Vol.16(2), pp. 80-xxx April-June 2024
DOI: 10.5897/JAERD2024.1411
Articles Number: 019AB0872232
ISSN: 2141-2170

http://www.academicjournals.org/JAERD

Journal of Agricultural Extension and Rural Development

Full Length Research Paper

Performance evaluation of three selected dryland maize cultivars under different agronomic practices in the Amahlathi Local Municipality, Amathole district, Eastern Cape: A synergetic approach

Azile Dumani*, Simphiwe Mhlontlo, Sibongiseni Silwana, Tembakazi T. Silwana and Awonke Sonandi

[1]Department of Rural Development and Agrarian Reform, Döhne Agricultural Development Institute, Stutterheim, Eastern Cape, South Africa.

Received 10 April, 2024; Accepted 15 May, 2024.

Despite the availability of numerous genetically improved maize cultivars, farmers in the Amahlathi Local Municipality (ALM) frequently grow locally available and inexpensive cultivars due to financial constraints and lack of agronomic skills and knowledge, resulting in low maize productivity. Consequently, an on-farm experiment was conducted in Donqaba village to evaluate the performance of three selected dryland maize cultivars under different agronomic practices in terms of yield. The experiment involved three dryland maize cultivars (PAN 5R590BR, PAN6R710BR, OKAVANGO) and two agronomic practices: farmer cropping practices (FP) (standard farmer practices) and recommended agronomic practices (RP) (application of fertilizers and lime based on soil analysis results and recommendations). The treatments were arranged in a randomized complete block design (RCBD) with three replications. The results revealed that farming systems play a crucial role in improving maize yield. The recommended RP showed a positive improvement in maize yield. The PAN6R710BR maize hybrid performed better in numerous yield attributes compared to OKAVANGO. The interaction between PAN6R710BR and RP significantly improved maize yield. This indicates that concerted efforts by various actors in the agricultural industry can enhance the quality of advice provided by extension practitioners to farmers, thereby improving rural livelihoods and food security in the rural communities of the Eastern Cape. The study recommends adopting a synergetic approach to encourage the regular transfer of technical skills and dissemination of information to the farming community through organized workshops and field trainings. Extension practitioners should encourage resource-limited farmers to apply agro-production inputs based on recommended quantities from soil analysis to achieve optimum maize yield.

Key words: Cultivar, maize, yield, recommended, agronomic, practices, farmer, extension.

INTRODUCTION

Maize (*Zea mays*) is a widely grown crop in most parts of the world due to its adaptability and productivity (Verma et al., 2021; Salami et al., 2007). The crop thrives across different soil types and climatic conditions in eastern and southern Africa (Nyamangara et al., 2011). In communities where hunger and starvation are prevalent, maize serves as a major staple food for people and is a crucial component of animal feed (Ayoola and Makinde, 2007). Its utilization has increased rapidly due to the growing human population, leading to significant demand. Consequently, some agro-ecological conditions where maize is grown are marginally suitable for its cultivation (Nyamangara et al., 2011).

In the Eastern Cape Province (ECP), maize is a dominant crop grown by smallholder farmers primarily for subsistence purposes, with some surplus being sold in local markets (Silwana, 2000; Mafu, 2006). However, maize yields have declined since the 1930s (Mandikiana, 2011). The average yield under dry-land conditions was 636 kg ha^{-1} in 1927, whereas it dropped to an estimated 189 kg ha^{-1} in 1998 (Anderson and Galt, 1998). Several factors linked to agronomic practices influence maize yields in specific agro-climatic environments (Tandzi and Mutengwa, 2019). Major challenges causing yield decline include reduced soil production potential due to low infiltration rates, soil compaction, and low organic carbon content (Mnkeni and Mkile, 2006). These conditions can be attributed to monoculture practices and continuous cropping of the same cultivars, even if their performance is poor, resulting in low yields and minimal financial returns (Solontsi, 2013).

Other constraints contributing to yield losses include inadequate fertilizer application rates, unavailability of improved seeds, and high labor costs (Cassman, 2016). Mandiringana et al. (2005) also attributed yield decline to soil acidity (pH < 5.5) in some regions due to high rainfall (> 600 mm p.a.), necessitating best production practices with regular liming to maintain maximum crop productivity. Additionally, financial constraints and a lack of knowledge and skills in crop production lead small-scale farmers to omit critical production practices such as the recommended application of fertilizers and lime to reduce production costs (Haynes and Mokolobate, 2001).

