academicJournals

Vol. 8(1), pp. 1-13, January, 2016
DOI: 10.5897/JDAE2014.0713
Article Number: 479D9C356638
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

An evaluation on the profitability of growing improved maize open pollinated varieties in the Eastern Cape Province, South Africa

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Received 13 June, 2014; Accepted 2 February, 2015

This study examined the profitability of growing Open Pollinated Varieties (OPVs) of maize against hybrids in the Eastern Cape Province, South Africa. Studies have shown that improved OPVs of maize can be a valuable step for smallholder farmers in semi-arid areas as they are relatively drought tolerant when compared to hybrids. Thirteen maize varieties were evaluated extensively by on-farm trials in selected areas under dry land and irrigated conditions. Nine were newly introduced and improved Open Pollinated Varieties (OPVs), while four were locally grown varieties. Among the locally grown varieties, one was a hybrid-check, while the remaining three were improved OPVs. The objective of this study was to assess the profitability of growing improved maize OPVs compared with hybrids. The Gross Margin analysis was employed to compute the gross margins of improved maize OPVs and hybrids. Results show that the hybrid PAN 6479 variety in general performed better than improved maize OPVs across all environments whereas in some areas, the improved maize OPVs had better gross margins and gross profit margins than the hybrid variety. The indicated genotypes however did not show specific adaptation to selected environments. From the results of the study, it could be put into perspective that it would be profitable to grow improved maize OPVs in the Eastern Cape Province by smallholder farmers given that the Province is semi-arid and farmers are resource-poor. On the other hand, hybrids require high-level use of inputs that could be costly for smallholder farmers.

Key words: Gross margins (GM), gross profit margins, hybrids, open pollinated varieties (OPVs), profitability, smallholder farmers.

INTRODUCTION

Maize (*Zea mays*) is a staple food and usually grown by smallholder farmers in South Africa (Mashingaidze, 2006). It is the main diet and also grown as a cash crop by resource poor smallholder farmers (Ebro, 2001). Since

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smallholder farmers in South Africa are resource-poor, they cannot afford to buy hybrid seed. As a result, they tend to grow old open pollinated varieties (OPVs) and other recycled seeds (Mashingaidze, 2006). A hybrid is a cross between crop types such as in maize, in order to maintain purity of F1 (first generation progeny) seed so that high performance is carried through to the commercial product (Sparks, 1992). The cross-pollination in this case, can either be accidental cross, when grown out, or a purposeful cross between two varieties known to produce a certain distinct variety after intensively studying and breeding the parent plants (Iannotti, 2004). Therefore with hybrids, two inbred lines are crossed; resulting in seed and the yield of the plants grown from the seed is greatly increased (hybrid vigour).

An OPV (landrace) on the other hand is a crop variety whose seed is produced by random cross pollination (there is no pollination control) produced by farmer-breeders, as a store of genetic variability, or a resource for breeders looking for specific traits (Brush, 2004). The pollination of the plants in the field is not controlled, which means the crop will not be uniform, for example the crop will vary in plant height, the colour of silks will vary, the cobs will not be the same size and shape and the plants will mature at different times. Open pollinated plants or seeds are also termed as non-hybrid. In the Eastern Cape Province, smallholder maize farmers are constrained by a combination of factors. These major factors are poor soil fertility and low rainfall. Other challenges include the use of inadequate inputs such as seeds, poor adoption and inadequate information on seed varieties, for example, drought tolerant OPVs of maize (Silwana, 2005). Such limitations therefore have implications on food security and sustaining livelihoods. Maize OPVs in some farming systems, particularly where yield is low, studies have indicated that they can be more profitable and sustainable than hybrids (Mashingaidze, 2006). Since 2001, the South African Government's National Department of Agriculture, the Consultative Group on International Agricultural Research (CGIAR) in collaboration with the International Maize and Wheat Improvement Center in Mexico (CIMMYT) have been involved in research to develop new maize varieties (Zhuwakinyu, 2001). The combined efforts have been investigating and developing new improved maize OPVs. As from 2009, these varieties (improved OPVs) have been introduced in the Eastern Cape Province from CIMMYT (Zimbabwe) and International Institute of Tropical Agriculture (IITA). The improved maize OPVs are stress tolerant and it was anticipated that they would be adopted by both dry-land and irrigation farmers because they can do well under low rainfall conditions and low soil fertility areas. Arguments have been raised whether hybrids have an advantage over OPVs for a resource-poor smallholder farmer where unreliable seed availability, low input use and crop failure is common (GrainSA, 2011). The real issue is which variety type; hybrid or OPV is more sustainable in terms of food security and income. Seed is a key input in all crop production and despite the approaches used, no agricultural practice (tillage, cultivation, weeding, irrigation, fertilizer application and pest control) could improve a crop yield beyond the limit set by genetic potential of the seed used (GrainSA, 2011). Therefore, seed becomes the baseline for success or failure of a crop planted. Usually smallholder farmers tend to plant maize saved from the previous harvest because of cash constraints. Such a practice with hybrid maize often reduces yields up to 50% compared to maize grown from fresh seed (GrainSA, 2011). On the other hand, use of saved grain from OPVs does not result in yield loss. According to Kutka (2011) focus by plant breeders has been on the sustainability of improved cultivars, which is a key element among practices used for integrated pest management and other approaches to agricultural sustainability. The major goal is to obtain varieties that are efficient in their use of plant nutrients that result in high-quality product per acre or unit area in relation to cost and ease of production. Again it is important that cultivars are able to withstand harsh conditions of cold or drought or resistance to crop diseases or insect pests.

Studies have shown that growing improved maize OPVs can be a valuable step for smallholder farmers as they can increase yield by 30 to 50% compared to traditional varieties (Ebro, 2001). Other advantages include tolerance to drought, resistance to maize streak virus disease, *turcicum* leaf blight and gray leaf spot (Ininda, 2007). Furthermore, OPV seed can be recycled for up to three years and reduce cost of the seed of OPVs than hybrid seed (MacRobert et al., 2007). A study conducted by Pixley and Banziger (2001) in Zimbabwe concluded that the use of maize OPVs may be more profitable and sustainable than purchasing hybrid seeds. Therefore, the profitability of growing the improved maize OPVs in the Eastern Cape Province against hybrids requires much investigation.

