90)*	*Hybrids (n=20)*	*OPVs (n=5)*	*Local (n=97)*	*Hybrids (n=10)*	*OPVs (n=12)*
Farm saved	79.5	16.0		86.6		20	90.7		58.3
Input shop	1.3	81.6	80	2.2	60	20		50	16.7
Other farmers	18	2.6		11.1			9.3		
NGO [§]									33.3

[*] Local = *Natal-8-row* and *Doylanda*, [†] Hybrids = Pannar hybrids, [‡] OPVs = Afric1, Kalahari Early Pearl, Nelson's choice and R0413, [§] NGO = Non-Governmental Organisations. Groupings "local", "hybrid" and "OPVs" were used for presenting the results as the farmers gave similar responses for the varieties within each of the groups.

An improved open pollinated variety (OPV), *Kalahari Early Pearl*, was grown by about 4–22 % of the farmers and was characterised by large cobs, but small kernels and 14–16 rows per cob. The grain was predominantly white and the texture dent and the cobs collected from the farmers were clean with no cob rots. Other improved OPVs were grown by less than 5 % of the farmers (Table 3). The most popular hybrids were PANNAR (PAN) hybrids. These were grown by 5–39 % of the farmers. Most of the farmers who grew PANNAR hybrids had large landholdings and sold part of the maize produced.

Sources of seed of the varieties grown by the farmers are presented in Table 4. The farmers indicated that, for the OPVs and local varieties (NTL8 and DL), they recycled the seed and in a few cases obtained it from other farmers. A small percentage of the farmers indicated saving hybrid seed.

3.3 *Farmers perceived advantages and disadvantages of the different maize types*

Farmers indicated why they preferred the varieties they grew (Table 5). Ninety-three percent of the farmers preferred NTL8 and DL, mainly for the grain that was tasty and recycled seed. In addition, they could grow the varieties with animal manure only and still get a satisfactory yield. The major disadvantage was that the local varieties were affected by diseases and insect pests, notably weevils which affected untreated seed in storage, especially when kept for more than two years. In addition, 14.6 % of the farmers mentioned that the local varieties were low in yield.

The hybrids were preferred for high yield and disease resistance, but the majority of farmers indicated that they were expensive to grow as the seed could not be recycled and they required inorganic fertilizers for them to grow well. Thirty-four percent of the farmers also pointed out that, although the mealie-meal from the hybrids was white, it was not tasty. Others preferred hybrids for the number of cobs per plant which varied from two to three with more than 12 rows per cob, and they were quick to dry and easy to shell. The improved OPVs, on the other hand, were favoured mainly for high yields compared to the local varieties. Thirty percent of the farmers also indicated that the OPVs were disease resistant, easy to shell and had many rows (14–20) per cob. However, the disadvantage was that they were affected by drought and the mealie-meal was not tasty.

3.4 *Farmers ranking of their varieties according to their own criteria*

Across the villages, preferred characteristics included ease to get seed, yield, and early maturity (Table 6). These three characteristics were not significantly different from each other in importance. Low input requirements, pest/disease resistant, drought resistant, more rows per cob and taste were not significantly different from each other and were ranked second. The last four characteristics which included whether the variety was good for livestock or sale and consumption in a variety of foods were not significantly different from each other and were ranked last by the farmers.

Table 5: *Farmers' perceived advantages and disadvantages of the different maize types grown in their area, Amazizi and the percentage of farmers mentioning the trait.*