The Amahlathi Local Municipality is among the areas in the Eastern Cape Province with potential for maize production based on climatic and edaphic factors. However, production is dominated by small-scale farmers who lack knowledge and skills (Sigigaba et al., 2021). Therefore, a synergistic approach involving researchers, extension practitioners, and seed manufacturers was employed to uplift small-scale maize producers through on-farm research studies. These studies aimed to address challenges encountered by farmers and provide evidence-based advice and recommendations. The objectives of this study are: i) To evaluate the performance of three selected dry-land maize cultivars grown under different agronomic practices; and ii) To determine the best production practice and provide evidence-based recommendations for successful maize production in the Amahlathi region.

MATERIALS AND METHODS

Experimental sites

On-farm experiment was conducted at Donqaba village [S32°44'41.915" E27 °28' 56.281"] situated in the South Eastern parts of Stutterheim, Amahlathi Local Municipality (ALM), Amathole District, Eastern Cape, South Africa (Figure 1). Donqaba is amongst the areas in the ALM with potential for grain production due to its good rains and soils and the farmers in this village participate and are the beneficiaries in the maize cropping programme, a food security programme of the Department of Rural Development and Agrarian Reform (DRDAR) that seeks to alleviate poverty and food insecurity in rural communities of the Eastern Cape.

Plant (Cultivar selection)

Three cultivars of maize (*Zea mays*.) consisting of two hybrids namely; PAN 5R590BR, PAN6R710BR and an open pollinated variety (OPV) namely; OKAVANGO were used in this experiment. These yellow maize varieties are commonly grown for both human consumption and livestock feeding by rural small-scale farmers in Donqaba village in Amahlathi local Municipality, Eastern Cape. The two certified seeds of these cultivars such as PAN5R590BR and PAN6R710BR were donated for the experiment by the seed manufacturing company called PANNAR and the OKAVANGO seed was sourced from the seed retail in Stutterheim.

Treatments and experimental design

A 3×2 factorial experiment was conducted during the summer of the 2020-21 cropping season. The first factor was the cultivars, and the second factor was the production practices. The three levels of the first factor were three dry-land maize cultivars (PAN 5R590BR, PAN6R710BR, OKAVANGO). The two levels of the second factor were agronomic practices: farmer cropping practices (FP) (the farmer's standard practices) and recommended agronomic practices (RP) (application of fertilizers and lime based on soil analysis results and recommendations). The treatments were arranged in a randomized complete block design (RCBD) with three replications. Main plots comprised three dry-land maize cultivars, while sub-plots comprised two production practices. Each plot consisted of six rows measuring 20 m in length, with inter-row and intra-row spacing of 0.9 and 0.5 m, respectively, resulting in a plant population of 30,000 plants/ha. Each plot size was 20 × 6 m = 120 m^2. Paths of 2 m between plots and replicates were llocated, making the total experimental area 2160 m^2. This area was sufficient to accommodate agricultural extension activities such as hosting farmer's days for technology transfer.

Corresponding author E-mail: aziledumani@gmail.com.

