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FARMER PERCEPTIONS ON MAIZE CULTIVARS IN THE MARGINAL EASTERN BELT OF ZIMBABWE AND THEIR IMPLICATIONS FOR BREEDING

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ABSTRACT

Productivity of maize *(Zea mays)* is low in the small-holder sector of Zimbabwe because the crop is grown under stress-prone environments and limited resources. The objective of this study was to investigate farmer perceptions on maize cultivars and their implications for breeding. Participatory rural appraisal and household surveys were conducted in the marginal eastern-belt of Zimbabwe, during 2004 to 2005. Although farmers predominantly grew hybrids, productivity (ranging between 240 and 500 kg ha^{-1}) was below national average of 1 t/ha; hence grain deficit was rampant. Surprisingly, farmers preferred hybrids of the 1970s to new hybrids, due to their superior tolerance to abiotic stress. Farmers also preferred a local landrace "Chitonga", because of its superior taste and flint grain. Nonetheless, farmers recognised that both "Chitonga" and hybrids lacked the drought stress recovery mechanism; which is prevalent in sorghum, thus failed to fit into short seasons. Cultivar preferences were area-specific with farmers in more productive Mutasa showing high preference for grain weevil resistance, while those in Chipinge and Mutare West preferred cultivars with drought tolerance, among other traits. Besides conventional breeding, integrated use of participatory approaches and other appropriate technologies such as molecular technology to fix novel stress tolerant genes in ultra-early cultivars for deployment in marginal areas is implied.

Key Words: Participatory breeding methods, production constraints, stress tolerance, *Zea mays*

RÉSUMÉ

La productivité de maïs *(Zea mays)* est faible dans le secteur du petit cultivateur du Zimbabwe parce que la culture est entretenue sous un environnement susceptible au stress et à cause de l'insuffisance de moyens. L'objectif de cette étude était d'enquêter saur les perceptions des cultivateurs au sujet des cultivars de maïs et leurs implications sur la propagation. L'évaluation rurale participative et les sondages par foyer étaient utilisés dans la région marginale de l'Est du Zimbabwe au cours de 2004 et 2005. Bien que les cultivateurs utilisaient des hybrides, la productivité (De l'ordre de 240 à 500 kg ha^{-1}) était sous la moyenne nationale d'une tonne par hectare de telle sorte qu'il existait un déficit pernicieux du grain. D'une manière surprenante, les cultivateurs préféraient les hybrides des années 1970 aux nouveaux hybrides à cause de leur tolérance plus élevée au stress abiotique. Les fermiers préféraient également une race terrienne locale 'Chitonga' grâce à son meilleur goût et la dureté du grain. Cependant les fermiers reconnaissaient qu'il manquait au Chitonga et aux hybrides le mécanisme de récupération du stress de sécheresse observable chez le sorgho ; ce qui les rendaient inaptes aux courtes saisons. La préférence de cultivars variait par localisation, avec les fermiers de la région de Mutasa, plus productive, exhibant une préférence élevée à la résistance du grain au charançon tandis que ceux de Chipinge et de Mutare de l'Ouest préférant les cultivars résistants à la sécheresse entre autres caractéristiques. A part la propagation conventionnelle, est impliquée l'utilisation intégrée d'approches participatives et autres technologies appropriées telles que la technologie moléculaire en vue de réparer les gènes inhabituels de tolérance à la sécheresse chez les cultivars ultra précoces pour développement dans les des régions marginales.

Mots Clés: Méthodes de culture participatives, contraintes à la production, tolérance à la sécheresse, *Zea mays*

INTRODUCTION

The production of maize, a staple food crop in southern Africa, is dominated by small-scale farmers in marginal areas. Given the highly variable conditions, stress-prone environments and limited resources (Banziger and de Meyer, 2002) under which the crop is grown, productivity is low. Maize yields are low, averaging below 1.2 t ha^{-1} (FAOSTAT, 2003) notwithstanding the more than 60-year history in crop research and development in the region. It is believed that some superior cultivars that have been released might not have been adopted because of lack of sufficient consideration of farmers' preferences in their development process. Breeders fail to consider the special preferences of farmers especially those in marginal areas (Toomey, 1999; Banziger and Cooper, 2001) possibly because they are unaware of them. Thus, effective breeding should be firmly based on clear identification of farmers' perceived constraints and their preferences for cultivars through researcher-farmer interaction and collaboration. Farmers can provide vital information on plant types, desired traits and insight into trade-offs they are willing to make among traits in designing cultivar types (Sperling *et al.*, 2001).

Small-scale farmers' involvement in participatory plant breeding is not new. For instance, Banziger and de Meyer (2002) reported that farmers participated in evaluation of pre-selected cultivars in CIMMYT's (International Maize and Wheat Improvement Center) mother-baby trials in southern Africa. Previously, farmers were reported to have been involved in rice varietal selection in India and Nepal (Joshi and Witcombe, 1996; Sthapit *et al.*, 1996; Witcombe *et al.*, 1996). More recently, Monyo *et al.* (2001) reported that farmers were engaged in pearl millet selection in Namibia.

