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Evaluation of Some Maize (*Zea Mays* L.) Varieties in Different Environments of the Nuba Mountain of Sudan

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Abstract: A field experiment was conducted during two successive rainy seasons (2002/03 and 2003/04) at two locations (Kadugli and Korgol) in the Nuba Mountains of Sudan, to evaluate eight maize varieties. Two local varieties (Dalanj and Kadugli) and six introduced varieties (Hudeiba I, Hudeiba II, Mugtama 45, Pannar 6804, Pannar 6568 and 113). A randomized complete block design in four replications was used. The results showed that, Variety 113 reached 50% tasselling earlier. Pannar 6568 was the tallest, Variety Hudeiba II scored the highest number of ears, number of rows per ear, ears weight and grain yield, whereas, the local variety Kadugli recorded the least grains number and the least grain yield. Positive correlation observed between grain yield and plant height, number of ears, number of seeds per ear and ears weight. Significant differences of grain yield were observed among varieties and locations. A cross locations and seasons, the variety Hudeiba II scored the highest grain yield.

Key words: Maize (*Zea mays* L.), evaluation, grain yield, Nuba Mountain

INTRODUCTION

Maize or corn (*Zea mays* L) is an annual grass belongs to the family Gramineae. The probable center of origin is the Central American and Mexico region [28, 29]. Maize has a wide range of plasticity to the environmental conditions. It is grown from latitude 58 N to 40 S on a range of 400 – 900 mm rain and temperature of 20- 30° C (Nour, A. M. and B. Lako, 1997). Maize is an important cereal food crop, and it ranks in the third position after wheat and rice in the world production of cereals (Poehlman, J.M., 1983; 3.Ahmed, F. E. 1999). The largest production countries in the world are USA, China, France, India, Canada, Argentina, Spain, Romania and Yugoslavia (EL younis, A., 1987). The total world cultivated area is about 601.66 million hectares [13]. The world productivity according to FAO statistics is about 4.2 tons per hectare. In the Sudan, Maize grown in small scales under rainfed conditions in Kordofan, Darfour, and Southern states, under irrigation in Northern States and under flood irrigation in Kassala State (Ali, F. M., 1991). The total cultivated area of maize in the Sudan increased from 80 thousand hectares in 1989/91 to 187 thousand hectares in 1998. Average yield was 632 kg/ hectare (FAO., 1998).

Maize has a lower priority in agricultural development plans in the Sudan due to low yield potential, limited local uses and low market price. However, Kim (Kim, S.K., 1981) and Ajala (Ajala, S.O., 1997) have the opinion that the lack of adapted lines with high yield potential and good resistance to water stress are the major limiting factors for maize production in the Sudan. Maize can occupy an important position in the economy of the country due to the possibility of blending maize with wheat for bread- making, the increase in the demand of maize for poultry feed and for forage as well as its great potential for export (to provide new source of hard currency), This needs, searching for increasing maize production and productivity in the Sudan.

In Nuba Mountains, maize is widely used as a food crop. It is grown almost in all villages and towns around the houses in small areas locally known as Jubraka or household garden. Productivity in the area is very low. Introduction of new varieties in the area might improve this productivity. Breeding of high yield crops require information on the nature and magnitude of variation in the available materials, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. Since grain yield in maize is quantitative in nature and polygenic ally controlled,

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effective yield improvement and simultaneous improvement in yield components are imperative (Bello, O.B. and G. Olaoye, 2009). Selection on the basis of grain yield character alone is usually not very effective and efficient. However, selection based on its component characters could be more efficient and reliable (Muhammad, B.A., 2003). Therefore the objectives of this study were to evaluate the performance of different maize varieties at different environments in Nuba Mountain of Sudan.