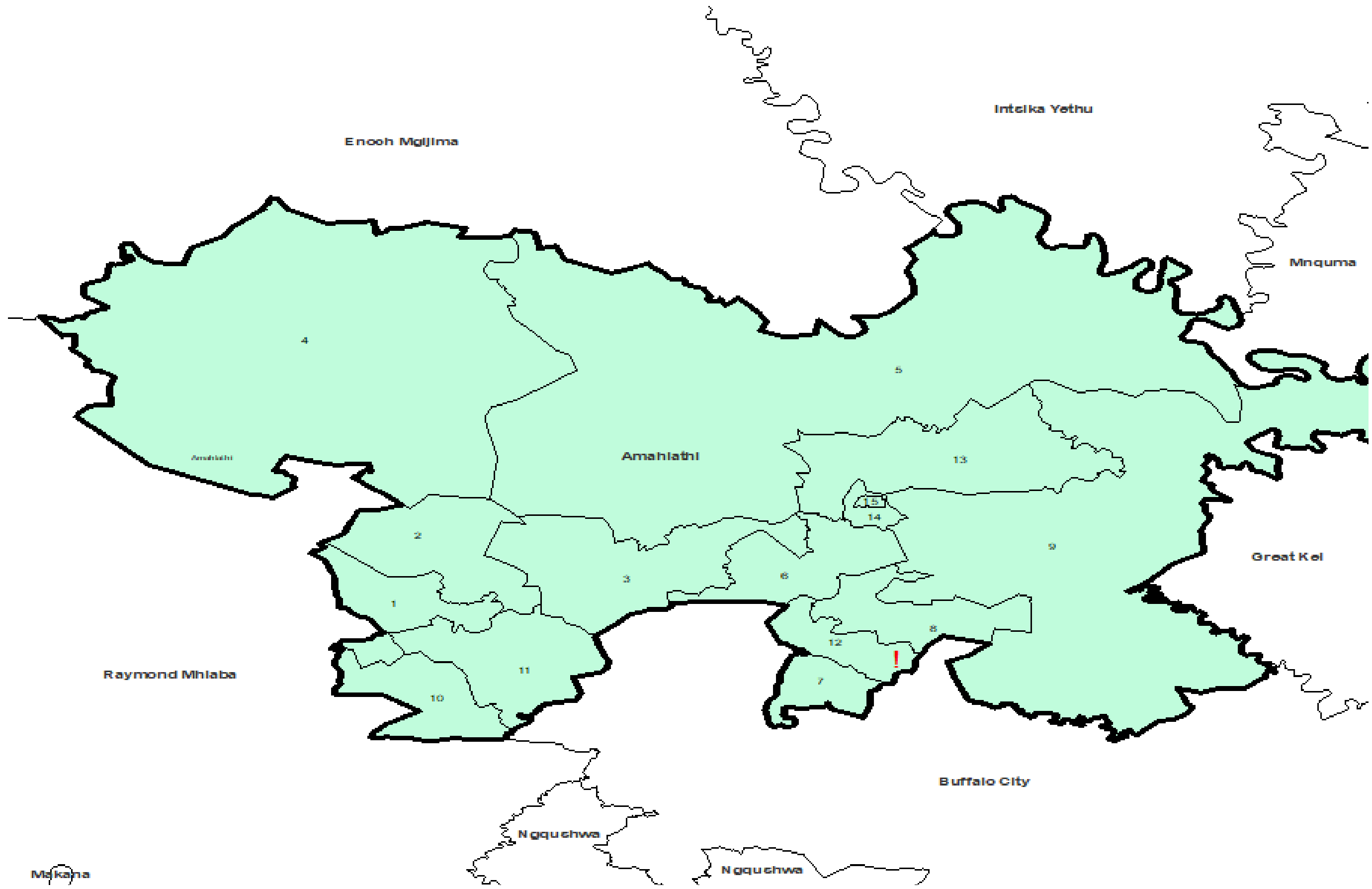

Figure 1. Locality Map of Amahlathi Local Municipality showing Frankfort village.

Agronomic practices

Prior to planting soil samples were collected in respective field and analysed to determine the basal nutrients composition at Dohne Analytical Laboratory, Stutterheim, Eastern Cape. The experimental site was ploughed and disk tilled prior to planting to achieve a good fine seedbed. On plots that were marked for RP treatments, the lime was applied in respective plots three (3) weeks prior planting based on laboratory recommendations. However, herbicide was applied on the site at least two weeks prior to planting for control of existing weeds. Post emergence herbicides were applied 2 weeks after emergence. Topdressing was done using LAN 28% at 21 days after emergence. On plots allocated for FCP treatments fertilizer was applied following the rule of thumb 200 kg/ha of *NPK 2:3:4 (30) + ZN,* no liming and LAN 28% topdressing, no post emergence weedicide were applied. Pest and disease control was done when the need arises during the season in all treatments.