This study assessed the profitability of growing improved maize OPVs against hybrids by smallholder farmers in the Eastern Cape, South Africa during the 2009/2010 farming season. Thirteen maize varieties (nine newly introduced improved OPVs, three locally grown improved OPVs along with a hybrid-check), were evaluated extensively through on-farm trials in selected areas under dry land and irrigated conditions. The varieties from CIMMYT included ZM 305, ZM 423, ZM 501, ZM 525, ZM 621, ZM 627 and Obatanpa and those from IITA were BR 993 and COM P4. The locally grown improved maize OPVs included Afric 1, Okavango and Nelson's choice (Fanadzo, 2009). A description of the materials and methods, and the management of the on-farm trials are discussed below. Among these varieties, a hybrid (PAN 6479) was considered a check variety. Through Participatory Variety Selection (PVS) the varieties were grown on demonstration plots through

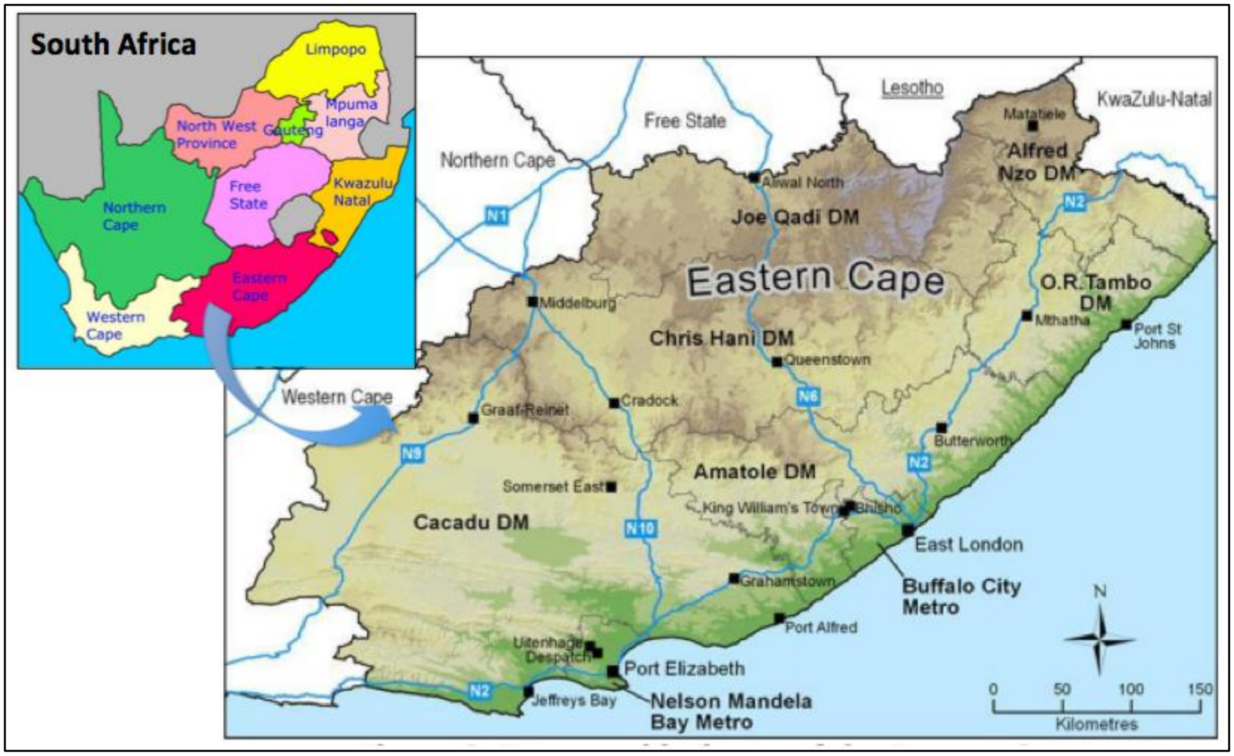

Figure 1. Map of the Eastern Cape Province, South Africa Adapted from Moya-NILU (2013).

partnership with extension services and farmers. Farmer participatory research programs encourage resource-poor farmers to use higher yielding varieties as farmers are able to identify "ideal plant varieties" (Witcombe, 2002). An on-farm yield trial underscores the importance of partnership between farmers and researchers, with the strong support of development workers for wider technology promotion (Abebe et al., 2005). Variety selections by farmers are an important starting point when initiating new varieties within diverse systems (Nkongolo et al., 2008). Using PVS to evaluate farmers' preference and variety adaptation can offer a solution of fitting pre-existing varieties in a multitude of target environments like that exhibited by the Eastern Cape Province.

MATERIALS AND METHODS

Study areas

The study was conducted during the 2009/2010 summer season in two districts in the Eastern Cape Province (Amathole and OR Tambo) of South Africa. Figure 1 shows the map of the Eastern Cape Province. The Amathole and OR Tambo districts were purposively selected because of their geographic and ecological characteristics. Rural Eastern Cape is generally economically deprived. Economic related activities in these areas are mainly based on agricultural activities. Produce includes field crops and vegetables such as maize, potatoes, pumpkins, butternut, dry beans, cabbages, tomatoes, spinach, beetroot, carrot, onion and green pepper. A study done by Monde et al. (2005) shows that the majority of the farming households can be described as low-income and resource-poor households. The majority of the population live in rural areas. Agriculture is mainly subsistence (Musemwa et al., 2008). Agricultural potential varies immensely across the districts due to rainfall distribution and soil characteristics, creating a highly heterogeneous agro-ecology. The specific study sites were Keiskammahoek [Silwindlala Women's Project (SWP)] and Zanyokwe Irrigation Scheme (ZIS) that fall under the former Ciskei homelands and Gogozayo, Jixini, Mkhwezo and Mqekezweni which all fall under the former Transkei homelands. These areas were purposefully selected by an agronomic team because of their agricultural potential, cropping history, geo-climatic and soil characteristics and consultation with ward extension officers. The Amatole district generally represents low rainfall patterns and soils generally tend to be shallow (less than 1 m in depth), poorly drained, highly erodible, poor quality and inherently low fertility (Van Averbeke, 1991). Both SWP and ZIS have irrigation to supplement the low rainfall. However, the O.R. Tambo District is generally favorable to crop farming (Manona, 2005) in terms of rainfall and the soils are of numerous doleritic intrusions generated from the Karoo Dolerite. The soils are strongly structured red or black clay soils that are prone to erosion (Catuneanu et al., 2005).

Keiskammahoek and Zanyokwe both fall under the Amahlati Local Municipality of the Amathole District. Keiskammahoek is located about 35 km west of King William's Town (SAexplorer, 2009) and Zanyokwe Irrigation Scheme is located about 30 km west of King William's Town (Monde et al., 2005). The climate for both areas is temperate to warm and sub-humid. Rain falls predominantly in the summer months with June and July being the driest months. The annual average summer rainfall for Keiskammahoek and Zanyokwe Irrigation Scheme is about 647 and