MATERIALS AND METHODS

Experiment:

A field experiment was conducted during two successive seasons (2002/03 and 2003/04) under rainfed, at two locations (Kadugli and Korgol) in the Nuba Mountain of Sudan. The experiment was laid out in a randomized complete block design (RCBD) in four replications. The plot size was 6m × 3.4m with four ridges, each six meters long. The treatments consisted of Eight maize varieties, six improved (Hudeiba I, Hudeiba II, Mugtama 45, Pannar 6804, Pannar 6568 and 113) and two local varieties (Dilling and Kadugli). Seeds were treated using Theram at a dose of 3 g/kg against insects and soil fungi. Sowing dates were on the July 19th, 2002 for first location, and 20th of July for second location. Seeds were sown on ridge 75 cm apart; in intra-row spacing of 25 cm. Three seeds were placed in each hill. After two weeks from sowing, seedlings were thinned to one plant per hill. Manual weeding was practiced twice in the two seasons for both locations. Total rainfall and its distribution in the experimental sites during the two seasons are shown in Table 1.

Characters Studied:

1. Number of Days to 50% tasselling: was calculated as the number of days from planting to when 50% of the population have tasseled.
2. Plant height (cm): measured from the ground level to the last node below the male flowering just before harvesting.
3. Number of ears per plant: the total number of ears harvested from the two central rows.
4. Number of rows per ear: determined as an average of 10 ears selected randomly.
5. Number of seeds per ear: determined as an average of 10 ears selected randomly
6. Grain yield (kg/ ha): the ears harvested from each plot dried, threshed and weighed and then grain yield per hectare was calculated as follows:
   Grain yield = grain wt. (Kg/plot) x 10000
   Harvested plot area (m2)
7. 100-Seeds weight (g): 100-seeds separated from each plot and then weight by using the sensitive balance.

Statistical Analysis:

Individual analysis of variance was carried out for each location separately in both seasons according to the procedure described by Gomez and Gomez (Gomes, K.A. 1984). The combined analysis of variance was done for the two locations in both seasons, according to Gomez and Gomez (Gomes, K.A. 1984).

Correlation:

The phenotypic correlation was calculated separately for each location in both seasons, by using the formula suggested by Miller *et al.* (Miller, P. A., 1958):

$$r = \sqrt{\frac{COV \times 1 \times 2}{(Var \times 1)(Var \times 2)}}$$

whereas :
r = correlation coefficient
cov X1 X2 = covariance between traits, X1 and X2
var X1 = variance of trait X1
var X2 = variance of trait X2.

RESULTS AND DISCUSSION

Number of Days to 50% Tasselling:

Highly significant differences among cultivars were observed in number of days to 50% tasselling at locations in both seasons (Tables 2, 3, 4 and 5). These differences indicate the existence of great amount of

variability among the tested cultivars. This variability might be attributed to genetic and/or environmental factor. Similar results were reported by Khalaflla (Khalafalla, M.M., 1993). The open pollinated cultivators reached the 50% tasselling earlier than the hybrids.

Plant Height:

Results of plant height are shown in Tables 2, 3, 4 and 5 . The variation in plant height observed in some locations and seasons. These results agree to those of Sindagi *et al*. (Sindagi, S.S., 1970) who noticed a wide range of genetic variability in plant height among different maize cultivars. Different results were obtained by Ahmed [2] who reported no significant differences in plant high among cultivars tested in his study.

Yield and Yield's Components:

Significant differences in the yield components were detected in locations and seasons among the different cultivars (Table 6). In maize, days to flowering, plant and ear height, number of grain ear^{-1} and 100-grain weight could be important selection criteria in obtaining proven open pollinated maize varieties and hybrids of high grain yielding (Bello, O. B., 2010). Grain yield depends upon the number of grains produced and the extent to which the grains were filled. The average grain yield at Korgol (Tables 2 and 3) was greater than that at Kadugli (Tables 4 and 5). This is due to the greater number of seeds per ear and weight of ears per plot at Korgol than that at Kadugli. Supporting evidences were reported by Ahmed and El Hag (Ahmed, F. E. 1999) who attributed the reduction in grain yield to the reduction in number and weight of developed seeds under waters tress. Classen and Show (Classen, M. M. and R. H. Show, 1986) and Hallauer and Miranda (Hallauer, A. R and J. B. Miranda, 1982) attributed the reduction in number of seeds per ear to the low relative amount of rainfall, and delay of silking. That pollen is shed from the tassels prior to the silks being receptive.