Data collection

Yield parameters

At physiological maturity, when the grain moisture content is at 12.5%, the crop was harvested to determine the yields in $kgha^{-1}$. Whereby, 5 ears will be randomly sampled from each replicate to determine the ear length, number of rows ear^{-1} and number of kernels**.** Number of ears per plant per cultivar will also be determined. Grain yield: The samples were oven dried at a constant temperature of 60°C to obtain the constant grain moisture of 12.5%. The grain weight per 1000 kennels was determined. The yield was then calculated using the following formula modified by Sapkota et al. (2016):

Yield (kg/ha) = [(number of kernel rows per ear-1 × number of ears m^{-2} / 100) × (weight of 1000 - kernel (g) / 1000) × 10,000]

Data was analyzed using GenStat 2016 software and the means was separated using Fischer's LSD test at $p = 0.05$.

RESULTS AND DISCUSION

Performance of cropping practices on yield and yield attributes of maize

The results (Table 1) indicate that the cropping practices had a significant influence on the measured yield and yield attributes of maize namely; number of ears $plant^{-1}$, number of rows ear^{-1} and the yield ha^{-1}. The maize grown

Table 1. Performance of cropping practices on yield and yield attributes of maize.

Treatment	No. of ear/plant	Ear length (cm)	No. of rows ear-1	No. of Kennels/row	Grain mass/1000 kennels (g)	Yield/ha^{-1}
FP	1.844[b]	16.14	13.4a	34.76	333	2.71[a]
RP	2.322[a]	17.02	13.9b	35.54	310	3.63[b]
Mean	2.083	16.58	14	35.15	322	3.17
CV (%)	21.7	15.1	3.4	11.6	22.1	34.8
P Value	0.01*	0.24	0.05*	0.62	0.31	0.01*

FP stands for farmer cropping practices and RP represent recommended agronomic practices. Values in a column followed by a different letter are significantly different at P≤ 0.05. p value: probability value. * indicate significance level at 0.05 probability level.

Table 2. The performance of cultivar on yield and yield parameters of different selected dryland maize cultivars.

Treatment	No. of ear/plant	Ear Length (cm)	No. of rows (ear^{-1})	No. of Kennels/row	Grain mass/1000 kennels (g)	Yield/ha^{-1}
PAN6R710BR	1.850[b]	17.50[a]	14.93[a]	39[a]	302.4[a]	3.333[a]
PAN5R590BR	2.683[a]	15.71[a]	13.33[b]	32.88[b]	331.4[a]	3.750[a]
OKAVANGO	1.717[b]	16.53[a]	13.17[b]	33.57[b]	331.0[a]	2.418[b]
Mean	2.1	16.6	13.8	35.2	322	3.17
CV (%)	21.7	15.1	3.4	11.6	22.1	34.8
P Value	0.001*	0.157	0.001*	0.016*	0.513	0.006*

Values in a column followed by a different letter are significantly different at P≤ 0.05. p value: probability value. * indicate significance level at 0.05 probability level.

under the recommended agronomic practices (RP) has significantly performed better compared to the maize grown under the farmers cropping practices (FP). Sanaullah et al. (2020) reported that recommended farming practices had a positive effect on maize yield. Exposing farmers to different farming practices and the adoption of recommended farming systems has improved their crop yields (Zhang et al., 2021). Yield is a complex trait that greatly interacts with the cropping practices and the environment at which the crop is produced (Butron et al., 2004).

The performance of different selected maize cultivars on yield and yield attributes of maize

Table 2 shows that cultivar performance significantly (p≤0.05) affected the yield and yield attributes of maize, with the exception of ear length and grain mass parameters. The PAN 5R590BR cultivar produced the highest number of ears per plant (2.683), significantly different from the OKAVANGO cultivar, which had the lowest number of ears per plant. The highest number of rows per ear (14.93) was obtained from the PAN 6R710BR cultivar, significantly different from all other cultivars. The lowest number of rows per ear (13.17) was observed in the OKAVANGO cultivar, which was not significantly different from the PAN 5R590BR cultivar.

Muthaura et al. (2017) found a maximum number of grain rows per cob (16) in hybrid maize

Table 3. Interactions between the cultivar and the cropping practice on production and yield parameters of the selected dryland maize cultivars.