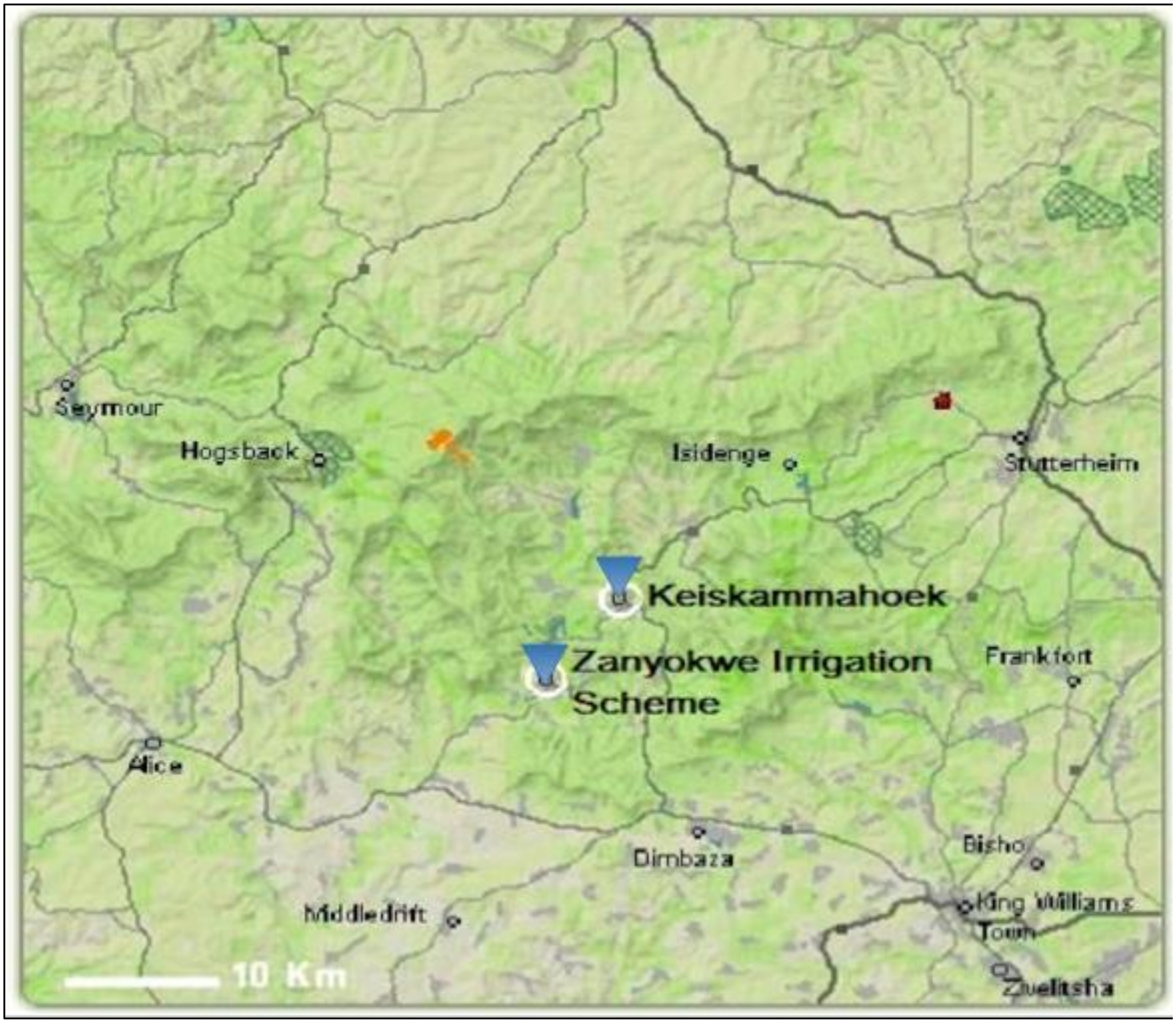

Figure 2. Map showing location of Keiskammahoek (SWP) and Zanyokwe Irrigation Scheme (ZIS) Adapted from: SAexplorer, 2009.

590 mm per annum, respectively. Both sites have Irrigation to supplement the inadequate rain.

In the O. R. Tambo District Municipality, Gogozayo represents an average potential agricultural areas with an average annual rainfall of about 800 mm and Jixini, Mkwezo and Mqekezweni represents the high potential agricultural areas with an average annual rainfall of more than 800 mm. Figure 2 and 3 shows the location of Keiskammahoek and the Zanyokwe Irrigation Scheme (Former Ciskei) and the location O.R. Tambo District Municipality study sites (former Transkei).

Field trials

This study was part of a broader study that evaluated stress tolerant open pollinated maize varieties in selected environments of the Eastern Cape Province in South Africa by agronomists at the university of Fort Hare. Thirteen maize varieties were evaluated by on-farm trials in selected areas under dry-land and irrigated conditions. Nine were newly introduced and improved Open Pollinated Varieties (OPVs), while four were locally grown varieties. Among the locally grown varieties, one was a hybrid-check, while the remaining three were improved OPVs. Table 1 summarizes the characteristics of maize varieties included in the participatory yield trials.

Plot sizes and location

The experiments were laid out as a randomized complete block design (RCBD). Gross plot size was 5 m × 4.5 m with a total of 5 m long rows. The net plots consisted of three middle rows. The two outside rows were considered as discards or border rows. Plant spacing was 0.9 m between rows and 0.3 m within the row for a target population of 37 000 plants/ha. The exact location of the plots were in the study sites SWP, ZIS, Gogozayo, Jixini, Mkwezo

