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Research Article

Evaluation of the yield performance of maize cultivars (Zea mays L.) in a Semi-Arid Region of the Eastern Cape Province in South Africa

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Abstract

Maize is considered as one of the important grain crop in the world. Maize is in high demand within district because it is one of the staple food and also used for animal feed. Current yield attained by small scale farmers is lower than the potential of our existing varieties. In field experiment at Njizweni situated in Gqeleni sub-district was conducted in November 2018 to evaluate the agronomic and yield performance maize cultivars in a semi-arid environment. Plant population, plant height, leaf area, number of cobs/plant, cob length, number of grains per cob, 100 grain weight and number of cobs were significantly different ($p<0.05$) between cultivars. There was no significant difference ($p>0.05$) on maize grain yield although maximum number of cobs per plant (1.76) was recorded on PAN 6R-710BR, PAN5R-591R, BG 5285 and WE 6208B.

Introduction

Maize or corn (*Zea mays* L.) is the mostly produced food worldwide and is the third most important cereal crop of the world after wheat and rice [1]. It is a staple food in South Africa for 70% of its population [2] and most smallholder farmers depend on the production of maize for their food security and livelihood [3]. It is projected that by 2050, maize production will double to meet the growing demands of human and animal consumption, and biofuel production, particularly in developing countries [4]. The adaptation properties of maize make it a viable crop in a variety of climate zones [5]. It is grown throughout South Africa under a variety of conditions including dry and rain-fed environments [6]. Small-scale farmers primarily cultivate maize in the Eastern Cape Province for subsistence purposes and surpluses are typically sold to surrounding communities (Mandikiana, 2011). It is an important component of food security in the province [7]. It is also a source of nutrients as well as phytochemical compounds such as carotenoids, phenolic compounds and phytosterols which play an important role in preventing chronic diseases [8]. Furthermore, maize products contribute significantly to South African nutrition - 35% of the carbohydrates, 15% of the fat, and 31% of the protein requirements of the South African diet are met by maize products directly. Among the South African population, white maize is the staple food, whereas yellow maize is used primarily in animal feed.

Baloyi, et al. [9] report that yields are between 1.8 and 3.5 tonnes per hectare in small-scale farm. In the rest of sub-Saharan Africa, small-scale farmers report average yields of 1.25 tonnes per hectare against a potential of 7 tonnes per hectare [10,11] noted that weed problems, insect pest attacks, poor plant population, insufficient fertilizer and selection of cultivars that are unsuitable for a given set of environmental conditions are the main constraints to increasing maize productivity. In addition to enhancing grain yield, the adoption of suitable high yielding cultivars will increase income per hectare, compared to conventional varieties of maize [12]. Due to the falling yield potential of some locally grown open pollinated varieties, selecting good varieties with high prospects and wide range of acceptability

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is of utmost importance. Beyond tolerance to abiotic and biotic stresses, more ear-bearing plants per unit land area without a reduction in kernels per ear are likely the reason for high yields in modern hybrids.

Adoption of improved maize varieties in the study region vary widely among small scale farmers due to socioeconomic factors, including inaccessibility of farm inputs and credit, poor agronomic management (especially low fertilizer application, suboptimal or untimely weeding, late planting, and low plant population) and poor market access for smallholder farmers [3]. Most cultivar evaluation trials in South Africa is conducted under irrigation in controlled experimental stations and there is no report of on farm performance of different maize hybrids under small holder farmers' conditions. It is crucial to study genetic gains under farmers' conditions to monitor the efficiency of varietal turnover. The superior performance of these new maize hybrids evaluated under researcher-managed on-station conditions needs to be verified under on-farm smallholder farmers' conditions, as farmers are the ultimate users of the new maize hybrids. Farmer participatory research programs encourage resource poor farmers to use higher yielding varieties as farmers are able to identify ideal plant varieties" [13]. 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 [14]. In consideration of this, the present study is aimed at comparing the production potential of different maize hybrids in Ngqeleni sub-district so as to choose a hybrid which is best suited for high yield.