Cultivar	Treatment	No. of ear/plant	Ear length (cm)	No. of rows (ear^{-1})	No. of Kennels	Grain mass/1000 kennels	Yield/ha^{-1}
PAN6R710BR	FP	1.600^{d}	16.92^{a}	14.27^{b}	38.77^{ab}	313.2^{a}	2.633^{cd}
	RP	2.100^{bc}	18.08^{a}	15.60^{a}	39.23^{a}	291.6^{a}	4.033^{a}
PAN5R590BR	FP	2.533^{ab}	15.45^{a}	13.67^{c}	32.80^{c}	352.2^{a}	3.633^{abc}
	RP	2.833^{a}	15.97^{a}	12.00^{d}	32.97^{bc}	310.5^{a}	3.867^{ab}
OKAVANGO	FP	1.400^{d}	16.07^{a}	12.00^{d}	32.70^{c}	333.8^{a}	1.853^{d}
	RP	2.033^{bc}	17.00^{a}	13.33^{cd}	34.43^{abc}	328.3^{a}	2.983^{bc}
Mean		2.083	16.58	14	35.15	322.0	3.17
CV (%)		14.7	8.8	2.3	9.2	15.0	17.5
p Value		0.649	0.928	0.001*	0.907	0.812	0.210_

Values in a column followed by a different letter are significantly different at P≤ 0.05. p value: probability value. FP stand for Farmer Cropping Practices and RP represent Recommended Agronomic Practices. * indicate significance level at 0.05 probability level.

seeds and a minimum number of grain rows per cob (13) in open-pollinated variety (OPV) maize seeds. Similarly, the PAN 6R710BR cultivar produced the highest number of kernels per row (39), significantly higher than the other cultivars. The highest yield per hectare was obtained from the PAN 5R590BR cultivar (3.750 tons/ha), followed by the PAN 6R710BR cultivar (3.333 tons/ha), both of which were significantly the same. The lowest yield per hectare was observed in the OKAVANGO cultivar.

Qian et al. (2016) reported that maize hybrids attained an average yield increase of 17.9 g per plant per decade, corresponding to an increase of 936 kg/ha per decade over the period from 1970 to 2010 in Northeast China. Furthermore, Badu-Apraku and Akinwale (2011) stated that newly developed maize hybrids show the highest yields compared to open-pollinated cultivars and possess characteristics that enable them to withstand various conditions.

Interactions between cultivar and cropping practice on yield and yield attributes of the selected dryland maize cultivars

Table 3 shows that the interaction between cultivar and the cropping practice did not differ significantly (p≤ 0.05) on yield attributes and the yield of the selected dry-land maize cultivars with the exception of number of rows which was significantly different. The potential yields of maize take into account several physiological components such as kennel moisture content, number of cobs per plant, kennel weight and ear length (Tandzi and Mutengwa, 2019). Although insignificant the highest number of ears $plant^{-1}$ (2.833) were obtained in PAN5R590BR when grown under recommended agronomic practice (RP), followed PAN6R710BR (2.533) grown under the farmer cropping practices (FP) and were not significant to each other. While the lowest number of $ears/plant^{-1}$was obtained in AKHOVANGO (1.400) grown under the farmer cropping practices (FP) and was significantly different to others with the exception of PAN6R710BR (1.600) when grown in RP. The longest ear^{-1} (18.08 cm) was obtained when PAN6R710BR was planted under the RP and the similar trends were observed with regards to number of $rows^{-1}$ (15.60), $Kennels^{-1}$ (39.23) and the $yield^{-1}$ (4.033 ton^{-1}). Tandzi and Mutengwa (2019) reported an increase of yield per plant, resulting from an increase in number of kernels per ear and an increased 1000 kernel weight under appropriate agronomic practices. Moreover, PAN6R710BR (15.60-14.27) produced the highest number of $rows^{-1}$ irrespective of the cropping practice and was significantly different to all others. Whilst the PAN5R590BR (12) RP and AKHOVANGO (12.3) FP produced the lowest number of $rows^{-1}$ and were significantly the same compared to others. Irrespective of the cropping practice the cultivar PAN6R710BR produced significantly higher number of kennels. Ghimire et al. (2016) reported that a hybrid maize variety perform better compared to the open pollinated maize variety in both improved farming practice and farmers practice of cultivation with maximum grain yield ranging at from (3.17 to 7.25 t/ha). Although not significant PAN5R590R produced the highest grain mass (352.2 g) followed by AKHOVANGO (333.8 g) all grown under FP and the lowest grain mass was obtained in PAN6R710BR (291.6 g) grown in RP. Subsequently,

Plate 1. Experimental layout and planting with the farmers.