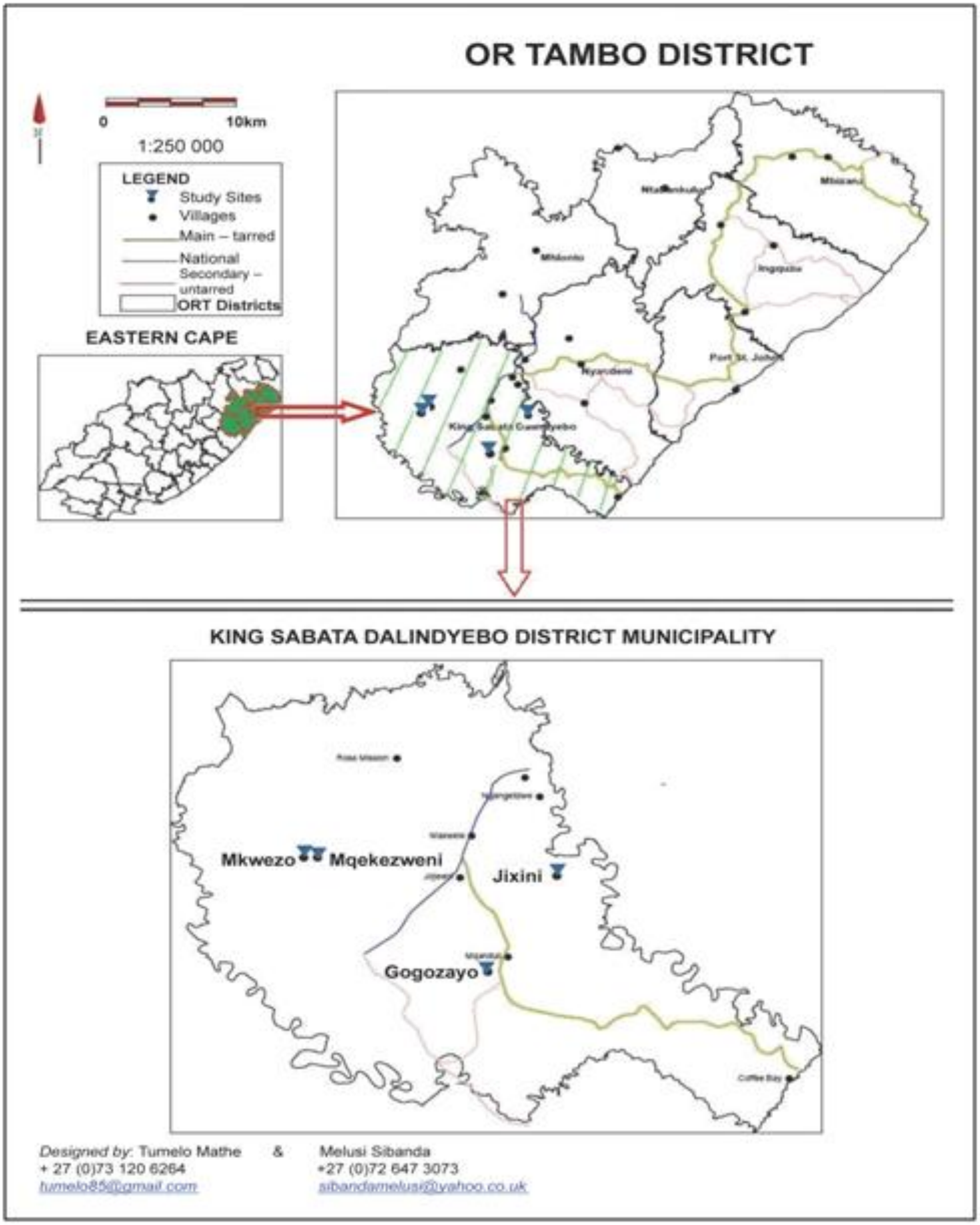

Figure 3. Location of the study sites in O. R. Tambo District Municipality. Source: Sibanda and Mathe (2010).

and Mqekezweni as shown by the latitudes and longitudes in Table 2. Table 2 also summarises the other characteristics such as altitude, annual precipitation and soil classification in the study areas.

Management

The on-farm trials were conducted using a Participatory Variety Selection. According to Chimonyo (2011) citing Odendo et al.

Table 1. Characteristics of maize varieties included in the participatory yield trials.

Variety	Origin	Seed colour	Type	Maturity	Yield potential (t/ha)
ZM 305	CIMMYT- Zim	White	OPV	E	2-4
ZM 423	CIMMYT- Zim	White	OPV	E	2-6
ZM 501	CIMMYT- Zim	White	OPV	E - M	2-6
ZM 525	CIMMYT- Zim	White	OPV	E - M	2-6
ZM 621	CIMMYT- Zim	White	OPV	M	3-6
ZM 627	CIMMYT- Zim	White	OPV	M	2-5
BR993	IITA- Ghana	White	OPV	L	2-5
COMP 4	IITA- Ghana	White	OPV	L	2-5
Obatanpa	CIMMYT- Zim	White	OPV	M – L	2-5
AFRIC 1	Nelson‘s Genetics-SA	White	OPV	M	1.5 - 6
Okavango	Capstone-SA	White	OPV	L	4 - 5
Nelson‘s Choice	Nelson‘s genetics-SA	White	OPV	M – L	4 - 5
Pan 6479[2]	PANNAR	White	Hybrid	M	5 -10

Characteristics of maize varieties. Source: Chimonyo, 2011. Maturity class in terms of days to 50% flowering in low altitudes: Early (E), 60-65; Medium (M), 65-70; Long (L), 70 -75; 2, check variety; Zim, Zimbabwe; SA, South Africa.

Table 2. Location of trials and characteristics in terms of altitude, average annual rainfall and soil classification).

Location	Latitude	Longitude	Altitude (m)	Annual average rainfall (mm)	Soils (FAO system[2]
ZIS	32°45’S	27°03’E	525	673.2	Lixisols
SWP	32°40’S	26°8’E	459	481.4	Lixisols
Gogozayo	31°51’S	28°44’E	1089	829.3	Lixisols
Jixini	31°43’S	28°50’E	643	918.7	Luvisols
Mkwezo	31°42’S	28°30’E	842	882.1	Acrisols
Mqekezweni	31°42’S	28^{0}°30’E	986	882.1	Lixisols

[2] World Reference base soil classification systems Source: Chimonyo, 2011.

(2002) smallholder farmers generally have to deal with variable environments, which greatly affect the choice and selection of maize varieties. Here farmers consider yield, yield stability and adaptation to agronomic management techniques (Odendo et al., 2002; Witcombe, 2002). A range of objectives often results in the use of a large number of varieties by individual farmers. According to Witcombe (2002), in order to encourage low-resource farmers to adopt higher yielding varieties, farmer participatory research can be used to identify farmers’ ideal plant varieties. During the research, the needs of farmers were established by identifying what varieties they could grow, and what traits they considered important. Interaction with farmers enables scientists to select new varieties that have the traits of farmers desire and that match the farmers' landraces for important characters such as maturity, plant height and seed type. Farmer participation in the selection of pre-existing crop varieties for smallholder farming conditions helps to ensure acceptance and eventual adoption as stipulated by Sperling et al. (1993). The researchers measured farmers’ satisfactions towards a variety by involving the farmers. Farmers gave detailed information on desirable agronomic traits and post-harvest traits. Due to the different socio-economic differences exhibited by farmers within a single location, criteria for selecting different genotypes differ. It has been observed by numerous researchers that farmers evaluate varieties for multiple traits, and do not place an overriding emphasis on grain yield (Nkongolo et al., 2008). For the purpose of this study, production costs (total variable costs) and yield (total value product) were measured for the computation of gross margins and gross profit margins that can be used as an indicator for profit by a farm enterprise.

Data collection

Primary data

Generally, smallholder farmers lack detailed record keeping on their farm operations and, as a result, information gathered is unreliable in exploring and relating performance of maize in farmers field (Fanadzo et al., 2009). For computing gross margins and the profitability of producing maize OPVs against hybrids, data was collected from on-farm trials that were conducted through Participatory Variety Selection explained. Therefore, detailed crop budgets for all the thirteen maize varieties were captured, based on variable costs and yields from the on-farm trials in the study sites. On the on-farm trials, farmers were actively involved in planting, applying fertilizer, recording keeping and demonstrations on cob size and palatability up to the final stage of the plant breeding process. Data collected from the on-farm trials for the purpose of this study included:

1. Yield per hectare - treated as a proxy for the Gross value of Production (GVP) calculated by using the value of maize per ton in