	Maize type					
	*Local (n = 280)**		*Hybrids (n = 35)*		*OPVs (n = 10)*	
	Trait	*%*	*Trait*	*%*	*Trait*	*%*
Advantages	Tasty in all foods	93.5	High yield	74.3	High yield	50.0
	Save seed	60.7	Disease resistant	42.9	Save seed	30.0
	Sweet	44.6	Insect pest resistant	17.1	Disease resistant	30.0
	Inexpensive variety	16.1	Mealie-meal white	20.0	14–20 rows/cob	10.0
	Early maturity	13.9	2–3 cobs/plant	14.3	Early maturity	10.0
	Enough/satisfactory yield	11.1	14–20 rows/cob	14.3	Easy to shell	20.0
	Drought tolerant	5.36	Easy to shell	20.0	Insect pest resistant	10.0
	Use manure only	8.6	Withstand lodging	17.1	2 cobs/plant	20.0
	No fertilizer or manure	4.0	Quick to dry	14.3		
	Cob rot resistant	2.5				
	Withstand lodging	2.1				
	Large kernels	5.4				
Disadvantages	Affected by diseases	39.3	Cannot save seed	42.9	Affected by drought	20.0
	Low yield	14.6	Late maturity	28.6	Small kernels	30.0
	Affected by weevils	15.7	Not tasty	34.3	Mealie-meal not tasty	20.0
	Affected by insect pests	26.8	Expensive variety	22.9		
	Mealie-meal dark	5.7	Affected by drought	14.3		
	Takes long to dry	5.4	Need to apply fertilizer	17.1		
	Hard to grind	5.7	Small kernels	11.4		
	Affected by stalkborer	5.6				
	Affected by cutworm	3.2				

* Local = *Natal-8-row* and *Doylanda*, † Hybrids = Pannar hybrids, ‡ OPVs = Afric1, Kalahari Early Pearl, Nelson's choice and R0413. Groupings "local", "hybrid" and "OPVs" were used for presenting the results as the farmers gave similar responses for the varieties within each of the groups.

Table 6: *Scores from pairwise ranking of the characteristics preferred by the farmers in Amazizi district during focus group discussions across the three villages.*

Characteristic	*Score* *			*Overall Mean*	
	Obonjaneni	*Busingatha*	*Okhombe*	*Score*	*Rank* †
Seed easy to get	10.0	10.0	11.0	10.3[a]	1
Yield	8.0	11.0	10.0	9.7[a]	1
Early maturity	8.0	7.0	6.0	7.0[a]	1
Less inputs needed	NA‡	7.0	6.0	6.5[b]	2
Drought resistance	5.0	7.0	7.0	6.3[b]	2
Insect pest/disease resistance	6.0	7.0	5.0	6.0[b]	2
More rows per cob	7.0	6.0	4.0	5.7[b]	2
Taste	4.0	4.0	7.0	5.0[b]	2
More than one cob	3.0	3.0	2.0	2.7[c]	3
Good for livestock	1.0	1.0	4.0	2.0[c]	3
Consumed in a variety of foods	2.0	2.0	2.0	2.0[c]	3
Good for sale	1.0	1.0	2.0	1.3[c]	3
Mean				5.3	
LSD(0.05)				2.1	
CV (%)				21.9	

* The total score for each characteristic obtained from pairwise ranking of characteristics preferred by farmers (data not shown). The score was equivalent to the frequency of the characteristic as listed by the farmers in the table. Means followed by the same letter are not significantly different and therefore the characteristics were ranked the same. † Rank; low score = high rank and indicates that the characteristic is less important.‡ NA = not a criterion in the area.

Table 7: *Characteristics of an "ideal" variety as indicated by farmers during the structured survey (% of farmers selecting characteristic).*