Plate 2. Field tour session.

PAN6R710BR (4.033 tha^{-1}) produced the highest yield followed closely by PAN5R590BR (3.867 tha^{-1}) all grown in RAP, whereas the lowest was obtained from AKHOVANGO (1.85 tha^{-1}) grown in FP and was significant different to all others. The results are at par with Ali et al. (2017) who reported relatively higher yield increments when the appropriate fertilization rates and agronomic practices are adopted.

Extension and technology transfer

The farmers were involved in all the stages of the research, from pre-planting, post planting activities and until to the harvesting and termination of experiment (Plate 1). This was done to expose the farmers to practicality of adhering to recommended agronomic practices (Plate 1). According to Lyimo et al. (2014) farmers do not use improved maize production practices due to lack of technical knowledge, high cost of genetic improved seed, and limited extension services (technology transfer). Technology transfer was achieved through an organized field day (Plate 2) and information sharing session (Plate 3) to practically educated and familiarizes the farmers with the performance of maize plant under different agronomic practices. It is necessary to involve farmers as active participants in the generation and conduction of recommended technological practices (Sanaullah et al., 2020). The maize producing farmers from all dimensions of Amahlathi local municipality eye witnessed the importance of cultivar selection and adherence to recommended agronomic practices. Involvement and practical education affect the adoption of new technologies, attitude of individual farmers towards the adoption of improved farming practices can be changed through practical education (Aziz et al., 2018).

Conclusion

This study indicated that farming systems or practices

Plate 3. Information session.

play a crucial role in the improvement of maize yield. The recommended agronomic practices (RP) showed significant positive yield improvement. The cultivar PAN6R710BR maize hybrid performed better in numerous yield attributes compared to the OKAVANGO open-pollinated maize cultivar, which is commonly planted by the small-scale farmers of the Amahlathi region. The interactions between PAN6R710BR and the RP showed significant yield improvement in maize within the Amahlathi local municipality. This indicates that coordinated efforts by different actors in the agricultural industry will enhance the quality of advice rendered by extension practitioners to farmers, leading to improved rural livelihoods and food security in rural communities of the Eastern Cape.

The study recommends the regular transfer of technical skills and dissemination of information to the farming community through organized workshops and on-field training. Extension practitioners should encourage resource-limited farmers to apply agro-production inputs based on recommended quantities from soil analysis to attain optimum maize yield.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Ali F, Ahsan M, Ali Q, Kanwal N (2017). Phenotypic stability of Zea mays grain yield and its attributing traits under drought stress. Frontiers in plant science 8:269808.

Anderson N, Galt K (1998). The Wild Coast SDI: community needs and views of development, 1997 baseline. CIET International, Bisho.

Ayoola OT, Makinde EA (2007). Fertilizer treatment effects on performance of cassava under two planting patterns in a cassava-based cropping system in South West Nigeria. Research Journal of Agriculture and Biological Science 3(1):13-20.

Aziz R, Siddiqui BN, Ali J, Ali A, Fahmid S, Raza Q, Akram, MAA (2018). Relationship between socio-economic aspects of farmers and their awareness and adoption of short agricultural messages telecast on PTV. International Journal Advanced Research and Biological Science 5(1):25-33.

Badu-Apraku B, Akinwale RO (2011). Cultivar evaluation and trait analysis of tropical early maturing maize under Striga-infested and Striga-free environments. Field Crops Research 121(1):186-194.

Butron A, Velasco P, Ordas A, Malvar RA (2004). Yield evaluation of maize cultivars across environments with different levels of pink stem borer infestation. Crop science 44(3):741-747.

Cassman KG (2016). Long-term trajectories: crop yields, farmland and irrigated agriculture. Economic Review Special 2016:21-46.

Ghimire S, Sherchan DP, Andersen P, Pokhrel C, Ghimire S, Khanal D (2016). Effect of variety and practice of cultivation on yield of spring Maize in Terai of Nepal. Agrotechnology 5(144):2.

