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Evaluation of maize (*Zea mays* L.) varieties for agronomic and yield performance in two locations of Northern Guinea Savanna agro-ecology of Nigeria

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ABSTRACT: Maize (*Zea mays* L.) is the third most important cereal in the world and the second in Nigeria after rice in terms of cultivation and utilization. Five varieties (TZESR-W, SUWAN-1-SR, DMR-ESR-W, Mega maize and Local cultivar) were evaluated during the 2018 cropping season with the aim of assessing the agronomic and yield potentials in two locations (Jalingo and Yola) of the northern guinea savanna agro-ecology of the country. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Seeds were sown on a plot size of 5 m x 5 m at a spacing of 75 cm x25 cm. Data collected on vegetative and yield parameters were analyzed using GENSTAT software and means were separated using Duncan's Multiple Range Test at a 5% level of probability. Results from the study showed high variability among the varieties across locations in most traits studied. However, SUWAN-1-SR and DMR-ESR-W performed better in both locations with an average number of grains per cob of 443 and 483 in Jalingo and Yola, respectively and are recommended for cultivation by farmers. Mega maize was the lowest in most traits suggesting that it is not suitable for Jalingo and Yola locations. The local variety, used as a check performed better than mega maize and TZESR-W, comparing well to SUWAN-1-SR and DMR-ESR-W, the leading varieties in most parameters. The significant differences among the varieties can be harnessed for selective breeding.

Keywords: Agro-ecology, maize, traits, variety, yield.

INTRODUCTION

Maize (*Zea mays* L.; 2n=20), a member of the grass family, *poaceae/graimineae* is one of the world most important cereal crop that is responsible for roughly 19.5% of human calorie intake. It is perhaps the most completely domesticated of all field crops that can effectively convert sun energy into carbohydrates (Balasubramaniyan and Palaniapan, 2014). Botanically, maize is a tall annual plant with an extensive fibrous root system. It is a monoecious plant that is mostly cross pollinating with the female flower (ear) and the male flower (tassel) located at separate places on the same plant. Maize, being a diploid species has a moderate genome size of approximately 2400 mb (Kola *et al*., 2006). Maize ranks third after wheat and rice in hectares and total production in the world (FAOSTAT, 2016) and has been accepted as one of the longest ever cultivated cereals. It is one of the most essential staple foods in the world and in combination with wheat and rice supplies over 50% of the world calorie intake. However, it provides more calorie than wheat (15.0%) and rice (16.5%) (World Atlas, 2017). Maize is grown in several regions of the world (temperate, sub- tropical and tropical) and it is described as the global best adapted crop (IITA, 2008). Therefore, the suitability of maize to diverse environments is unmatchable by any other crop. It has been forecast that between 1995 and 2020, the estimated demand for maize will increase by 50% world-wide and by 93% in Sub-Saharan Africa (FAO, 2015). Maize is the only cereal that can be harvested and utilized at various stages of the plant development. Apart from human consumption and livestock feed, maize is a rich source of raw material for the manufacture of hundreds of industrial products. These include corn starch, corn oil, corn syrup, corn flakes, maltodextrins and products of fermentation and distillation industries (Khali *et al*., 2011; Bello *et al*., 2013). In developed countries, maize is used more as livestock feed, while in the developing countries such as Nigeria, generally more as human food (Cornindia,2008).

In Nigeria, maize has the ability to thrive under different ecological conditions, hence the wide spread in its production across different parts of the country, from the swamp coast of the south to the dry savanna of the north (Remison, 2005). Even though the savanna agro-ecology of Nigeria has a great potential for food production due to its adequate solar radiation and moderate rainfall that favours crop production (Obi, 1991), large volumes of maize grains are produced in the northern parts and the areas fringing the forest and forming the transition to the southern guinea savanna (maize belt) where about 30% of the crop land is devoted to maize production under various cropping systems by small-scale farmers (Ayeni, 1991; Iken and Amusa, 2004).

Presently, there is high demand for maize in Nigeria as the crop has risen to a commercial scale on which many agro-based industries depend as raw materials for poultry feed as well as the main food for many households (Ogunniyi, 2011). In 2017, maize production stood at 10.5 million MT (FAO, 2017) being the second largest in Africa after South Africa. Despite its high production volume, maize is mainly produced by small holder farmers on small farm area of not more than 0.65 ha and with an average yield of 1.8 MT/ha (FAOSTAT, 2014) which is one of the lowest in Africa. Nigeria is still lagging behind countries such as Egypt and South Africa where the yield is 7.7 and 5.3 MT/ha, respectively (FAOSTAT, 2014). Addressing this low yield issue, Nigeria could become the largest maize producer in Africa and one of the largest producer in the world without necessarily increasing the current area under cultivation. According to Hussain *et al*. (2010), low yield is a major challenge between varieties and environment for a successful recommendation of a variety for a particular agro-ecology. Therefore, the low maize yield obtained in Nigeria could be attributed to constraints such as low access to improved varieties (Shiferaw *et al*., 2011) and poor soil fertility since maize is considered to have a high soil fertility requirement for maximum yield (Uribelarrea *et al*., 2009). In plant bleeding, the process of identifying varieties of high yielding potential across environments is a fundamental activity (Djurovic *et al*., 2014).