What might be most appealing to small-scale farmers in southern Africa is Sedgley's (1991) market and stress ideotype concept and not Donald's (1968) wheat- and Mock and Pearce's (1975) maize-ideotype concepts, which describe optimum plant types, the preferred option for plant breeders. The optimum plant type of Donald (1968) and Mock and Pearce (1975) describes a plant design that maximises photosynthetic efficiency due to upright leaves and a large sink resulting in high harvest index. However, their optimum plant requires adequate or optimum resources in terms of fertiliser and water, which makes it an option only for resourceful or large-scale commercial farmers. On the other hand, small-scale farmers in marginal areas have limited resources; hence they would not exploit the benefits of optimum plant type. These farmers would require a market and stress ideotype. According to Sedgley (1991), market ideotype identifies desirable traits of the end product such as quality, while the stress ideotype identifies characters required to fit the plant into its target environment in terms of climatic and soil factors, disease and pest resistance. Recently, de Groote *et al.* (2000) reported that farmers in eastern Kenya preferred early maturity ahead of yield, followed by yield-related traits namely cob size, grain size and drought tolerance. In southern Africa, Banziger and de Meyer (2002) reported that apart from yield related traits, farmers frequently mention early maturing varieties, hard endosperm types and good husk cover. These results do not have a global application, but would only pertain to specific areas covered by the study due to changing environmental and socio-economic conditions. The objective of the current study was, therefore, to investigate farmers' perception on maize cultivars in the marginal eastern-belt of Zimbabwe and their implication for breeding.

METHODOLOGY

Study area. The study was conducted in the Chimanimani, Chipinge, Mutasa and Mutare West (Marange) districts, which are marginal areas of the Manicaland Province of Zimbabwe, during 2004 to 2005. Population and number of households in the sample districts are shown in Table 1. The area falls within the rain shadow of humid and misty eastern highlands. Rainfall amount and pattern is modified by altitude, such that high elevation areas receive more rain than lowland areas. Agro-ecological regions are thus demarcated into five regions according to relief, rain fall adequacy and efficiency such that Natural Region I receives the highest and more reliable rainfall, while Natural Region V has the least and erratic rainfall (Vincent and Thomas, 1961). Area covered by the current study comprises Natural Regions IIb to V; stretching for ±200 km from Mutasa (North of Mutare City) to Chipinge District in the south and covering Save and Odzi River catchments. Altitude falls significantly from above 800 m in Mutasa down to about 430 m at Middle Save in Chipinge, thus representing mid altitude dry and lowland tropical dry macro-environments, respectively. In this area, rainfall is very erratic and crop production is to a great extent dominated by small-scale or resource poor farmers. Rainfall features of agro-ecological zones covered by the study area are presented in Table 2.

Sampling procedures. In order to capture the expected variability in agro-ecological and socio-economic environments, the above four districts situated to the North, South and West of the Provincial Capital of Mutare were selected by stratified sampling. The eastern side of the City could not be sampled because it is in Mozambique while the north-east and south-east parts are in the very high potential Natural Region I under high value large-scale commercial and plantation agriculture. Since the districts cut across all the agro-ecological regions in the country, further stratified sampling was applied in the selection of villages within each district to capture those within Natural Regions IIb, III, IV and V where maize is grown under moderate to severe moisture stress conditions (Table 2). In each of the villages, at least six farmers were randomly selected from lists provided by the local extension staff (Table 2). Additionally, three focus group discussions were held in Save River Valley area.

Data collection. Primary data were collected through both formal household survey and informal or Participatory Rural Appraisal (PRA). Local extension staff, councillors and village headmen facilitated the survey by creating a good rapport with local people, mobilised farmers for the focus group discussions and provided lists of farmers to be sampled for the formal survey. The PRA involved three focus group discussions and interviews with key informants such as local teachers, businessmen, school headmasters, councillors and agricultural extension staff in the Save Valley area of Chipinge and Chimanimani. The technique employed consisted of problem listing, analysis and ranking by key informants using semi-structured questionnaires designed to guide the discussions yet provided the group with sufficient freedom to bring up their own issues. In general, discussions started by asking farmers to list uses of maize, identify competing cereals and leguminous crops they grew in their area. Secondly, farmers were asked to list and rank key constraints to maize production. Thirdly, farmers listed cultivars they had grown, ranked them and identified preferred traits of stress tolerant cultivars. Farmers were also asked to list and give reasons for cultivars they would like to grow again and those they would never grow again. In addition, seed issues were discussed at great depth. Throughout discussions a local extension staff member guided the process, while enumerators