Haynes RJ, Mokolobate MS (2001). Amelioration of Al toxicity and P deficiency in acid soils by additions of organic residues: a critical review of the phenomenon and the mechanisms involved. Nutrient cycling in agroecosystems 59:47-63.

Lyimo S, Mdurum Z, De Groote H (2014). The use of improved maize varieties in Tanzania.

Mafu N (2006). The economic viability of substituting kraal manure for chemical fertilizer in small-scale maize production in the former Transkei region of the Eastern Cape. M.Sc. Dissertation. University of Fort Hare, Alice, South Africa'.

Mandikiana BW (2011). The economics of Bt maize/yieldgard production: case of smallholder farmers in the Eastern Cape Province.

Mandiringana OT, Mnkeni PNS, Mkile Z, Van Averbeke W, Van Ranst E, Verplancke H (2005). Mineralogy and fertility status of selected soils of the Eastern Cape Province, South Africa. Communications in Soil Science and Plant Analysis 36(17-18):2431-2446.

Muthaura C, Mucheru-Muna M, Zingore S, Kihara J, Muthamia J (2017). Effect of application of different nutrients on growth and yield parameters of maize (*Zea mays*), case of Kandara Murang'a County. ARPN Journal of Agricultural and Biological Science 12(1):19-33.

Mnkeni PNS, Mkile Z (2006). Characterisation of kraal manure and optimisation of its use as fertiliser in the eastern Cape Province. Smallholder farming and soil fertility management in the eastern Cape, South Africa.

Nyamangara J, Makarimayi E, Masvaya EN, Zingore S, Delve RJ (2011). Effects of soil fertility management strategies and resource endowment on spatial soil fertility gradients, plant nutrient uptake and maize growth at two smallhoder areas, north-western Zimbabwe. South African Journal of Plant and Soil 28:1-10.

Qian C, Yu Y, Gong X, Jiang Y, Zhao Y, Yang Z, Hao Y, Li L, Song Z, Zhang W (2016). Response of grain yield to plant density and

nitrogen rate in spring maize hybrids released from 1970 to 2010 in Northeast China. Crop Journal 4(6):459-467.
Salami AE, Adegoke SAO, Adegbite OA (2007). Genetic variability among maize cultivars grown in Ekiti-State, Nigeria. Middle-East Journal of Science Research 2(1):9-13.
Sanaullah Pervaiz U, Ali S, Fayaz M, Khan A (2020). The impact of improved farming practices on maize yield in Federally Administered Tribal Areas, Pakistan.
Sapkota TB, Jat ML, Jat RK, Kapoor P, Stirling C (2016). Yield estimation of food and non-food crops in smallholder production systems. Methods for measuring greenhouse gas balances and evaluating mitigation options in smallholder agriculture pp.163-174.
Solontsi M (2013). The Response of Maize to Selected Ratios of Organic fertilizers Mixed With Inorganic Fertilizers in Ndlambe Local Municipality, Eastern Cape, South Africa (Doctoral dissertation, Nelson Mandela Metropolitan University).
Sigigaba M, Mdoda L, Mditshwa A (2021). Adoption drivers of improved Open-Pollinated (OPVs) maize varieties by smallholder farmers in the Eastern Cape province of South Africa. Sustainability13(24):13644.
Silwana TT (2000). The performance of maize/bean and maize/pumpkin intercrops under different planting combinations and weeding in Transkei, South Africa. MSc. Dissertation. University of Fort Hare, Alice, South Africa.
Tandzi NL, Mutengwa CS (2019). Estimation of maize (*Zea mays L*.) yield per harvest area: Appropriate methods. Agronomy 10(1):29.
Verma HS, Sisodiya DB, Zala MB, Patel MB, Patel JK, Patel KH, Borad PK (2021). Evaluation of indigenous materials against fall armyworm, *Spodoptera frugiperda* (JE Smith) in maize. Pharmacological Innovative Journal 10:398-404.
Zhang S, Wang H, Sun X, Fan J, Zhang F, Zheng J, Li Y (2021). Effects of farming practices on yield and crop water productivity of wheat, maize and potato in China: A meta-analysis. Agricultural Water Management 243:106444.