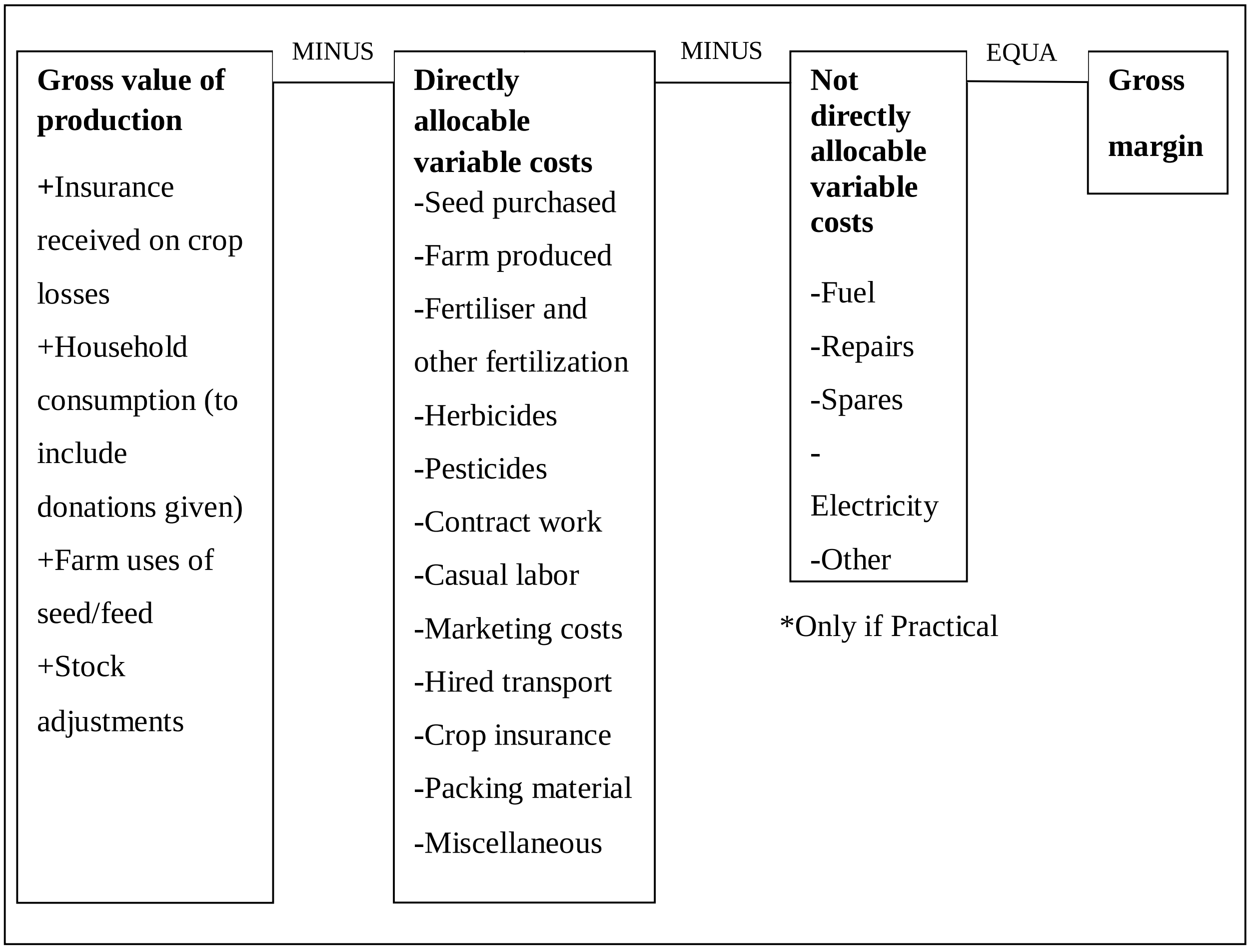

Figure 4. Gross margins of an enterprise. Source: Directorate of Agricultural Information Services (2005).

2011 market prices.
2. Quantities of seeds, fertiliser, chemicals (herbicides and pesticides) used per hectare, labour days per hectare (weeding, shelling and bird scaring).
3. Costs of contract work (labour) per hectare per day, tractor hiring per hectare, shelling and bird scaring.

Secondary data

Secondary data used on the computation of gross margins such as maize prices per ton and the costs of seeds, fertiliser, chemicals (herbicides and pesticides) used per hectare were obtained from the following sources: United States Department of Agriculture (USDA) website, Department of Agriculture, Forestry and Fisheries (DAFF), input supply companies and product markets (*see appendix*). Additionally, library based research was conducted. Sources of such information include journals, books, Internet and government documents.

Data analysis

Gross margin analysis

A gross margin for a crop is the sales revenue obtained from the crop sold minus the direct costs of producing it (Buckett, 1988). The direct costs are variable costs that increase or decrease based upon the quantity produced. The overhead is a group of expenses that remains fixed despite the quantity produced. Figure 4 is an illustration of how the gross margin of an enterprise is determined.

Gross margins = Revenue - Direct costs (variable costs) (1)

In simple terms, the gross margin of an enterprise is gross income less than the total variable costs. Gross income is a product of physical production measured in tones at current market price. Total variable costs are mainly a summation of operational costs that vary with changes in scale of operation, to include most of the inputs like fertilizers, seed, chemicals, transport, labor and land preparation. Equation 2 shows a simple mathematical expression of gross margin for an enterprise:

Gross margin = (GI – TVC) (2)

Where, Gross Margin = Gross margin measured in terms of the Rand, GI = Gross income measured in terms of the Rand and TVC = Total variable costs measured in terms of the Rand

The gross margins have the advantage of making express analysis that can be used by farmers to determine which crops to produce given several alternatives (Karen, 2006). Gross margins are simple to use and present simple calculations. A gross margin makes it possible to assess the market effectiveness of a crop. Calculating gross margins requires price information of all the inputs for a particular production and the quantity required per unit area (gross margins can be calculated for an acre or a hectare). Comparative analysis of gross margin data on the types of crops produced allows the smallholder farmer to establish the most efficient type of crop to produce (Karen, 2006). A smallholder farmer having figures of gross margins at his disposal is able to take motivated managerial decisions on economic development under market conditions.

Gross profit margin

However, a comparison of gross margins alone has the disadvantage of not showing the profit obtained by each enterprise. Comparing the gross margins gives a picture of an enterprise that provides a farmer with the most income after removing the costs. An enterprise's cost of sales represents the expense related to labor, raw materials and manufacturing overhead involved in its production process. This expense is deducted from net sales/revenue, resulting in a gross profit (Loth, 1999). A gross profit margin is gross margin expressed as a percentage or in total financial terms or the ratio of gross profit to cost of goods sold (Farris et al., 2010). The gross profit margin is used to analyze how efficient an enterprise is using its raw materials, labor and manufacturing related fixed assets to generate profits. A higher margin percentage is a favorable profit indicator.

$$\text{Gross profit margin} = \frac{\text{Gross profit} \times 100\%}{\text{Net sales (Revenue)}} \quad (3)$$

In computing the gross margins and gross profit margins, it was assumed that maize is sold immediately after harvesting; therefore, there were no storage loss. Since most smallholder farmers produce for subsistence, marketing costs after harvesting were not incurred. A list of prices used and a sample template used for the computation of the Gross Margins are presented as Appendix 1 and 2, respectively. Average yield, mean gross income, mean gross margin and mean gross profit margins per hectare for the 13 maize varieties were computed using data from the on-farm yield trials. The maize varieties included 12 maize OPVs (Afric1, BR 993, COM P4, Nelson's choice, Obatanpa, Okavango, ZM 305, ZM 423, ZM 501, ZM 525, ZM 621 and ZM 627) and a hybrid-check (PAN 6479).