TABLE 1. Population and household data for sample districts

District	Males	Females	Total	Number of households
Mutare Rural	106061	116322	222383	48631
Chipinge	134904	148888	283792	61860
Chimanimani	55494	59803	115297	26524
Mutasa	78470	88176	166646	39629

Source: Central Statistical Office (2004)

TABLE 2. Sample study area and number of respondents in the survey

District	Area or village	Ecological zone	Long term annual rainfall	Number of household
Pilot survey study				
Mutasa	Honde valley	Region II	700-1050 mm 16-18 wet pentads	6
Chipinge				9
	Birchnough Bridge	Region IV	450-500 mm <14 wet pentads	6
Mutare West	Marange	Region III	650-800 mm 14-16 wet pentads	3
Informal focus group discussion				
Chipinge				29
	Kondo Village Nyakunawa	Region IV	450-500 mm <14 wet pentads	12 17
Chimanimani				9
	Changazi			9
Formal household survey				
Chipinge				37
	Masocha Taozeni	Region III	650-800 mm 14-16 wet pentads	9 7
	Kondo Musapingura	Region IV	450-500 mm <14 wet pentads	14 8
Mutasa				25
	Sadziwa Tadyanemhandu Musakwa	Region IIb	700-1050 mm 16-18 wet pentads	9 8 8
Mutare West (Marange)				31
	Mafararikwa Sendamurambi Mushipe Mutsago Masase	Region III	650-800 mm 14-16 wet pentads	6 6 6 6 7
Total sample				146

concentrated on taking notes. Issues that were raised during focus group discussions were taken up for further analysis with local opinion leaders.

Prior to the formal survey, a pilot study was conducted involving 53 households in Marange, Honde Valley and Birchenough Bridge in Mutare West, Mutasa and Chipinge, respectively (Table 2). As indicated in Table 2, a total of 93 households in Mutasa, Chipinge and Mutare West participated in the formal survey designed to dissect issues raised during the PRA. The field research team comprised a principal investigator, three enumerators and a local extension staff member. The medium for discussion was the local dialect "Shona" (i.e. *Manyika* and *Ndau*, in the North and South, respectively), which is widely spoken in the area. To eliminate gender dominance in discussions expected at Nyakunawa Village and Changazi Ward 20, in Chipinge and Chimanimani, respectively, separate discussions were held with men and women farmers.

Both the formal and informal research methods were used to improve the precision and to obtain high evidential value in the study. According to Mergeai *et al.* (2001), the informal survey or the PRA approach would ensure that high evidential value is obtained by considering the farmers' local knowledge, and through identifying the key elements as perceived by farmers, while the higher precision for the study would be obtainable from the formal survey.

Data analysis. Statistical analysis of both quantitative and qualitative data was performed in SPSS (Release 11.5.0) computer package (SPSS Inc., 2002). Descriptive statistics, analysis of variance and mean comparisons were computed for data collected in each district followed by mean comparisons between districts.

RESULTS AND DISCUSSION

Features of farm economy. Although data is not shown, the PRA study established that maize is a significant staple food in the area, with uses ranging from "Sadza", the staple meal through traditional beer brewing to snacks both as fresh and dry grain. Data for the household and farm economy is presented in Table 3. Household sizes observed in Chipinge and Mutasa were similar and smaller than those observed in Mutare West. The results suggested that Mutasa was the wealthiest district with respect to the number of cattle, television sets and modern houses. There was at least one radio set per household in all districts, suggesting that extension communication could be effectively transmitted via the radio Average land holding differed significantly between districts, ranging from 3.22 acres in Mutasa to 5.57 in Chipinge. Whereas in Chipinge and Mutasa the dominant crop was maize, in Mutare West it was sorghum. All leguminous crops were grown as minor crops throughout the districts. While it may be difficult to explain the low average acreage planted to pearl millet in Mutasa, in Chipinge the traditional authorities, especially in Chief Musikavanhu's area of jurisdiction prohibited its cultivation. According to key informants, pearl millet is regarded as taboo in the area, because the chief does not eat pearl-millet food or beer brewed from it. According to farmers at Nyakunawa Village, sorghum is perceived to be the best crop for the area, while at Changazi pearl-millet was ranked as the best crop for the valley (Table 4). The farmer groups agreed that maize was not as drought tolerant as both sorghum and pearl-millet, but key informants argued that maize has generally been accepted in the area such that farmers have great interest in the crop in spite of its lack of tolerance to drought stress. Farmers' rank of crops during focus group discussion is presented in Table 4.

Maize production. Maize grain production differed significantly ($P<0.05$) between locations during 2002 to 2004 period with Mutasa having highest yields (Table 5). The estimated yields of between 240 and 500 kg ha^{-1} were significantly less than the national average of 1 t ha^{-1} (FAOSTAT, 2003) and developing world average of 3 t ha^{-1} (Pingali and Pandey, 2001). Farmers in only Mutasa district, however, had a marketable grain surplus of at least two bags during the same period as a result of their significantly higher yields (exceeding 500 kg ha^{-1}) compared to the other districts.