The soil in the Northern Guinea Savanna zone of Nigeria is friable with low organic matter content and poor water holding capacity, resulting in low nitrogen availability (Fakorede *et al*., 2003). Similarly, varietal selection in this country is based on the farmer's discretion where seeds of impressive maize plants are simply kept for the subsequent plating season. Therefore, maize being the highest yielding cereal crop in the world and of significant importance in Nigeria, where rapidly increasing population has out grown the available food supplies, a good variety with high yielding potential is key towards improving its yield (Tariku *et al*., 2019). Genetic variability and environmental interaction play a great role in optimizing maize production (Olakojo and Iken, 2001). Therefore, it is imperative to evaluate different maize varieties in various agro-ecological zones for their adaptation and yield potential and to recommend the most suitable variety for cultivation (Hussain, 2011). The present study was carried out to evaluate the agronomic and yield potential of some maize varieties in the Northern Guinea Savanna agro-ecology of Nigeria.

MATERIALS AND METHODS

The study was conducted in two locations during 2018 cropping season. The two locations were Teaching and Research Farm, Taraba State University, Jaingo (Lat.08^o 54^1N, Long. 11^o 22^1 E and Alt. 349 masl) and Teaching and Research Farm, Federal University of Technology, Yola (Lat. 09^o 14^1 N; long. 12^0 38^1 E and Alt. 158 masl). The materials for the experiment comprised four improved varieties of maize developed by International Institute for Tropical Agriculture (IITA), Ibadan and a local cultivar (check) obtained from a farmer at Sangere village. Land preparation involving the use of disc plough and harrow were adopted in both locations. Five different varieties of maize namely; TZESR-W, SUWAN-1-SR, DMR-ESR-W, mega maize and a local cultivar (check) were tested in both locations. The experiment was laid out in a Randomized Complete Block Design with four replications. A plot size of 5 m x 5 m with five rows at the spacing of 75 cm and 25 cm between plant stand was used. Immediately after the first weeding three weeks after planting, NPK fertilizer at the rate of 200kg/ha was applied. Before planting, germination test was conducted on each variety in the laboratory to ascertain the germination status of the seeds. Data was collected from five randomly selected plant on plant height, number of leaves, leaf length, cob length, cob diameter, number of grain per cob, grain yield per plant (g) and 1000 grain weight(g) per variety and subjected to Analysis of Variance (ANOVA) using GENSTAT software for individual location and combined locations. Means were separated using Duncan Multiple Range Test (DMRT) at a 5% level of probability.

RESULTS AND DISCUSSION

Significant ($p<0.05$) were observed in most of the traits. Significant and higher grain yield per plant (12.53 and 134833 g) were observed in SUWAN-1-SR and DMR-ESR-W in Jalingo and Yola, respectively. The result of the

Table 1. Physico-chemical properties of soil in both locations.

Parameters	Jalingo	Yola
Clay (%)	14.7	37.31
Silt (%)	12.4	26.43
Fine sand (%)	47.2	28.91
Course sand (%)	25.7	7.35
Textural class	Sandy loam	Silt clay loam
PH (H_2o)	6.1	6.7
Organic carbon (%)	0.27	0.16
Organic matter (%)	0.46	0.74
Available P mg/kg	0.80	1.50
Total nitrogen (%)	0.13	2.35
Exchangeable cation		
Na me/ 100g	0.75	0.83
K me/ 100g	4.74	5.61
Ca me/ 100g	3.24	1.81
Mg me/ 100g	0.9	2.47
CEC	9.85	10.28
Base saturation (%)	99.034	93.491

CEC= cation exchange capacity.

Table 2. Combined analysis of variance (ANOVA) for agronomic and yield traits.