Genotype X Environment Interactions:

Table 7 represents the combined analysis over locations and seasons. The results showed that, significant interaction of genotype x environment for the various characters: number of days to 50% tasselling, plant density, number of rows per ear, number of seeds per ear, ears weight per plot, grain yield and 100- grain weight indicated that, the performance of some cultivars was more adapted at some locations than others. Similar results were recorded by Abdalla [1] who reported significant genotype x location interaction for the different traits he studied except for number of days to 50% tasselling. On the other hand, the absence of significant genotype x environment interaction for number of ears per plot and plant height, indicate that, the cultivar performance was no dependent environment (locations) for these traits. Nour and Lako (1997) found the similar result; they reported that, the variety x season interaction was not significant for all the parameters, indicating that all the cultivars reacted similarly in different environments.

Correlation:

The results of correlations are shown in Table 8. In this study, there was significant positive correlation between grain yield and almost all other yield components (number of ears per plot, number of rows per ear, number of seeds per ear, and ears weight per plot. These findings coincide with the results of several workers: Annapurna *et al*. (Annapurna, D., 1998), Gautam *et al*. (4. Aken, J. V., 1962), Khatun *et al*. (Khatun, F.,1999), Mohammadi *et al*. (Mohammadi, S. A., 2003) and Bello *et al.* (2010). Xu (1986), observed high significant correlation between the grain yield and number of rows per ear. Ahmed (1995). found significant positive correlation between grain yield and number of seeds per ear. The non- significant negative correlation between the number of days to 50% tasselling and each of number of ears per plot and grain yield could be probably attributed to the effect of environment. Bello *et al*. (2010) reported that, days to 50% tasselling and silking were postively correlated with grain yield.

Plant height had positive significant correlation with most of the characters. Hayes and Johnson [18] and Bello *et al.* (2010) reported that significant positive correlation between grain yield and plant height. Khatun *et al*. (Khatun, F., 1999) found that grain yield plant^{-1} was positive and significantly correlated with number of kernels ear-^{1}, ear weight and ear insertion height. High correlation of grain yield with plant height is also reported by Annapurna *et al*. (1998) and Gautam *et al*. (1999). Plant density was positively significantly correlated with number of ears per plot ears weight per plot, and grain yield. Similar results were obtained in previous study by Hassan [17] who reported that, plant density was significantly affected number of ears and grain yield.

Table 1: Monthly mean (mm) rainfall during the growing season for maize (July - October) in Nuba Mountain of Sudan.

Month	200		22003	
	Kadugli	Korgol	Kadugli	Korgol
July	140	170	180	100
August	250	255	140	220
September	160	154	110	130
October	40	35	190	30
Total	520	614	620	480

Table 2: Mean values for various characters of eight maize varieties at Korgol during season 2002