Materials and methods

In the Ngqeleni sub-district, an experiment was conducted to determine the performance of different maize varieties under local conditions. Experimental site lies at 31˚46'43''S and 29˚54'52''E. An experiment was conducted using three replications of Randomized Complete Block Design (RCBD). The net plot size of the study was 5m x 5m. Crop was sown on 20th November 2018, with intra row spacing of 30 cm and inter row spacing of 100 cm. Fertilizer was applied to maize crop at a rate of 90 kg N, 45 kg P and 60 kg K per ha in all plots. All the P, K and a third of the N fertilizer was applied at planting as a compound (6.7% N; 10% P; 13.3% K + 0.5% Zn) and the rest (60 kg) as Limestone Ammonium Nitrate (LAN) at 6 weeks after planting by banding. In all treatments, gaps were filled and thinning was performed after germination to control plant populations. Agricultural practices were uniformly carried out throughout all treatments. On July 25, 2019, the crop was harvested. Field data on plant population, height, number of ears per plant, number of grains per ear, cob diameter, grain length, 100-grain weight, ear affected by maize weevil, and grain yield were collected and analyzed statistically. Analysis of variance techniques were used as a way to carry out the statistical analysis as outlined by Gomez & Gomez (1984). The analysis of variance (ANOVA) was performed using JMP version 13.1 (SAS Institute Inc.). Significant difference was identified at P<0.05. Correlation analyses was done to determine the relationships between maize yield and plant population. Significant differences were identified at $p \le 0.05$.

Results and discussion

Maize hybrid differed significantly ($p<0.05$) for plant height. Different cultivars of plants have different heights that are genetically and environmentally determined. Significantly the maximum plant height (224 cm) was recorded in PAN5R-591R followed by P2823WB. The minimum plant height (173 cm) was observed in PAN 6R-710BR. These findings are in agreement with those of Tahir [10] and Ali [15] who also found differences in plant heights among hybrids. This was due to the fact that plant height is a genetically controlled factor so the height of different varieties does not remain equal. Cultivars had no significant effect on leaf area. The maximum leaf area (880.38 cm^2) was observed in WE 6208B and minimum (596.21 cm^2) recorded in PAN5R-591R. Cultivar PHB33442 had the maximum (20.0 cm) significant effect on cob length and WE 6208B recorded the lowest (15.33 cm) cob length. Besides genetics, environmental and nutritional factors are also factors that can influence the number of cobs per plant. The greater the number of cobs per plant, the greater the grain yield. A significant difference in the number of cobs per plant is evident from the Tables 1,2. Maximum number of cobs per plant (1.76) was recorded in PAN 6R-710BR, PAN5R-591R, BG 5285 and WE 6208B. Minimum number of cobs per plant (1.0) was found in Phb33H54BR, P2137, PHB33442, PAN6R880CBT and WE 6207B. Efendi, et al. [16] found that the percentage of plants that have more than one ear or prolific were significantly influenced by varieties and spacing. There is a direct relationship between grain yield and number of kernels per cob. The analysis of the data revealed that all cultivars affected the number of grains per cob in a significant way. Maximum number of grains per cob (684.0) was found in PAN6R880CBT which differed significantly from all other cultivars. Minimum number of

Table 1: Growth parameters.

Treatments	Plant population	Plant height (cm)	Leaf area (cm^2)	Cob length (cm)
Phb33H54BR	96.33^{a}	202^{abcd}	722.88^{a}	17.17^{bc}
BG 5285	92.33^{ab}	214^{ab}	718.50^{a}	18.50^{ab}
PAN 4A111	89.00^{abc}	208^{abcd}	675.79^{a}	18.67^{ab}
P2137	88.00^{abc}	210^{abc}	694.63^{a}	18.17^{ab}
PHB33442	87.00^{abc}	206^{abcd}	768.38^{a}	20.00^{a}
WE 6210B	87.00^{abc}	209^{abcd}	685.02^{a}	19.17^{ab}
PAN6R880CBT	86.33^{abc}	184^{cde}	675.79^{a}	17.83^{abc}
WE 6207B	86.33^{abc}	188^{bcde}	707. 75^{a}	17.83^{abc}
PAN 6R-710BR	85.00^{abc}	173^{e}	790.28^{a}	17.33^{bc}
P2432R	84.67 ^{abc}	197^{abcde}	612.03^{a}	19.33^{ab}
PAN 6Q-245	84.67^{abc}	181de	812.73^{a}	18.17^{ab}
SC 701	84.67^{abc}	195^{bcde}	813.13^{a}	17.50^{abc}
PAN5R-591R	84.00^{bc}	224^{a}	596.21^{a}	17.50^{abc}
WE 6208B	83.67^{bc}	190^{bcde}	880.38^{a}	15.33^{c}
PAN 6R-680R	83.33^{bc}	190^{bcde}	684.55^{a}	19.67^{ab}
PAN 1745R	80.00^{c}	187^{bcde}	725.48^{a}	18.83^{ab}
P2823WB	79.33^{c}	217^{abc}	741.75^{a}	17.83^{abc}
CV %	8.31	8.53	25.91	8.48