Characteristic	*Village*			*Mean (%)*	*Rank* †
	Obonjaneni (%)	*Busingatha* (%)	*Okhombe* (%)		
High yield	6.2 (38.0)*	3.7 (14.0)	4.2 (18.0)	5.1 (26.0)	1
Good taste	4.6 (21.0)	2.2 (5.0)	3.3 (11.0)	4.9 (23.7)	2
Low input variety	3.3 (11.0)	3.0 (9.0)	3.0 (9.0)	4.6 (21.0)	3
Inexpensive seed	4.9 (24.0)	3.0 (9.0)	3.7 (14.0)	4.6 (22.3)	3
Early maturing	2.4 (6.0)	2.4 (6.0)	1.7 (3.0)	4.0 (16.3)	4
Disease resistance	5.5 (30.0)	2.6 (7.0)	2.8 (8.0)	4.0 (17.7)	4
Tolerant to acid soils	3.0 (9.0)	1.7 (3.0)	1.7 (3.0)	4.0 (16.3)	4
Drought resistance	3.2 (10.0)	1.4 (2.0)	2.2 (5.0)	2.9 (8.3)	5
Enough/satisfactory yield	2.4 (6.0)	1.7 (3.0)	2.0 (4.0)	2.1 (4.3)	5
2–3 cobs	1.0 (1.0)	2.0 (4.0)	2.2 (5.0)	1.8 (3.3)	6
Insect pest resistance	4.6 (21.0)	0.0 (0.0)	0.0 (0.0)	1.5 (10.5)	7
All purpose variety	2.2 (5.0)	0.0 (0.0)	1.7 (3.0)	1.3 (4.0)	7
Resistant to lodging	2.0 (4.0)	0.0 (0.0)	1.4 (2.0)	1.1 (3.0)	7
Weevil resistance	1.4 (2.0)	0.0 (0.0)	1.7 (3.0)	1.1 (2.5)	7
Good cooking qualities	2.8 (8.0)	0.0 (0.0)	0.0 (0.0)	0.9 (4.0)	7
Mean				2.9	
P-value				<.001	
S.E.D				0.97	
LSD(0.05)				1.42	

* Data transformed (square root transformation). Values in parenthesis are the untransformed percentages.
† Ranking based on transformed means, the lower the rank, the more important the constraint.

The farmers who participated in the structured survey listed characteristics they considered as important for an "ideal" variety (Table 7). Some of these characteristics were similar to what farmers listed in group discussions, with a few additional ones, including tolerance to soil acidity, resistance to lodging and weevils. Farmers from Obonjaneni listed the following in order of importance; high yield, disease resistance, inexpensive seed, insect resistance and good taste as the most important. Busingatha farmers, on the other hand, considered high yield, inexpensive seed and low inputs needed, disease resistance and early maturity as the most important attributes. Farmers from Okhombe had high yield, inexpensive seed, good taste, low inputs needed and disease resistance amongst the important characteristics. Overall, the characteristics that were ranked between 1 and 4 across the villages were; high yield (1), followed by good taste (2), inexpensive seed and low inputs (3), early maturity, disease resistance and tolerance to acid soils (4).

3.5 Farmers evaluation of maize varieties grown in Amazizi district through matrix ranking

Natal-8-row was rated highly by the farmers on; ease to get seed, tolerance to low nitrogen (N) and acid soils, grain size, resistance to cob rots and taste (Table 8). The farmers rated the variety poorly on the number of rows/cob, number of cobs/plant, colour of mealie-meal, shelling and grinding qualities, and not good for sale. On the other hand, the PANNAR (PAN) hybrids were rated highly on yield, number of cobs/plant, number of rows/cob, good for sale, colour of mealie-meal and shelling and grinding qualities. The characteristics of hybrids that received low scores included not able to save seed, and not tolerant to acid soils or low N. The Kalahari Early Pearl was rated highly on ease to get seed, number of cobs/plant, shelling and grinding qualities, tolerance to diseases and insect pests, and yield. However, it was scored low on tolerance to acid soils and low N, not good for sale and grain size. Overall, Kalahari Early Pearl was selected as the best variety by the farmers, followed closely by PANNAR hybrids and last *Natal-8-row*.