Character / Variety	No. Of days to 50% tasselling	Plant height (cm)	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot (g)	Grain yeild Kg/ha	100-seed weight (g)
Hudeiba I	47.25^{d}	143.797^{abc}	40.75^{a}	40.943^{ab}	12.550^{a}	255.912^{a}	2207.175^{a}	1741.900^{a}	12.438^{a}
Hudeiba II	49.75^{c}	147.560^{abc}	39.25^{ab}	46.905^{a}	10.445^{ab}	154.528^{b}	2076.200^{a}	1782.000^{a}	13.050^{a}
Mugtama 45	48.75^{c}	013.758^{bc}	32.25^{b}	18.715^{bc}	11.102^{ab}	194.215^{ab}	0745.375^{b}	0574.375^{b}	11.195^{a}
Pannar 6804	52.50^{b}	136.272^{bc}	42.00^{a}	20.750^{bc}	07.500^{c}	127.500^{b}	0925.000^{b}	0772.250^{b}	10.615^{a}
Panaar 6568	54.50^{a}	155.170^{ab}	46.25^{a}	22.250^{bc}	09.250^{bc}	128.500^{b}	0587.500^{b}	0437.500^{b}	10.303^{a}
113	45.00^{e}	126.310^{c}	40.25^{a}	24.750^{abc}	10.250^{abc}	122.250^{b}	0725.000^{b}	0550.000^{b}	12.078^{a}
Dilling	49.50^{c}	135.695^{bc}	41.75^{a}	16.500^{c}	11.125^{ab}	143.000^{b}	0505.000^{b}	0387.500^{b}	10.285^{a}
Kadugli	53.00^{b}	161.378^{a}	41.25^{a}	22.118^{bc}	11.830^{a}	166.503^{b}	0471.418^{b}	0289.105^{b}	11.035^{a}
Mean	50.031	142.869	40.461	26.616	10.507	161.551	1030.331	816.8289	11.375
CV%	1.36	10.21	12.44	54.87	13.7	29.65	61.45	67.95	16.59

Means in the same column followed by the same letter are not significantly different at 0.05 level

Table 3: Mean values for various characters of eight maize varieties at Korgol during season 2003.

Character / Variety	No. Of days to 50% tasselling	Plant height (cm)	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot (g)	Grain yeild Kg/ha	100-seed weight (g)
Hudeiba I	45.50^{de}	104.643^{ab}	37.750ab	20.75^{ab}	09.55^{oa}	157.850^{a}	746.575^{a}	584.75^{a}	10.595^{a}
Hudeiba II	45.75^{de}	121.072^{ab}	33.750^{abc}	23.00^{a}	09.525^{a}	129.872^{a}	795.000^{a}	636.65^{a}	12.533^{a}
Mugtama 45	46.25^{d}	128.533^{ab}	32.000^{bc}	08.00^{abc}	09.337^{a}	145.250^{a}	225.000^{a}	170.75^{a}	12.283^{a}
Pannar 6804	53.50^{b}	100.470^{b}	05.750^{d}	04.00^{c}	11.300^{a}	210.975^{a}	243.800^{a}	183.75^{a}	13.320^{a}
Panaar 6568	55.00^{a}	134.350^{ab}	35.250^{ab}	07.25^{bc}	07.871^{a}	117.600^{a}	229.350^{a}	175.00^{a}	11.922^{a}
113	42.25^{g}	086.448^{b}	24.250^{c}	09.25^{abc}	09.000^{a}	115.975^{a}	205.625^{a}	156.25^{a}	12.517^{a}
Dilling	44.25^{f}	149.963^{a}	43.500^{a}	18.50^{abc}	11.100^{a}	194.900^{a}	666.875^{a}	540.00^{a}	13.633^{a}
Kadugli	49.00^{c}	121.435^{ab}	24.000^{c}	08.50^{abc}	09.150^{a}	130.125^{a}	252.775^{a}	191.50^{a}	13.158^{a}
G.Mean	47.75	118.364	29.531	12.406	9.605	150.318	420.625	329.88	12.495
CV%	1.02	24.56	21.31	75.43	21.42	38.56	87.67	88.75	16.06

Means in the same column followed by the same letter are not significantly different at 0.05 level

Table 4: Mean values for various characters of eight maize varieties at Kadugli during season 2002