Productivity data confirms that in the 2002 - 2003 period, drought was most severe in 2004. This is supported further by the point that majority (62%) of farmers in the area regarded 2004 as the worst drought year in three years, while 21% expressed the view that 1992 was the worst drought year in the area (data not shown). Differences in grain productivity among districts can also be explained by the different rainfall patterns and nature and intensity of drought in the area. Mutasa experiences moderate late season drought, while the other two districts reported severe drought at anthesis (Table 8), which is a very critical stage in maize grain formation. Scientists are very much in agreement that flowering is the most critical stage associated with greatest yield loss due to drought of between 66 and 83%, especially during tassel emergence and ear formation (Cakir, 2004; Campos *et al.*, 2004). This has serious implications for food security in the area, given that average

TABLE 3. Farm economy and household characteristics in sample districts

Characteristic	District			Overall mean	Statistic: (F. probability)
	Mutasa (n=25)	Chipinge(n=37)	Mutare West(n=31)		
Number in household					
Male adults	1.00	0.93	1.58	1.19	0.009
Female adults	1.20	1.37	2.03	1.57	0.008
Male children	2.52	2.41	3.58	2.88	0.358
Female children	2.56	2.81	3.26	2.9	0.653
Total Household size	7.28	7.52	10.45	8.54	
Number of farm assets per household					
a) Livestock					
Cattle	7.56	4.52	4.77	5.53	0.017
Chicken	10.92	10.52	9.03	10.08	0.473
Goats	3.36	4.85	6.68	5.08	0.032
Sheep	0.32	1.67	0.00	0.64	0.011
Donkey	0.04	0.63	0.06	0.24	0.001
Pigs	0.04	0.00	0.00	0.01	0.317
b) Farm tools or physical stock					
Tractor	0.04	0.07	0.00	0.04	0.327
Cart	0.76	0.48	0.45	0.55	0.045
Plough	0.92	0.81	1.10	0.95	0.085
Harrow	0.56	0.22	0.00	0.24	0.000
Well	0.48	0.48	0.68	0.55	0.317
Pump	0.00	0.00	0.00	0.00	
c) Household amenities					
Modern house	1.56	1.19	1.29	1.34	0.183
Traditional hut	1.56	2.15	2.23	2.00	0.039
Motor Vehicle	0.12	0.07	0.03	0.07	0.567
Television set	0.24	0.00	0.03	0.08	0.003
Radio	1.08	1.07	1.13	1.10	0.981
d) Land holding and crops grown (acres)					
Maize	2.54	3.93	1.34	2.54	0.000
Bean	0.28	0.14	0.16	0.14	0.002
Sorghum	0.00	0.91	2.08	1.07	0.000
Groundnuts	0.40	0.59	0.42	0.47	0.312
Pearl-millet	0.00	0.00	0.33	0.12	0.001
Total land holding	3.22	5.57	4.33	4.34	

household grain consumption was estimated at two buckets (±40 kg) per month (Table 5). Calculations show that an average household requires at least 480 kg of grain per annum, which is far above the average yield or total production in Chipinge and Mutare West during 2002 to 2004, suggesting that there is a serious grain deficit in the area.

TABLE 4. Rank of crops grown in the area by farmers during focus group discussion

Crop	Changazi ward 20	Middle save
Sorghum	2	1
Maize	3	2
Sunflower	4	3
Pearl-millet	1	4
Finger millet	5	5

Scores: 1 = best and 5 = least crop for the area

Production constraints. The data show significant differences in ranking production constraints between districts but not between gender groups (Table 6). Farmers in Mutare West ranked drought first, followed by non-availability of seed as most important, while their counterparts in Chipinge and Mutasa identified drought and low soil fertility as most important, respectively. Household data from Chipinge support findings from the focus group discussion at Nyakunawa, Kondo and Changazi where drought was ranked ahead of soil fertility (Table 7). Overall results from both focus group discussion and household survey indicate that non-availability of seed on the formal market followed by drought were the most important constraints in this marginal eastern belt.