Table 8: *Farmers' evaluation of their varieties according to their own criteria (1=very poor, 5 = excellent).*

Characteristic	*Obonjaneni*			*Busingatha*			*Okhombe*		
	NTL8 *	PAN †	KEP ‡	NTL8	PAN	KEP	NTL8	PAN	KEP
Save seed	5	1	5	5	1	5	5	1	5
Early maturity	5	2	4	4	3	4	4	3	4
Yield	3	5	5	3	5	5	2	5	5
Number of rows/cob	1	5	5	1	5	5	1	5	5
Number of cobs/plant	1	5	5	1	5	5	1	5	5
Grain size	5	2	2	5	2	2	5	2	2
Cob rots	5	3	4	5	4	4	5	4	4
Tolerant to diseases	3	5	3	3	5	4	3	5	4
Insect pest resistance	2	4	4	2	4	4	3	4	4
Drought tolerant	4	3	4	3	3	3	3	3	4
Withstand lodging	4	3	3	5	4	4	5	3	4
Tolerant to low N	5	1	3	4	1	3	4	2	3
Tolerant to acid soils	4	1	2	4	1	3	3	1	2
Taste	5	2	4	5	2	3	5	3	4
Colour of mealie-meal	2	5	4	2	5	4	2	5	4
Good for sale	2	5	3	2	5	4	2	5	3
Easy to shell	5	5	5	5	5	5	4	5	5
Easy to grind	2	5	5	3	5	4	3	5	5
Quick to dry	5	5	4	4	5	4	4	5	4
Total score	68	67	74	66	70	75	64	71	76
Mean	3.6	3.5	3.9	3.5	3.7	3.9	3.4	3.7	4.0

Variety	*Overall score* §	*Ranking*
Natal-8-row	198	3
Pannar	208	2
Kalahari early Pearl	225	1

* NTL8 = Natal-8-row, † PAN = PANNAR hybrids, ‡ KEP = Kalahari early pearl
§ Overall score for each variety across the villages

4 Discussion

The majority of farmers within the studied community were older than 45 years due to the younger generation that is moving away from farms. The area has been reported to have strong migrant labour links with urban areas and most of the men, especially in the past, have migrated and the movement in search of new opportunities was still taking place in significant numbers within the younger population (Krone, 2006). The community was relatively literate, with more than three-quarters having attended formal education. This implies that it would be easy to set up training programmes for farmers and educate them on important farming aspects, or include them in participatory plant breeding programmes without problems in them grasping and following simple instructions and keeping records.

The landholdings, which averaged 1.4 ha per farmer, were comparable in size to the observation made by Byerlee & Heisey (1997) that smallholder farmers in Sub Saharan Africa (SSA) had land holdings ranging from 0.5 to 3.0 ha. The study also established maize as the principal crop in this district as shown by the land allocated to its production. The farmers grew maize mainly for subsistence and livestock feed and relied mostly on low-input farming. The grain colour was mostly white for consumption and yellow for livestock feed. In addition to maize, a few farmers grew other crops mainly vegetables, potatoes, beans and pumpkins and some had fruit trees such as peach and guava and they sold the fruits to supplement their incomes.

The selection of maize varieties in the community was not as diverse as has been reported from other communities in SSA. In total, the farmers listed about 10 varieties, with almost 100 % growing the local landrace NTL8. Other communities, for example in western Kenya, had about 20 varieties they grew, with about 8 local landraces to choose from (Odendo *et al.*, 2002). Farmers in Manicaland area of Zimbabwe had more than 12 hybrids to choose from and one local landrace (Derera *et al.*, 2006). Nonetheless, in this study, the adoption of hybrids was low, despite South Africa having many seed companies that produce hybrid seed. Farmers cited expensive seed, need for extra expensive inputs, and non tolerance to acid soils or low N as the main reasons for not growing hybrids. This finding is in agreement with reports by Aquino *et al.* (2001) and FAO & CIMMYT (1997) that, although improved superior varieties have been developed in most countries of SSA, the majority of the smallholder farmers still relied on unimproved open-pollinated varieties (OPVs) for their plantings. This was partly because the OPVs were easy to multiply and therefore cheap and readily available (FAO & CIMMYT, 1997).