SV	DF	PH (cm)	NL(cm)	LL(cm)	CL(cm)	CD(cm)	NG	GY(g)	1000 grain [wt (g)]
R	3	262.3	1.64	17.0	1.51	0.14	401.47	69.54	731.10
L	1	136.2**	1.99**	73.4**	1.24**	0.96**	466.31**	83.44**	566.31*
V	4	2063.2**	3.23**	94.8**	0.89	2.34**	5131.22*	748.16	482.92
V x L	4	124.5*	1.51	12.4	0.11	0.43	209.11	53.33	221.31
Error	12	74.57	0.71	5.5	0.73	0.31	143.42	292.93	570.76

*, **= significant at 5 and 1 %, respectively, SV= source of variation, DF= degree of freedom, PH = Plant height, NL= number of leaves, LL= leaf length, CL= cob length, CD = cob diameter, NG = Number of grains, GY = Grain yield, R= Replicate, L= Location, and V= Variety.

physicochemical properties of the soils at the two locations (Table 1) showed that the soils were slightly acidic but varied in type. Although the soils of the two locations were low in organic carbon, organic matter, available P and total nitrogen, however, available P and total nitrogen of the Yola location were higher than those of the Jalingo location. Due to the low content of essential macronutrients in both locations, the soils can be observed to be poor for maize production. Combined means analysis of variance for locations, varieties and variety by location interaction showed significant and highly significant ($p<0.05$ and $p<0.01$) differences for most of the parameters studied (Table 2). Differences in varietal performance observed in this study may also be due to variation in soil types and the inherent nutrient status of the soil as observed by Trethowan *et al*. (2001) who reported that maize yield varies from one location to another.

Mean square values for plant height (cm), number of leaves, leaf length (cm) and cob diameter (cm) for variety and location were highly significant even at a 1% level of probability. Also highly significant were the mean square for the number of grains and grain yield (g) for location only. However, mean square values for the number of grains in variety and 1000 grain height (g) of location were significant at a 5% level of probability. The significant and highly significant difference observed in the number of leaves, number of grains per plant, plant height, leaf length and cob diameter among the varieties signified abundant variability in the maize and so the population was amenable to selection for these traits. This observation is in agreement with previous findings of Workie *et al*. (2013) in maize and Rezene *et al.* (2014) in field pea. It is reasonable to argue here that selection could be performed on the varieties for further improvement to produce at least a variety that will be suited to northern guinea conditions because of the large variability that occurred in some yield components. However, traits such as cob length, grain yield and 1000 grain weight did not show any significant differences indicating that no variability existed in these traits, as such cannot be used

Table 3. Main effect of variety on vegetative traits of maize.

Variety	PH (cm)		NL		LL (cm)	
	Jal.	Yol.	Jal.	Yol.		Yol.
Mega maize	113.93^{a}	154.25^{a}	9.96^{a}	10.85^{a}	51.04^{a}	55.39^{a}
TZESR-W	114.09^{b}	205.25^{bc}	11.03^{b}	12.95^{b}	59.97^{c}	64.51^{c}
SUWAN-1-SR	118.38^{a}	194.25^{b}	13.63^{c}	12.58^{b}	56.20^{b}	59.47^{b}
DNR-ESR-W	116.59^{a}	199.25^{b}	13.63^{c}	12.85^{b}	57.201^{b}	61.63^{bc}
Local cultivar	119.31^{a}	213.25^{c}	12.02^{bc}	12.80^{b}	55.04^{b}	62.60^{bc}
LSD (0.05)	11.04	13.30	1.1	1.3	2.5	3.6

Jal. = Jalingo, Yol. = Yola. PH = Plant height, NL= number of leaves, LL= leaf length.

Table 4. Main effect of variety and yield and yield components of maize.

Variety	CL (cm)		CD (cm)		NG		GY		1000 grain (g)	
	Jal.	Yol.	Jal.	Yol.	Jal.	Yol.	Jal.	Yol.	Jal.	Yol.
Mega maize	15.00^{b}	19.01^{a}	11.00^{b}	13.09^{a}	392.11^{a}	400.98^{a}	100.31^{a}	109.73^{a}	203.41^{a}	274.98^{a}
TZESR-W	17.00^{a}	18.91^{a}	12.22^{a}	13.55^{ab}	410.56^{ab}	488.36^{b}	113.42^{a}	126.98^{a}	213.11^{a}	294.28^{a}
SUWAN-1-SR	17.51^{a}	19.96^{a}	13.88^{c}	15.21^{c}	433.56^{b}	461.00^{b}	124.53^{a}	134.96^{b}	224.13^{a}	296.68^{a}
DMR-ESR-W	17.07^{a}	19.15^{a}	14.256^{c}	14.08^{b}	443.72^{b}	489.00^{b}	122.21^{a}	138.33^{b}	261.11^{a}	275.90^{a}
Local cultivar	17.14^{a}	19.11^{a}	12.55^{c}	13.66^{ab}	412.34^{ab}	460.38^{b}	114.41^{a}	130.85^{b}	224.15^{a}	275.58^{a}
LSD (0.05)	1.00	1.32	0.34	0.85	43.72	58.46	21.31	26.83	22.31	26.37