Farmers perceived their soils were of adequate fertility (Table 8) yet they applied ±32 (480 kg) wheel burrows of cattle manure per acre and at

TABLE 5. Grain production, productivity and consumption per household

	Mutasa	Chipinge	Mutare West	Overall mean	Statistical F. probability
Number of bags produced (1 bag = 50kg)					
2004	11.88	5.11	1.13	5.66	0.000
2003	13.36	7.56	1.10	6.89	0.000
2002	15.32	10.11	4.77	9.65	0.000
Number of bags sold					
2004	2.08	0.00	0.00	0.63	0.000
2003	3.24	0.30	0.00	1.07	0.000
2002	4.76	0.63	0.19	1.71	0.000
Grain consumption in number of buckets per month (1 bucket = 20kg)					
Male	2.09	1.18	1.82	1.65	
Female	2.19	1.79	2.26	2.14	
Average	2.12	1.33	2.06	1.84	0.078
Grain yield in number of bags per acre (1 bag = 50 kg)					
2004	4.68	0.38	0.84	1.97	
2003	5.26	1.92	0.82	2.67	
2002	6.03	2.57	3.56	4.05	
Grain yield in kg ha^{-1}					
2004	578.21	46.95	103.78	243.39	
2003	649.86	237.21	101.31	329.87	
2002	745.00	317.52	439.83	500.37	

least 1 to 2 bags of inorganic fertiliser (per acre) as basal and top dressing. In Mutasa on the other hand, farmers raised soil fertility as a major production constraint (Table 6), which together with late season drought could partly explain why Mutasa yields were below the national average. Results from the focus group discussions showed that farmers recognised drought as a key constraint to maize productivity ahead of low soil fertility (Table 7). Farmers concurred that soil fertility was not a problem in the area. They strongly agreed that their soil was naturally good and fertile, a view that was shared with key informants. Local businessmen and extension staff reported that farmers perceived their soil to be highly fertile to the extent that they sold the free packs of fertiliser from donors. Again farmers were very clear in their perception that use of inorganic fertiliser would damage their inherently good soil. However, farmers and key informants at Changazi mentioned that although their soils were of good fertility, there were isolated areas with salt problems. Apart from drought farmers at Changazi also mentioned poor seed distribution

TABLE 6. Mean rank for perceived production constraints from formal survey*

Constraints	District			Overall mean	F. Probability
	Mutasa	Chipinge	Mutare West		
Overall response					
Seed availability	1.52	1.30	2.31	1.71	0.000
Drought	3.00	2.30	2.00	2.40	0.000
Poor soil fertility	2.24	3.22	2.81	2.77	0.000
Cultivar problems	4.48	4.42	4.50	4.47	0.974
Disease and insect pest	4.14	5.08	4.33	4.47	0.023
Female respondents					
Seed availability	2.13	1.00	2.36	1.97	-
Drought	3.13	2.57	2.18	2.50	-
Poor soil fertility	2.13	3.43	2.94	2.84	-
Disease and insect pest	3.86	5.00	3.50	3.90	-
Cultivar problems	4.00	4.00	4.50	4.23	-
Male respondents					
Seed availability	1.24	1.40	2.25	1.55	-
Drought	2.94	2.20	1.79	2.33	-
Poor soil fertility	2.29	3.15	2.64	2.73	-
Cultivar problems	4.67	4.45	4.50	4.57	-
Disease and insect pest	4.27	5.08	6.00	4.68	-

Note: * Characteristic with smallest mean rank within a column is perceived to be most important

TABLE 7. Mean rank for perceived production constraints informal focus group discussion*

	Nyakunawa	Kondo	Changazi	Key informants
Low rainfall	1	1	1	1
Non-availability of seed		2	2	2
Salt in isolated areas	-	-	4	-
Termite damage	2	-		
Damage by quelea birds, armoured cricket and mice	3	-		
High heat stress		-	3	3
Draught power	-	3		
Low soil fertility	5	4	5	5
Land too small	4	5	-	-

Note: *Scores used were: 1= most important and 5= least important as a major problem since there was no commercial seed that was available on the formal market during the period 2002 to 2004.

The survey data revealed that the rainy season started in November and ended in March during 2002 to 2004 seasons (Table 8). Farmers in Mutasa rated rainfall amount as moderate, while their counterparts in Chipinge thought it was too little for the maize crop. In general drought occurs from mid to late season with an intensity rated as