Based on cob characteristics, the most popular local grown landrace NTL8 is similar to the Hickory King (HK) variety. The HK was introduced into Southern Africa from the USA in 1905 (Weinmann, 1972). The variety is characterized by large dent kernels and can tolerate poor soils (McCann, 2005). Currently there are different versions of HK available, ranging from six- to ten-rowed, dent, semi-dent and semi-flint (Magorokosho, 2006). This landrace is still popular in Southern Africa as shown in collections done by Magorokosho (2006). Results from PRAs by other researchers in Zimbabwe, Kenya and Zambia also indicated landraces with similar characteristics to the HK (Leley, 2007; Miti, 2007; Derera *et al.*, 2006). In Zambia, the landrace was referred to as *Gangata* (Miti, 2007), whilst in eastern Kenya it was called *Kinyanya* (Leley, 2007) and *Chitonga* in the eastern highlands of Zimbabwe (Derera *et al.*, 2006). This suggests the local landraces being grown in eastern and southern Africa could all be related to the HK. The different variations of the local landraces could be a result of hybridizations taking place in the field when farmers grow other varieties. For example, in Amazizi district, the farmers indicated the DL variety was a hybrid between the NTL8 and PAN hybrids and this variant had rows varying from 10 to 12, large grains and the seed was recycled.

Farmers preferred growing the local landrace mainly for its taste, recycled seed, early maturity, tolerance to acid soils and drought tolerance, and satisfactory yields even during bad seasons. This is in agreement with findings by Magorokosho (2006) on landraces collected from Malawi, Zambia and Zimbabwe, whereby farmers kept landraces because of the taste, tolerance to most abiotic and biotic stresses, early maturity and yield stability. The few farmers who grew hybrids in Amazizi district preferred them mainly for yield, disease resistance, white mealie-meal, and shelling and grinding qualities. Most of these farmers grew the hybrids for sale and preferred them because they were also prolific, giving two to three cobs per plant. The improved OPVs were preferred mainly for the seed that could be recycled, yields that were higher than those of the local variety and their resistance to the main biotic stresses.

Cost of seed was the most important factor considered by farmers when choosing a variety, with most farmers desiring varieties with seed that could be recycled. Although, the farmers preferred growing their local variety for the taste, they still preferred high yield and ranked it first. Taste was ranked second, although it was amongst the top perceived advantages of the local variety. Early maturity and low cost of inputs were also important characteristics and were ranked first and second. Pests/diseases and drought were second to high yield. The farmers planted early to escape diseases

and drought and thus preferred early maturing varieties. Based on these characteristics, the Kalahari early pearl was ranked as the best variety, although rather only a small proportion of farmers cultivated this variety. This improved OPV was preferred ahead of the PAN hybrids and NTL8, mainly for the recycled seed unlike the hybrids and yield that was higher than of the local variety. The farmers indicated they would want to grow hybrids and improved varieties, but only if they could afford the seed and inputs required and the other characteristics they preferred were incorporated into these varieties. Additionally, the majority of the farmers cultivated maize purely for subsistence and there was, therefore, no incentive for them to buy maize seed when they anticipated no profit from it. Nevertheless, opportunities do exist of improving the local landraces for yield and still maintain the other characteristics preferred by the farmers or introduce other improved open-pollinated varieties which incorporate the farmers' preferences.

5 Conclusions

The study established that maize was the principal crop grown in Amazizi district. However, the number of varieties grown was limited and the most popular was a local landrace (*Natal-8-row* or *IsiZulu*). The low adoption of hybrids and improved OPVs in the area was attributed mainly to the high cost of seed and inputs, and that the modern varieties lacked the traits the farmers preferred mainly taste, and tolerance to acid soils and low N that are a problem in the area. One key and significant observation was that the farmers still preferred high yielding varieties and were thus willing to grow hybrids, but only if their preferred traits were incorporated. The results imply that crop improvement and adoption of improved varieties by this community would be possible. This could be achieved by involving farmers in the breeding and selection process through participatory plant breeding to ensure that the farmers' priorities and needs are incorporated into the existing local varieties or creation of new varieties. This is likely to increase the chances of making appropriate and sustainable recommendations.

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