PROJECT NUMBER		M101/80
PROJECT TITLE		Evaluation of maize open-pollinated varieties (OPV's) for economic viability
PROJECT MANAGER		SH Ma'ali
PROJECT STATUS		Complete
PROJECT DURATION		01/04/2001 - 31/03/2010
CO-WORKER(S)	Internal	D De V Bruwer, CS de Klerk, SJ Mashao,
	External	DAFF, seed industry, farmers, co-operatives

ABSTRACT

The identification of correct maize cultivars for successful maize production in smallholder communities is essential. Characteristics such as adaptability, lodging and yield stability are very important to every farmer. Approximately 95 successful trials with three replications were accomplished in the eastern and western production areas under low and high production potential conditions. Co-workers mostly consisted of developing farmers. Each trial consisted of nine to sixteen entries consisting of hybrids and open-pollinated varieties. Data were compiled and analysed using GENSTAT. The AMMI model was used to estimate yield potential and stability values of tested genotypes under different environments. The average grain yield over localities and years was 4.79 t ha^{-1}. Out of 69 hybrids and open-pollinated varieties tested during the last five years of the project, only eight that were present in each year were compared because stakeholders nominated different cultivars each year. PAN 67 was the best performer followed by AFG 4501 and both were hybrids and the lowest performer was ZM 521, which is an open-pollinated variety. Results of the 2008/09 growing season indicated that PAN 6053 (hybrid) yielded the best followed by SA7, SA1 and SA3 which were all open pollinated varieties. A significant effect of genotypes as well as genotype x environment interactions was observed. Based on AMMI analysis CG 4141(hybrid) was the most stable genotype followed by ZM 1523 (OPV) over test localities.

KEYWORDS

AMMI, genotype, open-pollinated varieties, maize, genotype x environment interaction.

INTRODUCTION

At the beginning of each season, one of the most important decisions that upcoming and small-scale farmers have to make is that of choosing the correct cultivar for their area. Input costs, including seed, are on the increase. Correct cultivar choice contributes to successful production and can lead to yield increases of as much as 20 - 25 % (du Toit, 1999). Superior open-pollinated varieties (OPV's) with high, stable yields under low potential conditions should be considered since hybrid seed is very expensive and usually only planted under high potential conditions. Resource poor farmers who are confronted by high seed prices can use existing seed from their OPV crop to plant next season. Unbiased information regarding the performance of these cultivars should be available to enable farmers to make proper decisions. Relevant information regarding the performance and stability of new cultivars is not always available for proper cultivar recommendations.

The project was initiated in 1999 as part of the National Cultivar Evaluation project to fulfil the need for unbiased information about the performance of open-pollinated varieties (OPV's). This information should be available to resource poor and smallholder producers or producers who are practising maize production under low input environments. The project has been co-funded by the Maize Trust and the Agricultural Research Council – Grain Crops Institute in order to cater for testing yield potential and stability of cost effective open-pollinated varieties and hybrids (Du Plessis & Bruwer, 2001). Originally, information on cultivars consisted of simple regressions that indicated how cultivars perform over a range of yield potentials. In 2005 the computer programme, GENSTAT, was adapted and used to analyse data according to the Additive mean effects and Multiplicative interaction (AMMI) model. This method enhanced the selection criteria since it estimates the yield potential as well as stability of tested cultivars under different environments (Purchase, 1997 & Ma'ali, 2008). Identification of correct maize cultivars for successful maize production in smallholder communities is essential (Smallberger & du Toit, 2001). Characteristics such as adaptability, lodging and yield stability are very important to every farmer. Yield potential and stability of cultivars in specific environments, are the most important criteria for measuring cultivar performance (Alberts, 2004; Oosthuizen, 2005 & Ma'ali, 2008). Environmental conditions differ from year to year, thus more reliable conclusions can be drawn from multi-seasonal data than from one year's results. The perception does exist that hybrids could react differently under lower production potentials with low input costs compared to high yield potential conditions and that open-pollinated varieties could perform better than hybrids under lower production potentials. This could have a major impact on especially smallholder farmers that do have a diversity of soils and lack resources to acquire inputs.

The objectives of the project were (i) to make comparisons between newer open-pollinated varieties (OPV's) and low-cost maize hybrids and (ii) to demonstrate differences between hybrids and OPV's.