TABLE 8. Farmers' perception of soil fertility, rainfall and drought

Characteristic	Mutasa	Chipinge	Mutare West	Overall mean	Statistics F. probability
Soil Characteristics (Fertility: 1 = Good, 2 = Moderate, 3= Low; * Texture: 1 = Sand, 2 =Clay, 3 =Loam)					
Texture	2.00	2.41	1.80	2.06	0.000
Fertility	1.92	1.63	2.15	1.90	0.003
Soil fertility management					
Manure applied in number of wheel burrows per acre					
Cattle manure	34.88	30.74	30.59	31.93	0.842
Chicken manure	2.04	2.33	0.03	1.38	0.000
Goat manure	1.76	0.96	0.46	1.02	0.164
Mean rank of productivity of manure					
Cattle manure	1.33	1.20	1.43	1.33	0.298
Chicken manure	1.45	1.91	2.12	1.91	0.040
Goat manure	2.67	2.67	2.32	2.50	0.168
Number of bags of inorganic fertiliser applied per acre (1 bag = 50 kg)					
Basal fertiliser	1.84	1.96	0.87	1.52	0.012
Top dressing	1.48	1.48	1.81	1.16	0.291
Amount of rain (1= little, 2= moderate, 3= sufficient for maize crop)					
2004	2.00	1.11	2.00	1.71	0.000
2003	2.40	1.63	2.00	2.00	0.004
2002	2.72	1.07	2.11	1.95	0.000
Nature of drought (1=early, 2= mid, 3=late, 4 = whole season drought					
	2.96	2.26	2.26	2.47	0.000
Intensity of drought (1= little, 2= moderate, 3 = severe					
	2.08	2.85	2.94	2.65	0.000
Rainfall dates					
Date of first rain (1 = late Oct, 2 = Nov, 3 = Dec and 4 = Jan					
2004	2.00	2.81	1.77	2.18	0.000
2003	2.04	1.37	1.97	1.79	0.000
2002	2.80	1.44	1.96	2.05	0.000
Last rain (1= Feb, 2 = March, 3 = April 4 = May)					
2004	2.08	1.44	1.00	1.47	0.000
2003	2.80	2.59	1.07	2.10	0.000
2002	2.04	2.44	1.22	1.90	0.000

moderate in Mutasa but severe in Chipinge and Mutare West (Table 8).

Maize varieties grown. Table 9 shows maize varieties grown by farmers in the area between 2002 and 2004. During focus group discussions, additional varieties that were mentioned to have been grown in the past include R201, R200, R215 and new dwarf hybrids. Both formal and informal surveys established that farmers predominantly grow improved hybrids as well as a traditional land race called "Chitonga", but reckoned that it was not the ideal cultivar. According to the farmers in Chipinge and Chimanimani, "Chitonga" is also a common variety in Mozambique to the east and from where it enters Zimbabwe through Ndowoyo area in Chipinge and Rusitu Valley in Chimanimani. Farmers in Changazi thought that "Chitonga" requires higher rainfall than hybrids SC403 and PAN 413 that are grown in the area. Farmers in Nyakunawa village shared similar sentiments on "Chitonga", but added that it was late maturing and very tall. All farmers agreed that the preferred attributes of this landrace was better taste and resistance to grain weevils than standard hybrids.

Although farmers indicated that they grew at least 10 kg seed of hybrids (data not shown), it was not possible to establish whether they grew first (F_1), second (F_2) or later generation hybrids. We can only speculate that farmers were planting F_2 hybrid grain as seed, because 16% of farmers

TABLE 9. Maize varieties or brands grown and mean rank of performance

Cultivar	Mutasa	Chipinge	Mutare West	Overall mean
% farmers indicating they grow the variety				
SC500 Brand*	0	0	87	32
SC513	40	48	6	30
SC401	36	0	3	12
PAN 6479	0	22	0	7
SC400 Brand*	4	4	13	7
SC403	0.0	15	0	6
Farm saved seed	16	4	0	6
PANNAR* Brand	8	0	10	6
PAN 413	0	15	0	5
SC601	12	0	0	4
SC501	8	0	0	2
SC701	4	0	0	1
Pioneer Brand	0	0	3	1
Mean rank of performance				
Pioneer Brand	-	-	1.00	1.00
SC513	1.42	1.17	1.33	1.30
SC400 Brand	2.00	-	1.35	1.42
SC601	1.60	-	-	1.60
PAN6479	-	1.64	-	1.60
SC500 Brand	2.00	1.00	1.65	1.64
SC401	1.64	2.00	2.00	1.76
SC403	2.00	2.05	1.00	2.00
SC517	-		2.00	2.00
SC501	2.00	-	-	2.00
SC701	2.00	-	-	2.00
SC700 Brand	2.00		-	2.00
PAN413	-	2.13	-	2.13
PANNAR Brand	2.00	-	2.27	2.20
Farm saved seed	2.87	3.20	2.75	2.94
SC407	3.00	-	-	3.00

*Farmers recognised the brand but not specific hybrid name in Mutasa indicated that they grew farm saved seed (Table 9). Unfortunately, hybrid vigour or heterosis that confers high yield in F_1 hybrids declines sharply by over 50% in F_2 and subsequent generations (Falconer, 1981), which can partly explain below national average yields in the area.

Though exposed to hybrid brands from at least four seed companies namely Seed Co, Pannar, Pioneer and Agricura, some farmers were not able to recognise commercial hybrids by their exact names, but could only remember the brand names. This suggests that farmers could easily be cheated by unscrupulous dealers selling them varieties not recommended for their areas. There were no significant differences in mean rankings of varieties between districts, but the hybrid SC513, a popular variety among farmers was consistently ranked among top performers (Table 9). Throughout the survey, farmers indicated their interest in growing yellow maize for consumption as fresh maize, but none knew the name of any locally available yellow maize varieties. It was clear that their experience with yellow maize was from food aid donations through drought relief programmes. However, inspection of seed variety register maintained by Seed Services Institute in the Ministry of Agriculture showed that there are 16 yellow maize varieties that are registered in Zimbabwe (Second Schedule of Seeds Certification Scheme Notice of 2000: as at 18 August 2005).