RESULTS AND DISCUSSION

Gross margins and gross profit margins per hectare were computed from the on-farm trials for each cultivar planted. Gross profit margin is a metric that defines the percent profit that a farm enterprise makes for every rand of yield produced as already discussed. Therefore in this study, gross profit margins were used as the basic unit of analysis in evaluating enterprise viability. Gross profit margins vary significantly in enterprises. Although, there is no standard or average gross profit margin for small businesses such as the case for smallholder farmers, according to Morgan and Media (2014) many small businesses or enterprises operate within the parameters of having between a gross profit margin of 25 and 35%. For the purpose of this study, a positive gross margin reflects a profit and a negative gross margin reflects a loss. A positive gross profit margin or above zero simply reflects that a farmers can be able to break-even. Table 3 shows the average yields, gross margins and gross profit margins per hectare of the 13 genotypes (varieties) obtained across different environments (irrigated and rain-fed) during the 2009/2010 season. Results show that yields potential and performance of maize varied in different environments. SWP and ZIS were regarded as a low potential areas based on rainfall averages and soil types. However, there is irrigation to supplement the low annual rainfall in these two areas. At SWP, the hybrid PAN 6479 gave gross margins and gross profit margins of R462.80 and 0.08 GM/R100 per hectare, respectively. The other genotypes (improved maize OPVs) produced negative gross margins and gross profit margins indicating a loss. The poor performance of varieties in SWP can be attributed to problems that were reported by farmers such as damage by birds (picking seeds, damage seedlings, eating of flower buds, destroying flowers, pecking holes in maize cobs) and thieves stealing maize cobs (green mealies). In ZIS, again PAN 6479 showed gross margins and gross profit margins of R5550.29 and 0.49 GM/R100 per hectare, respectively. It ranked highest in terms of gross margins and gross profit margins as compared to the improved maize OPVs.

In O.R. Tambo study sites (Jixini, Mkwezo and Mqekezweni) were regarded as high potential areas since they were favorable in terms of rainfall except Gogozayo, which was ranked on an average potential area. In Jixini and Gogozayo, PAN 6479 showed a higher gross margin and gross profit margins than the improved maize OPVs. In Jixini, the gross margin and gross profit margins were R6952.29 and 0.54 GM/R100 per hectare, respectively. However, there was a slight difference in gross profit margin between PAN 6479 and the improved maize OPV ZM 525 that also showed a high gross margin and gross profit margin of R6059.42 and 0.50 GM/R100 per hectare, respectively, in Jixini. The gross margin and gross profit margins of PAN 6479 in Gogozayo were R3455.79 and 0.37 GM/R100 per hectare respectively. The gross profit margins of PAN 6479 in Gogozayo were almost twice that of the improved maize OPV that ranked second (Nelson's choice which had a gross profit margin of 0.18 GM/R100 per hectare. Mkwezo and SWP are both sites where the gross margin and gross profit margin is very low in all the varieties. In these areas the gross profit margin for both the hybrid PAN and the improved maize OPVs in most cases is negative. In Mqekezweni, the improved maize OPVs Nelson’s choice and ZM 525 outperformed all the other varieties including the hybrid PAN 6479. These varieties came first with gross margins and gross profit margins of R9666.92 and 0.62 GM/R100 (ZM 525) and 9671.66 and 0.61 GM/R100 (Nelson’s choice) per hectare.

Generally, the results show that the highest yielding variety across all environments was PAN 6479 (4.617 t/ha) followed by ZM 525 (4.5 t/ha), ZM 305 (4.191 t/ha),

Table 3. Gross margins and gross profit margins of 13 genotypes obtained across different environments during the 2009/2010 season per ha^{-1}.

Variety	SWP (Low Potential)			ZIS (Low Potential)			Gogozayo (Average Potential)			Mkwezo (High Potential)			Jixini (High Potential)			Mqekezweni (High Potential)		
	Yield ($t\ ha^{-1}$)	GM	GM/ R100	Yield ($t\ ha^{-1}$)	GM	GM/ R100	Yield ($t\ ha^{-1}$)	GM	GM/ R100	Yield ($t\ ha^{-1}$)	GM	GM/ R100	Yield ($t\ ha^{-1}$)	GM	GM/ R100	Yield ($t\ ha^{-1}$)	GM	GM/ R100
PAN 6479 (Hybrid-check)	3.26	462.8	0.08*	6.01	5550.29	0.49*	5.04	3455.79	0.37*	2.58	-1095.21	-0.23	6.93	6952.29	0.54*	7.49	7988.29	0.58
Nelson's Choice	2.21	-1646.34	-0.4	4.63	2830.66	0.33	3.97	1309.66	0.18	3.19	-133.34	-0.02	5.02	3252.16	0.35	8.49	9671.66	0.61*
Obatanpa	2.81	-1889.34	-0.49	3.42	3678.96	0.39	2.97	1417.96	0.19	3.94	-1024.04	-0.2	4.69	4673.96	0.43	6.23	8632.96	0.58
ZM 423	2.08	-1889.54	-0.49	5.09	3678.96	0.39	4.03	1417.96	0.19	2.71	-1024.04	-0.20	5.79	4673.96	0.43	7.93	8632.96	0.59
ZM 627	2.73	-763.55	-0.15	4.69	2862.45	0.33	3.48	323.45	0.05	2.53	-1433.55	-0.31	5.65	4338.45	0.42	8.1	8870.95	0.59
BR 993	2.03	-1974.84	-0.53	3.87	1429.16	0.19	2.96	-554.34	-0.10	3.44	333.66	0.05	4.26	1850.66	0.24	5.8	4699.66	0.44
COM P4	2.85	-408.34	-0.08	4.75	3106.66	0.35	3.63	734.66	0.11	2.66	-1059.84	-0.22	4.7	2714.16	0.31	6.25	5581.66	0.48
AFRIC 1	1.7	-2675.34	-0.85	3.85	1302.16	0.18	4.24	1723.66	0.22	3.27	-70.84	-0.01	6.06	5090.66	0.45	5.42	3906.66	0.39
ZM 621	2.93	-353.94	-0.07	3.68	1033.56	0.15	3.36	141.56	0.02	2.28	-1856.44	-0.44	5.73	4526.06	0.43	6.8	6505.56	0.52
ZM 525	2.72	-707.58	-0.14	4.43	2455.92	0.29	3.54	509.42	0.08	3.44	324.42	0.05	6.54	6059.42	0.50*	8.49	9666.92	0.62*
ZM 501	2.53	-1071.45	-0.23	4.07	1777.55	0.24	3.57	552.55	0.08	3.2	-131.95	-0.02	5.22	3605.05	0.37	7.86	8489.05	0.58
ZM 305	2.55	-972.35	-0.21	5.02	3597.15	0.39	3.16	-143.85	-0.03	3.47	429.65	0.07*	5.03	3315.65	0.36	8.15	9087.65	0.60
Okavango	1.76	-2608.44	-0.80	4.73	2886.06	0.33	3.64	569.56	0.09	2.53	-1483.94	-0.32	5.91	4769.06	0.44	6.54	5934.56	0.49

* Indicates the variety with the highest gross margin and gross profit margin per site. Yellow , highest performing varieties (gross profit margin > 35%); Orange , average performing varieties (gross profit margin between 25% and 35%); Blue , low performing varieties (gross profit margin >0% but less than 25%) and Red , Negative gross profit margin < 0%). Highlighted areas show the overall performances of variety.