MATERIALS AND METHODS

A randomised complete block design with three replications was used throughout the project period to accommodate different genotype numbers. About 95 trials were successfully accomplished throughout the project period and each trial had its own randomization. Entries consisted of only white maize genotypes. Each plot had 40 plants and choice of row widths and spacing was left to the co-workers' discretion. Soil types normally used for maize production were utilised where possible. Fertiliser applications were not prescribed but applied according to soil fertility and the maize yield potential of that area. Accepted planting dates for successful maize production in the area involved were recommended. Trials were mechanically or manually planted (two or more seeds per hill) and thinned out as soon as the seedlings were strong enough. Suitable herbicides and insecticides were used for effective weed and pest control. Trials were mechanically or hand harvested. Yield was determined for all replications. Trials were harvested when the grain moisture was 19.0 % or lower. The following information and observations were recorded each year: number of lodged plants, number of plants per net plot, number of tillers per net plot, number of ears per net plot, ear mass, grain mass and grain moisture content. Grain yield was the only parameter statistically analysed. An AMMI analysis was used to determine the adaptability and stability of cultivars across different environments. The combined analysis of variance according to the AMMI model was preformed using the GENSTAT computer package. Statistical procedures normally used to identify and exclude outlier trials from the AMMI model were used. Diagnostic parameters were also used to help in the selection of trials with reliable data.

RESULTS AND DISCUSSION

The overall results showed that the average grain yield over localities and years was 4.79 t ha^{-1}. Out of 69 cultivars that had been tested during the last five years of the project only eight cultivars were tested in combination because stakeholders nominated different cultivars each year. Mean yields of these cultivars are presented in **Table 1**. PAN 67 was the best performer followed by AFG 4501 which are both hybrids. SAM 1107 an open-pollinated variety produced 4.94 t ha^{-1} and Nelson’s Choice, also an OPV produced 4.54 t ha^{-1}, which could be considered very good yields under low input farming conditions. ZM 521 (OPV) was the lowest performer and produced 3.80 t ha^{-1}.

Table 1 Mean yield (ton.ha^{-1}) of eight maize cultivars tested in the last five years of the project (2004-2009)

Genotype		yield(t.ha^{-1})
RO413	OPV	4.58
PAN67	Hybrid	5.01
Nelson`sChoice	OPV	4.54
PAN6671	Hybrid	4.13
ZM521	OPV	3.80
AFG4501	Hybrid	4.99
SAM1107	OPV	4.94
Mean		4.57

During the 2008/09 growing season grain yield and other agronomic parameters of 16 genotypes were measured in 17 different environments. The mean grain yield was 4.96 t ha^{-1} over locations and the best yielding genotype was PAN 6053 with 5.75 t ha^{-1} followed by the open-pollinated varieties SA7, SA1 and SA3 with grain yields of 5.59, 5.34 and 5.19 t ha^{-1}, respectively. Statistically there were no significant differences between the hybrid PAN 6053 and the top three OPV’s (**Table 2**). This result supports the argument that OPV’s might perform better than hybrids under low input environments. Significant effects of genotype as well as genotype x environment interactions were observed. Based on AMMI analysis CG 4141 was the most stable genotype followed by ZM 1523 and SA 1 over test environments (**Table 3**). A direct and easy way to assist farmers with choosing suitable cultivars is an AMMI selective table. **Table 4** indicates the best genotypes for specific areas and from this table a producer can select the best four cultivars for his specific environment.

A summary of the mean values of agronomic characteristics for the genotypes tested in different environments during the 2008/2009 growing season is presented in **Table 5**. Other agronomic parameters and yield data for different seasons can be obtained from ARC-GCI reports which are available in hard copies or on the ARC-website.

Table 2 Mean yield (t ha^{-1}) for different maize genotypes under different environments in the small scale regions during 2008/09