Surprisingly, during the PRA farmers and opinion leaders showed very high regard for old commercial hybrids such as R201. Although they have accepted the new early maturing hybrids such as PAN 413 and SC403, farmers did not think they measure up to R201 in terms of performance although opinion leaders in Save Valley believed the latter could still be improved for "sorghum-type" tolerance. "Sorghum-type" tolerance was defined as "the ability of a drought stricken variety to recover when rains resumed later in the season". Their explanation was that the rainy season begins very well in November, with good precipitation continuing into December and a drought spell in January. When rainfall resumes in February, sorghum has the ability to recover but not maize. This implies that January is the "black" month in the area, and an "ideal" maize variety should combine earliness with the ability to tolerate drought stress at flowering. In addition, opinion leaders mentioned that such a variety should have tolerance for high heat stress that is experienced during summer. The take home message is that scientists should work towards imparting some drought stress recovery mechanism in maize for deployment in this marginal area. Another important lesson that could be drawn from the study is that since farmers have accepted local landrace "Chitonga", breeders can make impact by improving this cultivar. According to farmers and opinion leaders, a significant improvement should be aimed at reducing plant height and maturity period of "Chitonga", while maintaining its good taste. Such improvement would not only benefit farmers in Zimbabwe but also their Mozambican counterparts who also grow the variety.

Maize cultivar trait preferences and ranking. Mean ranks of trait preferences for maize cultivars are presented in Table 10 and Table 11. Except for maturity period and yield, farmers showed significant differences in ranking of cultivar trait preferences between districts. Although the whole sample level analysis showed high yielding as the most important criterion used in varietal selection and drought third, farmers in Mutare West identified maturity period as the most critical factor while those in Mutasa ranked grain weevil and disease resistance as third ahead of both tolerance to drought and low soil fertility stress. The lower ranking of drought stress tolerance in Mutasa could be explained by the moderate drought stress experienced there compared to areas in the South where drought stress is severe and coincides with flowering (Table 10). Given the differences in rainfall pattern, the results suggest that an early maturing cultivar will most likely escape late season drought in Mutasa, but be affected at flowering in the South. Possibly because of excess production over consumption (requiring storage over extended periods) coupled with high relative humidity, farmers in Mutasa prefer grain weevil resistance to drought stress tolerance. Tolerance to low soil fertility would be equally important in Mutasa, because of the high rainfall leading to leaching of nutrients from the soils compared with the severely drought prone Chipinge and Mutare West. As expected farmers in Mutare West showed their strong preference for drought stress tolerance ahead of high yield (Table 10), suggesting that they are prepared to trade off a high yielding variety for a drought tolerant cultivar. In the absence of a truly drought tolerant maize variety, farmers prefer to plant more sorghum than maize as the former is perceived to have better tolerance to drought (Table 3).

In general, farmers in all districts were not concerned much about prolificacy (number of cobs per plant), cob size, husk coverage and pounding ability hence, their low ranking (Table 10). The apparent lack of concern for pounding ability and good husk coverage contrast sharply with previous results that farmers in southern Africa preferred hard endosperm types for ease of pounding and good husk cover against storage pests and ear rots (Banziger and de Meyer, 2002). The first contrast may be explained by the increased use of mechanical mills while the second by the relatively limited excess production demanding little or no storage at all. Farmers' preference for early maturing varieties was consistent with previous reports that farmers would prefer these cultivars because they can escape late season drought, provide food when home stores become depleted and command a higher market price when sold as green maize (Banziger and de Meyer, 2002).

During both the household survey and focus group discussion, farmers were shown sample cobs representing different grain texture, cob size and grain colour (Tables 10 and 11). There were no significant differences (P>0.05) between districts for grain texture preferences. Consistently, farmers showed their preference for intermediate and flintier than dent grain texture (Table 10). At Changazi group discussion farmers were of the opinion that grain of intermediate texture would have high storability, better taste than dent and would yield higher grain than both flint and dent due to superior test density. Furthermore farmers overwhelmingly prefered long thin cobs to medium and long fat cobs, which is rather difficult to explain because scientists would expect farmers to have a higher preference for fat cobs. These results differ from those of de Groote (2000) who

TABLE 10. Mean rank values for preferred traits of stress tolerant cultivars from formal survey*