ZM 627 (4.177 t/ha) and ZM 423(4.143 t/ha) and their yields were not significantly different from each other. The lowest yielding variety was BR 993, with a mean yield of 3.440 t/ha. These findings concur with Gouse et al. (2006), Kogbe and Adediran (2003) and those of Masood et al. (2003) who conducted field trials on hybrids and OPVs in both dry-land and irrigated areas. Their findings suggested that hybrid maize gave higher yields than other varieties. This can be attributed to the fact that hybrids use nitrogen (from fertilizers) more efficiently as compared to maize OPVs (Masood et al., 2003). However, other studies such as Machado and Fernandes (2001) suggest that in marginal conditions (drought, heterogeneous environments), hybrids may not perform so well as compared to OPVs. Differential yield performance of genotypes could be explained by the differences in the climatic conditions (Nakitandwe et al., 2005). These findings, therefore, emphasis the importance of recommending genotypes with good yields and gross profit margins to farmers producing maize in different climatic conditions. The differences in yield performance and gross profit margins observed in the genotypes could have been due to the difference in their genetic structure and morphological characteristics. The observed performance of early maturing (ZM 305, ZM 501, ZM 423), and medium maturing (ZM 627) OPVs could be attributed to the intensive screening for tolerance to various stress conditions that they receive. It is noted that when irrigation can be provided, hybrid is always the best performing variety (Figure 5). In terms of gross profit margins were irrigation farming was practiced, the hybrid PAN 6479 performed better than improved maize OPVs. The other genotypes of improved maize OPVs under irrigation farming showed low performance and some OPVS showed negative gross profit margins indicating a loss. Instead, when there is no irrigation; maize OPVs showed positive gross margins in most cases under rain-fed conditions. However, due to the experimental design one may not conclude so strictly because hybrids and OPVs do not have the same agronomic characteristics and are bound to perform differently. From these results, it could be put into perspective that the production of hybrid maize by smallholder farmers under high level potential fields that are under irrigation could be

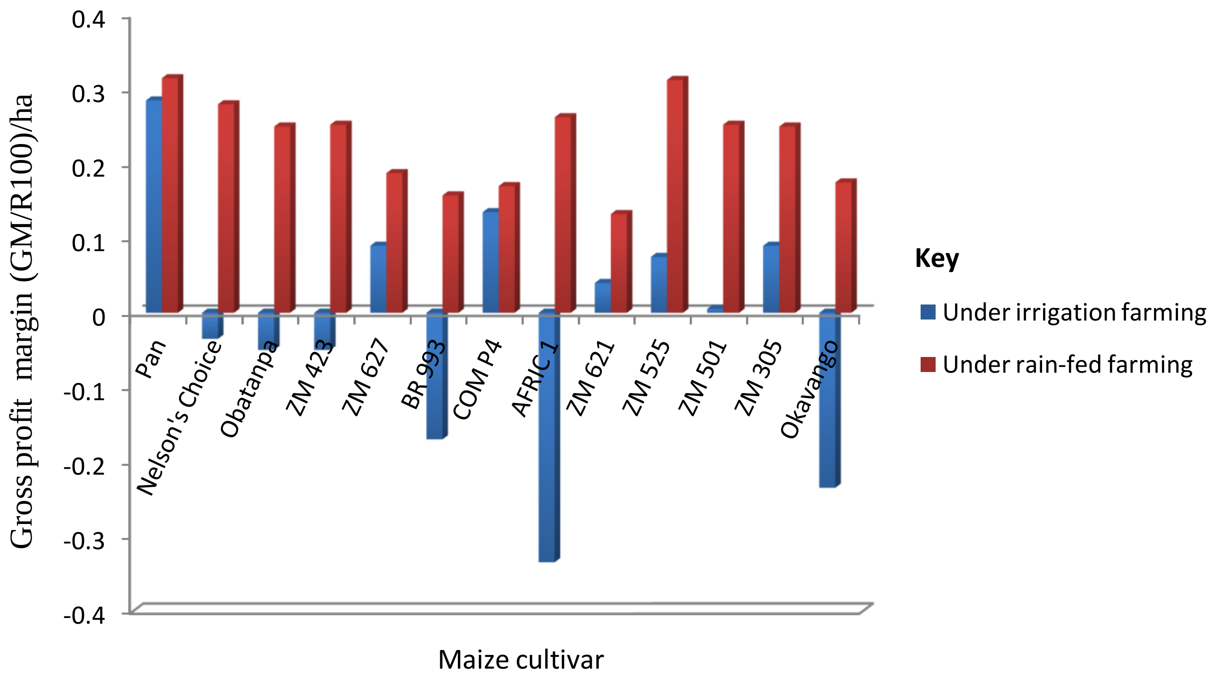

Figure 5. Average gross profit margins of cultivars under irrigation and rain-fed conditions.

profitable than the production of maize OPVs.

On the other hand, in resource-poor, low input systems under marginal conditions were farmers can not afford irrigation farming, such as is the case with most smallholder farmers in the Eastern Cape Province, the improved maize OPVs may be a better option. Findings by Serpolay-Besson et al. (2014) suggested that maize OPVS have an inherent genetic diversity with a strong potential of evolution and thus can adapt to new conditions when subjected to mass selection especially in organic and low input systems. Such a characteristic in maize OPVs given the drought prone conditions of the Eastern Cape Province can be an advantage. Beside, the improved agronomic performance, improved maize OPV seeds can be recycled for two to three years, which means farmers will not have to buy seeds every planting season as compared to hybrids. This can reduce total variable costs; given the cost of hybrid maize seed (Gouse, 2006); instead, costs of buying seeds may be channeled to other priorities (inputs) such as buying fertilizer, which may in turn improve the yields, and thus total gross income will increase. According to Chimonyo (2011) citing van Wijk (1994) hybrid seed is more expensive because its production is technically more complex than that of OPV seed. For example, the cost of OPV seeds on average costs about R25 per kg, whilst the same amount of hybrid seed costs, on average, R36 (*see appendix*). Hybrid seed is therefore generally more expensive than OPV seed. With high costs associated with hybrid seeds would suggest that farmers who purchase and grow hybrid seed yearly, may not be able to break-even. This is especially true if the cost of labour is to be factored in and, fertilizers and agro-chemicals are to be purchased as noted by Pixley and Banziger (2001). Again hybrids require more inputs to produce, and have a lower land output efficiency rate than OPV seed (Chimonyo, 2011). However, recommending which variety to be adopted by farmers based on one season's data can sometimes be misleading because seasons fluctuate. Data averaged over a number of seasons will be more dependable.