Genotypes	Beth-lehem C1	Beth-lehem C2	Potchef-stroomC1	Potchef-stroomC2	Potchef-stroomC3	Cedara	Vander-bijlpark	Wessels-bron	Bezena	Potchef-stroom P1	Potchef-stroom P2	Los-kop	Cedara Sprayed	Cedara Unsprayed	Lim-popo	Petit	Warm-bad	Gem Mean
CAP311	3.71	3.83	4.45	4.36	4.42	6.89	4.75	3.22	4.33	8.66	7.41	3.94	7.93	6.19	2.93	3.50	2.86	4.90
CAP341NG	3.55	4.04	5.28	3.88	4.66	6.55	6.03	3.36	3.43	8.39	9.22	3.71	7.78	6.64	3.07	3.83	2.97	5.08
CG4141	4.21	3.64	3.89	3.84	4.14	6.56	4.75	3.26	4.89	7.83	8.32	3.39	8.17	5.35	2.31	5.57	1.44	4.80
DKC80-31	3.23	3.56	3.14	2.16	4.42	5.55	4.79	2.59	1.79	3.76	5.34	2.86	6.23	4.84	2.93	3.67	2.18	3.71
DKC80-33	6.57	3.77	4.56	3.30	2.86	7.34	5.82	3.26	3.77	8.95	7.79	4.20	8.05	6.43	2.93	4.67	1.72	5.06
Nelson`s Choice	5.72	3.58	4.36	4.05	4.25	6.52	4.80	2.66	4.04	8.62	8.77	2.73	7.31	6.37	2.25	3.23	2.76	4.82
Nevada	4.69	4.56	4.42	2.86	4.66	4.91	5.65	2.31	3.65	6.68	8.07	3.59	7.63	5.58	2.22	5.13	1.77	4.61
PAN6053	4.04	4.91	5.70	5.48	5.95	7.38	6.29	3.45	3.78	10.40	9.69	4.48	8.16	6.51	4.74	4.63	2.10	5.75
PAN6671	5.92	3.63	4.62	4.06	4.78	5.44	5.42	2.62	3.08	7.42	6.66	2.42	6.34	4.60	2.17	3.63	1.87	4.39
PAN67	4.65	3.47	4.10	3.51	4.47	6.87	4.85	3.40	5.12	8.14	5.58	3.99	8.86	8.02	2.63	3.86	2.71	4.95
RO413	5.07	4.09	5.37	4.24	5.52	6.45	5.22	2.91	4.13	8.83	8.89	3.80	6.75	5.45	2.52	4.86	3.96	5.18
SA1	6.20	5.17	5.18	3.79	4.83	7.02	5.53	4.77	3.18	9.00	8.15	2.38	8.31	6.48	2.77	5.62	2.34	5.34
SA3	4.64	4.62	4.84	4.04	4.87	7.15	6.36	3.62	4.25	7.19	7.99	3.04	8.50	7.10	2.72	5.21	2.05	5.19
SA7	6.23	4.83	5.98	5.18	5.29	6.57	5.70	3.97	3.79	7.02	8.43	4.34	8.94	6.69	3.33	5.63	3.14	5.59
SNK2147	4.23	4.02	5.94	3.79	5.79	7.24	3.88	2.60	4.76	9.61	9.03	3.56	7.63	6.25	1.94	4.48	2.65	5.14
ZM1523	3.46	3.80	4.71	4.25	4.34	6.84	5.99	3.28	3.25	7.83	8.01	3.80	6.94	6.30	2.16	3.65	2.90	4.79
mean	4.76	4.09	4.78	3.92	4.70	6.58	5.36	3.21	3.83	8.02	7.96	3.51	7.72	6.18	2.73	4.45	2.46	4.96
CV%	26.70	18.00	13.52	21.90	8.20	9.30	18.70	19.80	22.90	15.23	19.00	16.30	16.20	11.20	13.8	22.00	20.49	19.1
LSD (0.05)	2.120	1.229	1.098	1.632	0.640	1.019	1.674	1.059	1.460	2.090	2.519	0.956	2.090	1.154	0.629	1.632	0.851	1.515

Table 3 Mean yield (t.ha^{-1}),rank, IPCA1 and IPCA2 scores and AMMI stability value (ASV) of maize genotypes analysed according to the AMMI model over 17 environments during the 2008/09 season

Genotypes	Genotype No.	Mean yield	Rank 1	IPCA1	IPCA2	ASV	Rank 2
PAN6053	8	5.75	1	-0.878	0.403	1.371	13
SA7	14	5.59	2	0.633	0.361	1.011	12
SA1	12	5.34	3	0.262	0.136	0.414	3
SA3	13	5.19	4	0.499	-0.115	0.754	7
RO413	11	5.18	5	-0.508	0.595	0.964	11
SNK2147	15	5.14	6	-1.049	-0.083	1.567	14
CAP341NG	2	5.08	7	-0.414	0.236	0.662	5
DKC80-33	5	5.05	8	0.138	-0.631	0.663	6
PAN67	10	4.95	9	0.429	-1.550	1.676	15
CAP311	1	4.91	10	-0.368	-0.535	0.767	8
Nelson`sChoice	6	4.82	11	-0.516	-0.169	0.788	9
CG4141	3	4.80	12	-0.047	-0.220	0.231	1
ZM523	16	4.79	13	-0.216	0.083	0.332	2
Nevada	7	4.61	14	0.503	0.544	0.927	10
PAN6671	9	4.39	15	0.231	0.530	0.632	4
DKC80-31	4	3.70	16	1.302	0.414	1.987	16