Characteristic	Mutasa	Chipinge	Mutare West	Overall	F. probability
General traits					
High yielding	2.68	1.78	2.79	2.42	0.065
Maturity period	3.16	2.54	2.59	2.75	0.348
Drought stress tolerance	5.32	3.11	3.82	4.05	0.000
Low soil fertility tolerance	4.96	5.64	4.04	4.85	0.003
Grain weevil resistance	3.60	4.30	6.68	4.91	0.000
Cob size	7.00	6.29	3.59	5.51	0.000
Disease resistance	3.80	4.60	7.86	5.58	0.000
Number of cobs per plant	8.36	7.13	6.00	7.13	0.000
Cob husk coverage	6.52	7.65	8.33	7.51	0.004
Pounding ability	9.60	10.00	8.82	9.38	0.018
Ear or cob aspect					
Long thin	1.64	2.17	1.48	1.73	0.003
Medium	2.08	2.09	2.06	2.08	0.995
Long fat	2.28	1.61	2.45	2.15	0.000
Grain texture					
Flint	1.76	1.58	1.81	1.73	0.497
Intermediate	1.72	1.75	1.71	1.73	0.984
Dent	2.52	2.62	2.48	2.54	0.712

Note: * Characteristic with smallest mean rank is the most important in each column observed that farmers in eastern Kenya were not interested in flintiness and cob length. Farmers also mentioned that they prefered plants of medium height, ranging from the dwarf hybrids to SC403. Although farmers claimed ignorance of any name of local yellow maize varieties, they strongly expressed their preference for yellow maize for food when cooked as fresh or green cobs due to their good aroma and for livestock feed (data not shown). It is, therefore, recommended that small-scale farmers should be given access to yellow cultivars since they have many uses for it.

CONCLUSIONS AND IMPLICATIONS FOR BREEDING

Using both formal and informal survey methods, this study examined maize production constraints and farmers' specific preferences for stress tolerant cultivars in the marginal areas of the Manicaland Province of Zimbabwe. The results showed that given the diametrically different agro-ecologies, maize production constraints differ between survey districts influencing farmers' preferences for maize variety traits. For instance, farmers in more productive areas with the potential of producing grain surpluses strongly prefer weevil resistant cultivars, while those in less productive areas prefer drought stress tolerant varieties. However, a variety combining high yield and early maturity is generally preferred. This suggests that scientists should consider exploiting stay green trait or genes that would confer high grain yield in early maturing cultivars due to extended leaf area duration. In addition, ultra early maturing cultivars (i.e. less than 90 days) with tolerance to drought stress at flowering are suggested for deployment in the very dry areas such as Save Valley, Chipinge and Mutare West. Farmers' quest for drought tolerant maize with a stress recovery mechanism similar to that of sorghum should be taken seriously. It is, thus, suggested that genes conferring recovery from drought stress in sorghum should be investigated, followed by consideration for transferring these genes to maize. Production of such maize or "*sorghum-maize*" would constitute appropriate biotechnology for small-scale farmers in dry and drought prone areas such as Save Valley. On the other hand, cultivars tolerant to low soil fertility are desirable in high rainfall areas such as Mutasa where nutrient leaching can be a problem.

Apart from lack of appropriate cultivars, farmers identified availability of seed of improved cultivars as a major constraint to production. To reduce the chances of being cheated by unscrupulous seed vendors who may want to exploit the lack of seed on the market by trading in fake seed, farmers' knowledge on commercial cultivars should be improved beyond the brand name. Such exploitation is probably already taking place judging from the relatively poor yields that farmers reported although recycling of hybrid seed of later generations could also be blamed. Unfortunately, this study did not prove whether farmers grew hybrids in the first generation (F_1) or in the second (F_2) or subsequent generations which lack hybrid vigour. Use of farm saved seed as mentioned by at least 13% of the farmers might suggest replanting of hybrid seeds or traditional landraces. Reducing the height and maturity period of the landrace "*Chitonga*" largely grown in Chipinge and Changazi area without compromising on its sweetness and flintier grain would potentially have a large positive impact on households' livelihoods with spill over effects

TABLE 11. Mean rank values for preferred traits of stress tolerant cultivars from informal focus group discussion*

	Nyakunawa	Kondo	Changazi	Key informants
High yield	3	1	3	3
Drought tolerance	1	2	1	1
Early maturing	2	3	2	2
Resistance to insects	4	4	-	4
Disease resistance	5	5	-	5
Cob size	-	5	-	5
Low soil fertility tolerance	5	5	-	5

Note: *Scores used were: 1 = most important, 5 =least important into neighbouring Mozambique where it is also widely grown.

In sum, the study showed that small-scale farmers recognise the prevailing "key" production constraints peculiar to their environment, and have specific preferences for stress tolerant maize cultivars. These results imply that scientists should employ both participatory or interactive breeding strategies and molecular technologies to improve existing cultivars and also develop new varieties that are tolerant to prevailing stresses and adaptable to short growing seasons in these marginal areas.

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