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grains per cob (403.67) was found in SC 701. In all grain crop research, the ultimate goal is to maximize the grain yield. A number of other factors such as plant density, cob size per plant, and grains per row are important in determining grain size. So an increase or decrease in any of the above factors may influence the crop yield. Although no significant effect of cultivars was observed on grain yield, data in the table indicated that PAN6R880CBT recorded maximum (6.17) grain yield whilst PAN 6R-680R had the minimum (5.05) grain yield. Maize grain yield was negatively correlated to plant population (Figure 1). According to our findings, higher planting density reduced grain size, number of grains per row, and number of grains per plant, similarly to Lemcoff and Loomis [17]. Increasing the plant population beyond optimal levels leads to extreme competition between plants for soil water and nutrients, as well as photosynthesis photon flux density. Sher, et al. [18] also stated that high plant population density can cause reduced leaf area index and photosynthetically active radiance (PAR) interception which plays a role in photosynthesis and kernel formation [19-21].

Table 2: Yield parameters.

Treatments	No. of cobs/plant	No. of grains/cob	Grain yield (tons/ha)
Phb33H54BR	1.00[c]	541.00[cd]	5.81[a]
BG 5285	1.67[ab]	567.67[cd]	6.01[a]
PAN 4A111	1.50[abc]	602.33[abc]	5.76[a]
P2137	1.00[c]	595.00[bc]	5.99[a]
PHB33442	1.00[c]	490.33[d]	5.78[a]
WE 6210B	1.17[bc]	533.33[cd]	5.50[a]
PAN6R880CBT	1.00[c]	684.00[a]	6.17[a]
WE 6207B	1.00[c]	540.33[cd]	5.52[a]
PAN 6R-710BR	1.76[ab]	653.33[ab]	5.70[a]
P2432R	1.33[abc]	673.67[ab]	5.81[a]
PAN 6Q-245	1.67[ab]	556.63[cd]	5.38[a]
SC 701	1.17[bc]	403.67[e]	5.43[a]
PAN5R-591R	1.83[a]	498.00[d]	5.23[a]
WE 6208B	1.67[ab]	546.33[cd]	5.91[a]
PAN 6R-680R	1.33[abc]	571.63[cd]	5.05[a]
PAN 1745R	1.33[abc]	610.00[abc]	5.28[a]
P2823WB	1.17[bc]	597.33[bc]	5.55[a]
CV %	25.76	8.64	31.70

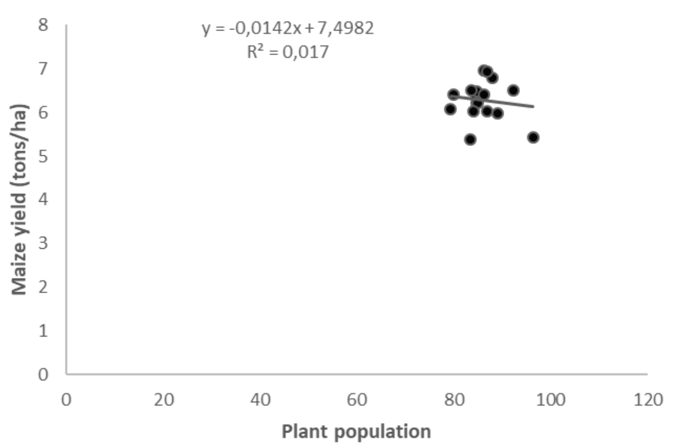

Figure 1: Grain yield and plant population.

Conclusion and recommendations

Although, significant difference was not observed both in yellow and white cultivars in terms of grain yield parameter. Maize cultivar PAN 6R-710BR, PAN5R-591R, BG 5285 and WE 6208B recorded the highest percentage of prolificacy. Further studies focusing on the influence of management practices on agronomic performance of different maize varieties is required. The results are applicable to the semi-arid areas of the Eastern Cape region.

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