Rank 1= ranking among the genotypes

Rank 2= ranking in the ASV among the genotypes

Table 4 The AMMI model's best four genotype selection for mean yield in relation to environments used during 2008/09

Environment	Mean	IPCA 1 Score Score	AMMI selection			
BethlehemC1	4.76	0.647	SA7	SA3	SA1	PAN67
BethlehemC2	4.10	0.387	SA7	PAN6053	SA1	SA3
Bizana	3.83	-0.222	PAN67	PAN6053	DKC80-33	SNK2147
Cedara	6.58	-0.182	PAN67	PAN6053	SNK2147	DKC80-33
Cedara sprayed	7.72	0.396	PAN67	SA7	DKC80-33	SA3
Cedara unsprayed	6.18	0.219	PAN67	DKC80-33	SA3	SA7
Limpopo	2.73	0.323	SA7	PAN6053	SA1	SA3
Loskop	3.51	0.092	PAN6053	SA7	SA1	PAN67
Petit	4.45	0.625	SA7	SA1	SA3	PAN6053
PotchC1	4.78	-0.312	PAN6053	RO413	SA7	SNK2147
PotchC2	3.89	-0.433	PAN6053	SNK2147	RO413	SA7
PotchC3	4.70	-0.034	PAN6053	SA7	RO413	SA1
Potchp1	8.04	-1.537	PAN6053	SNK2147	CAP311	Nelson's Choice
Potchp2	7.96	-1.053	PAN6053	RO413	SNK2147	CAP341NG
VanDerBijlPark	5.36	0.563	SA7	SA1	SA3	PAN6053
Warmbad	2.45	0.032	PAN6053	SA7	SA1	RO413
Wesselsbron	3.20	0.490	SA7	SA1	SA3	PAN67

Table 5 Summary of mean values for agronomic characterstics for 2008/09

Genotypes	lodged %	tillering %	ears plant^{-1}	grain moisture	grain yield (t ha^{-1})
CAP311	10.57	19.00	1.32	14.27	4.90
CAP341NG	8.62	18.63	1.21	14.10	5.08
CG4141	11.76	19.69	1.36	13.20	4.80
DKC80-31	8.16	19.44	1.53	13.00	3.71
DKC80-33	10.12	20.70	1.55	14.29	5.06
Nelson's Choice	11.03	13.56	1.24	15.01	4.82
Nevada	10.48	16.58	1.33	13.79	4.61
PAN6053	9.19	27.27	1.49	14.06	5.75
PAN6671	7.71	16.14	1.42	14.02	4.39
PAN67	12.04	13.01	1.36	15.35	4.95
RO413	9.31	17.28	1.43	16.12	5.18
SA1	7.36	11.89	1.49	13.47	5.34
SA3	6.43	10.06	1.53	13.05	5.19
SA7	8.45	18.94	1.95	14.06	5.59
SNK2147	8.64	16.39	1.34	14.03	5.14
ZM1523	10.54	16.64	1.38	14.86	4.79
Mean	9.40	17.20	1.43	14.17	4.96

CONCLUSION

The results of this project indicated that open-pollinated varieties might be a good alternative to hybrids under low yield potential environments. The results support the argument that OPV's might perform better than hybrids under low input environments. Some of the tested OPV's produced over 5.0 t ha^{-1} indicating the importance of good agronomic management in enhancing yields, even under low input conditions.

REFERENCES

ALBERTS, M.J.A. 2004. A comparison of statistical methods to describe genotype x environment interaction and yield stability in multi-location maize trials. *MSc (Agric.) Thesis*, Department of Plant Sciences (Plant Breeding), Faculty of Agriculture, University of the Free State, Bloemfontein, South Africa.

DU PLESSIS, J.G. & BRUWER, D.DE V., 2000. National cultivar trials for maize, short-growing-season cultivars. Annual Report. 85 pp.

Ma'ali, S.H., 2008. Additive mean effects and multiplicative interaction analysis of maize yield trials in South Africa. *S. Afr. J. Plant Soil* 25, 185 - 193.

OOSTHUIZEN, E., 2005. An evaluation of cultivar stability in ARC maize trials over a six year period. *MSc (Agric.) Thesis*, Department of Plant Sciences (Plant Breeding), Faculty of Natural and Agricultural Sciences, University of the Free State, Bloemfontein, South Africa.

PURCHASE, J.L., 1997. Parametric analysis to describe genotype x environment interaction and yield stability in winter wheat. *PhD Thesis*, Department of Agronomy, Faculty of Agriculture, University of the Free State, Bloemfontein, South Africa.

TOIT, W, DU., 1999. Guide for the production of maize in the summer rainfall area. ARC-Grain Crops Institute.