Jal. = Jalingo, Yol. = Yola. CL=cob length, CD= cob diameter, NG = Number of grains, GY = Grain yield.

as a selection index for yield improvement. Similarly, significant and highly significant differences in locations were observed for all the traits indicating that varietal performances are due to a particular environmental condition and sometimes varieties that are exceptionally good across locations as observed in the sweet potato genotype by Ngailo *et al*. (2019) and in hybrid maize by Masila and Langat (2020). However, the genotype by location interaction was only significant for plant height signifying that the genetic expressions of plant height was affected by environmental conditions at the two locations. This observation is in agreement with the findings of Mageto *et al*. (2017) and Masila and Langat (2020).

Results of the main effect of vegetative traits (Table 3) showed that the varieties were not consistent in performance across locations. Mega maize was the poorest and statistically different from the remaining varieties in most of the traits across locations. This inconsistency in performance could be attributed to variations in physcio-chemical nature of the two soils and biological factors as postulated by Tariku *et al*. (2019). All the maize varieties used in this study were of diverse genetic backgrounds, hence the varied vegetative traits observed. A similar observation had earlier been reported by Beyene *et al*. (2011) where variations in vegetative traits were reported in different maize varieties. However, in this study, mega maize was observed to be the poorest in most traits, suggesting that such a variety is not suitable for northern guinea savanna agro-ecology of Nigeria. This could be due to inadequate adaptation to the hot Yola and Jalingo conditions. The mean performance of varieties for yield and yield components (Table 4) revealed significant differences among the varieties and across locations in some traits. 1000 grain weight though not statistically significant across locations in all the varieties, the Yola location had slightly higher weight compared to Jalingo.

Similarly, cob length (cm) was not statistically significant across locations in all the varieties, except mega maize where Jalingo differed significantly from Yola. It is not surprising therefore, that 1000 grain weight and cob length did not show any tangible difference among the different varieties because all the varieties were statistically the same, particularly in cob length and 1000 grain weight. With respect to number of grains per plant and grain yield, mega maize gave the lowest mean value that differed statistically (p<o.05) from the other varieties, however, TZESR-W also performed statistically poor. The inconsistent performance of yield traits among the maize varieties in the study area may be due to physical, chemical and biological factors as observed by Tariku *et al*. (2019) in some midland maize varieties in selected districts of southern Ethiopia. Generally, maize varieties performed better in the Yola location than that in the Jalingo location. However, in both locations, the local varieties surprisingly performed reasonably well in terms of yielding ability, outperforming the mega maize and TZESR-W, suggesting that these two varieties need not be grown in these locations as they do not out class the local

variety. As a matter of fact, even the remaining two varieties (SUWAN-1-SR and DMR- ESR-W) did not perform statistically better than the local variety, though they slightly ranked higher in terms of yield. It is therefore reasonable to suggest that more maize varietal trials be conducted in this area to identify good varieties that can out yield the local variety significantly. It is not surprising however, for all these varieties not to perform well, because they were not selected in the two locations of the study and probably were never meant to be grown under the Northern Guinea Savanna zone of north eastern Nigeria as all the varieties were selected in Ibadan (forest zone), south western Nigeria and probably were not tested in different agro-ecologies of the country before releasing them as varieties.

Conclusion

Variability component analysis of five maize varieties in two locations in the Northern Guinea Savanna of Nigeria revealed significant differences among the varieties across locations suggesting that they could be amendable to selection. Mega maize being the poorest in most traits studied is not suitable for the locations. However, SUWAN-1-SR and DMR-ESR-W, the local variety performed statistically better than all the other varieties. Mega maize and TZESR-W also performed well in terms of yielding ability when compared to the aforementioned.

Recommendations

Although, in this study, only a few varieties were tested in two locations, there is a need for more varieties to be tested across more locations of the northern guinea savanna agro-ecology to promote effective maize breeding for adaptation in the study area. The impressive performance of the varieties, SUWAN-1-SR and DMR-ESR-W in all indices indicate their adaption to the area. Therefore, there is a need for further tests in more environments in order to increase maize production in Nigeria. Similarly, the local cultivar that compared favourably with the aforementioned improved varieties should also be developed as a variety for adoption in the Northern Guinea Savanna agro-ecology.

Conflicts of interest

The author declares no conflict of interest.

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