Character / Variety	No. Of days to 50% tasselling	Plant height (cm)	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot (g)	Grain yeild Kg/ha	100-seed weight (g)
Hudeiba I	46.750^{e}	62.42^{a}	10.25^{e}	05.33^{b}	09.33^{a}	103.33^{ab}	100.00^{b}	050.00^{b}	10.68^{a}
Hudeiba II	47.500^{d}	67.89^{a}	19.50b^{cde}	07.00^{b}	07.00^{b}	074.00^{ab}	116.66^{b}	081.33^{b}	09.90^{a}
Mugtama 45	46.500^{e}	57.50^{a}	12.00^{de}	06.00^{b}	08.66^{ab}	114.33^{a}	100.00^{b}	065.66^{b}	10.58^{a}
Pannar 6804	49.500^{c}	66.97^{a}	20.50^{bcd}	11.23^{ab}	08.78^{ab}	104.30^{ab}	239.28^{ab}	175.23^{ab}	11.42^{a}
Panaar 6568	53.000^{b}	86.83^{a}	31.75^{a}	17.66^{a}	07.33^{ab}	095.00^{ab}	450.00^{a}	316.66^{a}	11.01^{a}
113	45.500^{f}	59.85^{a}	29.50^{ab}	04.33^{b}	09.00^{ab}	079.33^{ab}	83.330^{b}	047.66^{b}	10.49^{a}
Dilling	47.500^{d}	72.67^{a}	18.25^{cde}	07.94^{b}	06.66^{b}	051.61^{b}	54.760^{b}	037.30^{b}	09.64^{a}
Kadugli	53.500^{a}	64.36^{a}	27.00^{abc}	06.37^{b}	08.25^{ab}	115.57^{a}	119.55^{b}	076.98^{b}	09.03^{a}
G. Mean	48.719	67.31	21.09	8.237	8.126	92.18	157.947	106.35	10.34
CV%	0.43	16.81	26.69	50.51	13.92	28.26	105.59	90.53	12.89

Means in the same column followed by the same letter are not significantly different at 0.05 level

Table 5: Mean values for various characters of eight maize varieties at Kadugli during season 2003.

Character / Variety	No. Of days to 50% tasselling	Plant height (cm)	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot (g)	Grain yeild Kg/ha	100-seed weight (g)
Hudeiba I	48.250b	089.605d	20.000ab	12.750abc	10.525ab	192.150a	509.875bc	381.500bc	13.255b
Hudeiba II	47.750b	113.225abe	21.750ab	17.250a	12.000a	234.200a	956.500a	711.125a	16.930ab
Mugtama 45	47.750b	125.625a	21.250ab	15.000ab	09.975ab	181.350a	703.125ab	535.725ab	16.705ab
Pannar 6804	56.500a	104.520cd	03.000d	03.000d	11.325ab	209.050a	184.375c	145.050c	18.617a
Panaar 6568	57.750a	115.585ab	20.500ab	16.000a	08.700b	162.550a	640.750ab	484.375ab	16.063ab
113	45.250c	096.810cd	16.000bc	08.500cd	10.725ab	163.400a	333.500bc	251.150bc	14.250b
Dilling	47.500b	101.140cd	26.250a	16.000a	09.925ab	161.000a	570.175abc	434.625abc	14.455ab
Kadugli	47.000b	127.870a	12.250c	07.000cd	11.250ab	204.340a	345.750bc	245.275bc	15.428ab
G. Mean	49.719	109.298	17.625	11.938	10.553	188.506	530.506	398.603	15.713
CV%	1.59	10.13	24.41	37.06	15.04	31.73	47.35	49.38	16.12

Means in the same column followed by the same letter are not differ significantly different at 0.05 level

Table 6: Maize varieties performance across locations and seasons .