Future research design

This study used average yield data for the growing season 2009 to 2010 to compute gross margins and gross profit margins. This might mean, it is a bit pre-mature to judge their performance. In future, a yield average over a longer period of about three to five years may be used to ascertain if there are any changes in terms of performance and profitability due to different rainfall patterns or any other factors. Because hybrids and OPVs do not have the same agronomic characteristics and are bound to perform differently, in order to improve the experimental design, future trials should take into account of different management testing for example, in each site, in the irrigated areas, irrigated and non-irrigated trials should be conducted, and same remark for inputs: in a given place, trials with high level of inputs and low level of inputs should be conducted together in order to better compare performances (given that hybrids are better adapted to high inputs systems and OPV to low input systems). Again in future experimentation, instead of one hybrid check, two or more hybrid checks can be used.

Conclusions

Generally, across different environments, varieties performed differently and did not show specific adaptation to specific environments. PAN 6479 (a hybrid) generally showed better performance than the improved maize OPVs across all environments except in Mqekezweni in O.R. Tambo. In Mqekezweni, where the improved maize OPVs, Nelson's choice and ZM 525 had higher gross margins and gross profit margins. These varieties came first with gross margins and gross profit margins of R9666.92 and 0.62 GM/R100 (ZM 525) and 9671.66 and 0.61 GM/R100 (Nelson's choice). Generally, production of hybrid maize by smallholder farmers in the Eastern Cape Province remains more profitable more particularly in the Amatole District (SWP and ZIS) that are under irrigation. Farmers with irrigation, under good management levels (weeding and fertilizer application) hybrids yield and perform better than maize OPVs. In other areas, improved maize OPVs also performed well and in some cases there was a slight difference in terms of yield and profitability as compared to hybrids. The findings may suggest that the newly introduced improved maize OPVs may be profitable for the smallholder farmers taking into account that hybrids require high level management and its high costs associated with fertilizer and chemical components. Cheaper, open-pollinated maize varieties, that are recyclable and more tolerant to low-input conditions, could be better suited to smallholders' needs and practices.

Recommendations

Generally, smallholder farmers in the Eastern Cape Province are characterized by low incomes (Monde et al., 2005). This suggests that, they are resource-poor and may not have extra income to acquire the necessary farm inputs and implements. Therefore, the use of the new improved maize OPVs can be a better option for them, especially ZM 525, ZM 305, ZM 627 and ZM 423 varieties that proved to be high yielding and showed high gross margins and gross profit margins. These improved maize OPVs can be recycled for two to three years and even maybe adapt to the specific location and practices of the farmers if some selection is done, unlike the hybrid varieties. This means the farmers will not have to buy seeds every planting season. This can reduce the total costs of buying seeds and the money saved may be channeled into buying inputs such as fertilizer and other farm implements that can enhance the yields and thus the total farm gross income. Generally, farmers do not have knowledge or information on the newly introduced improved maize OPVs (CIMMYT, 2007). Therefore, there is need for government to improve information provision for example through extension services and improvements in infrastructure such as communication, roads and networks. By so doing, farmers can become well informed about new technologies and innovations and the gains associated with their use. On the other hand, innovators (seed companies) can easily access the farmers and establish seed production centers in rural areas. Such efforts can facilitate wide spread use of new innovations such as the improved maize OPVs.

There are a significant number of maize producers in South Africa. As a result there is increased competition in the industry. The government can offer programs such as the provision of subsidies to smallholder farmers willing to produce maize that can empower them to become sustainable and competitive like commercial farmers. A market exists for the production of maize in the Eastern Cape Province taking into account that there are other farmers involved in livestock farming such as dairy farming schemes for example the Fort Hare Dairy Trust that operates on a commercial level basis. Therefore, maize grain that can be produced from the production of improved maize OPVs can also be marketed to livestock farmers. Therefore, farmers can bolster their incomes and thus improve their income levels. Participatory Plant Breeding programs could also be developed in order to increase farmers' empowerment about seed production and selection (seed autonomy).

Improved maize OPV production in the Eastern Cape Province can be coupled with other smallholder agricultural projects such as piggery, cattle fattening and poultry (chicken rearing). Farmers producing maize and at the same time doing other projects such as livestock farming may not necessarily need to buy livestock feeds. This can be an advantage to the farmers. Generally, unemployment levels in the rural areas of South Africa and the Eastern Cape are wide. Increased production of maize farming along with these other agricultural projects (livestock farming) may mean creation of employment opportunities.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

Much gratitude and appreciation goes to Technology Innovation Agency (TIA) for providing support to this research.

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APPENDIX

List of prices used in the computation of gross margins and gross profit margins

The selling price of maize/tons as of October 2011- R1850.00 (United States Department of Agriculture (USDA), 2011). The average price for tractor hiring to plough 1 ha - R600.00. The seed costs of the varieties (taken from purchasing receipts) were as follows:

PAN 6479 (White hybrid) - R36.00 per kg
Afric 1- R32.58 per kg
Okavango - R36.99 per kg
Nelson's Choice - R24.03 per kg

The prices of the newly introduced improved maize OPVs were based on the maturity range, when compared with maize OPVs that are on the market as follows:

Obatanpa - R24.03 per kg (early maturing)
ZM 423 - R24.03 per kg (early maturing)
ZM627 – R32.58 per kg (late maturing)
ZM 621 – R32.58 per kg (late maturing)
ZM 525 - R24.03 per kg (early maturing)
ZM 501 - R24.03 per kg (early maturing)
ZM 305 – R24.03 per kg (early maturing)
COM P4 – R32.58 per kg (late maturing)
BR 993 - R32.58 per kg (late maturing)

The prices of fertilizers (taken from purchasing receipts) were as follows:

LAN 28 % - R20.00 per kg
Compound 2:3:4 - R27.20 per kg

The buying price of Chemicals (taken from purchasing receipts):

Herbicides-Pre-emergent (Alachlor) - R 44.75 per liter
Post-emergent (Atrazine) - R36.20 per liter
Post-emergent (Basagram) - R91.60 per liter

The buying price of: Insecticide (taken from purchasing receipts):

Cut worm (dusban) - R78.80 liter
Maize stalk borer (Dusban) - R78.80 liter
Hygromix – R5 per kg
Gramoxone R47.25 per liter
Hydrogro R13.20 per kg
Fastac R189.00 per liter
Erase R 35.60 per liter

Contract work: Planting, herbicide and insecticide application, irrigation, weeding, harvesting, Shelling and bird scaring was each R50 per worker per day for 9 labor days per site.