Character / Variety	No. Of days to 50% tasselling	Plant height (cm)	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot (g)	Grain yeild Kg/ha	100-seed weight (g)
Hudeiba I	46.833^{f}	098.470^{b}	26.333^{b}	19.000^{ab}	10.483^{a}	178.767^{a}	917.000^{a}	669.333^{ab}	11.587^{a}
Hudeiba II	47.667^{de}	109.073^{ab}	26.333^{b}	21.833^{a}	10.342^{a}	141.284^{abc}	918.625^{a}	747.375^{a}	12.613^{a}
Mugtama 45	47.917^{d}	114.600^{ab}	23.917^{b}	11.750^{bcd}	10.142^{a}	170.233^{ab}	458.083^{b}	350.075^{bc}	12.563^{a}
Pannar 6804	53.000^{b}	099.331^{b}	16.167^{c}	09.558^{cd}	09.308^{ab}	143.392^{abc}	390.575^{b}	316.375^{c}	12.922^{a}
Panaar 6568	55.000^{a}	123.802^{a}	32.333^{a}	14.667^{abc}	08.433^{bc}	129.650^{bc}	456.992^{b}	343.000^{bc}	12.379^{a}
113	44.417^{g}	097.648^{b}	24.08^{3b}	11.830^{bcd}	09.958^{ab}	127.425^{bc}	357.458^{b}	269.967^{c}	12.340^{a}
Dilling	47.167^{ef}	113.564^{ab}	33.167^{a}	15.225^{abc}	10.167^{a}	149.308^{abc}	487.565^{b}	372.833^{bc}	12.346^{a}
Kadugli	49.167^{c}	113.670^{ab}	25.417^{b}	05.343^{d}	07.222^{c}	116.325^{c}	183.758^{b}	129.633^{c}	9.592^{ba}
G. Mean	48.896	108.77	25.969	13.62	9.507	144.548	521.257	399.824	12.043
CV%	1.53	16.67	20.6	74.25	19.21	31.52	86.64	94.65	15.92

Means in the same column followed by the same letter are not significantly different at 0.05 level

Table 7: Combined analysis over locations and seasons.

Source of variation	D.f.	No. Of days to 50% tasselling	Plant height	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot (g)	Grain yeild Kg/ha	100-seed weight (g)
Year (y)	1	1.500	574.238	969.010**	658.982*	74.448**	66098.559**	735037.986	399784	410.027**
Location (L)	1	4.167**	43336.784**	6885.094**	1179.362**	1.887	160.736	2188026.327**	1826320.100**	108.971**
Y×L	1	108.375**	47265.187**	994.594**	1448.322**	38.684**	59172871**	6639866.324**	4648349.464**	46.343**
R(L ×Y)	8	3.990**	2341.611**	232.948**	415.035**	8.985*	7740.014**	870654.051**	564578.170**	8.682*
Factor A (varieties)	7	143.923**	1073.009**	337.260**	330.377**	15.611**	4540.254*	825571.001**	508609.823**	13.497**
Y A	7	18.517**	884.865*	308.177**	124.84	16.261**	4983.227*	415351.835	225124.407	24.529**
L A	7	9.000**	463.64	51.07	240.674*	20.453**	8557.860**	490979.560*	3811.858*	13.991**
Y L A	7	1.589*	884.274*	47.713	167.474	11.557**	3785.91	415582.708	324852.017*	10.554*
Error	56	0.561	328.947	28.626	102.258	3.334	2076.215	203950.318	143202.272	3.675

*and** = significant different at 0.05 and 0.01 level, respectively

Table 8: Correlation coefficients among different characters in maize combined across seasons and locations.

Character	No. Of days to 50% tasselling	Plant height	Plant density	No. Of ears per plot	No. Of rows per plot	No. Of seeds per ears	Ears weight per plot	Grain yeild Kg/ha	100-seed weight (g)
No. of days to 50% tasselling									
Plant height	0.204								
Plant density	0.050	0.487**							
No. ears per plot	-0.032	0.542**	0.543**						
No. of rows per ear	0.165	0.448**	0.151	0.329					
No. of seeds per ear	0139	0.550**	0.117	0.335*	0.732**				
Ears weight per plot	0.002	0.613**	0.430*	0.918**	0.411*	0.535**			
Grain yield	-0.011	0.602**	0.427*	0.926**	0.429*	0.517**	0.992**		
100-seed weight	0.229	0.340	-0.059	0.125	0.387*	0.490**	0.218	0.197	

* and ** = significant different at 0.05 and 0.01 level respectively

Conclusion:

Based on the results obtained, the superiority of the cultivar Hudeiba II over the other cultivars in all environments suggests its adoption as one of the high yielding cultivars in this area and proposed to be recommended in Nuba mountain of Sudan

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