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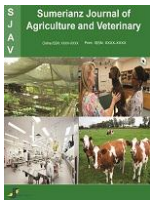

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Morphological, Phonological and Yield Attributes of Maize (*Zea mays* L.) as Affected by Different Sowing Methods Intra-Row Spacing and Varieties at Gash Scheme

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Abstract

To check the performance of maize under various sowing methods, intra-row spacing and varieties, two experiments were conducted at Kassala Research Station Experimental farm atTakroof during two successive 2015and 2016seasons. The experiment was carried out in RCBD, with three replications, arranged in split-split trail, with the sowing methods at the main plot, the intra-row spacing at the sub plot and the varieties at the sub-sub plot. Three sowing Methods (SM) were (Ridge, Flat and Local Framers' Methods) and three intra-row spacing (20, 30, and 40cm) and three maize varieties(Hudeiba-1,Hudeiba-2 and variety113). Results of morphological and phonological attributes showed that, ridge sowing method significantly affected population density (42.0) and plant height (177.5cm).While flat SM significantly affected 50% Silking (57.6 days). Also, variety 113 significantly affected population density (39.9) and leaf area index (1.99). While intra-row spacing of 20 cm affected population density(48.1,) gave seed yield of (1732 kg/ha). Also,40 cm significantly affected plant height (191.2cm). 30cm significantly affected 50% tasselling of (59.9 days) and 50% silking of (63.8 days). But 30 cm affected leaf area index (2.06 and 1.92). Accordingly, Variety113, grown on ridge and with intra-row spacing of 30 cm gave the highest maize grain yield in Gash Scheme.

Keywords: Population density; Yield; Maize variety; Sowing method.

1. Introduction

Maize (Zea mays L.) Known as "corn" is one of the most versatile emerging cash and food. Maize is the third most important cereal crop after wheat and rice.Maize is one of the highest value crops, with multimillion dollar annul contribution to agriculture. The great adaptability and high yield as a food, feed and forage crop have led to its production on a massive scale, with average expanding at the expense of other crops [1]. Maize has a highly desirable characteristics which is high yield and feed value of grains,leaves and stemsas reported by Ullah, *et al.* [2]. About 50% to 55% of total maize production is used as food in developing countries [3]. Due to its high cross pollination characteristics, maize is grown in a wide range of environments more than wheat and rice because of it greater adaptability [4]. According to USDAFAS [5], USA leads the World in both maize tonnage (341 million tons) and acreage (88 million acre). According To USDAFAS [5], about 158 million hectares of maize are harvested worldwide. A major shift in global cereal demand is underway, and by 2020, demand for maize in developing countries is expected to exceed demand for both wheat and rice [6].

In Sudan Maize is of minor importance, only grown in limited areas in irrigated schemes, and in modern irrigation systems in Khartoum, River Nile and Northern States. In Sudan grain yield of maize is very low compared to other growing countries. The demand for maize is increasing in Sudan due to the establishments of many poultry and diary industries, [7]., also maize flour blended with that of wheat for bread production, to save hard currency. This makes it imperative to boost the yield per unit area of maize and to explore the optimum cultural practices of the crop to meet the increasing demand. Gash scheme with its most fertile soil in the world constitute a high potential to satisfy the needs for this crop. Hence, more research should be carried out to determine the optimum

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growing techniques for the crop. Therefore, this study was conducted to determine the suitable sowing method, intra-row spacing and variety for optimum output, higher yields and yield components of maize in the Gash Scheme.

2. Materials and Methods

2.1. Experimental Site Plant Materials Design and Cultural Practices

Two consecutive seasons experiments were conducted at Kassala Research Station Experimental Farm(Takroof.) latitude 15° 43' N and longitude 36° 38' East, elevation 596 m above sea level. There are two types of soils in Gash Scheme known locally aslebad and padobe, AS labade soil is rich in silt and constitute major soil type of Gash area (Appendix 1). The soil of the experimental site is mild alkaline with PH range from 7.5 to 8.1. None saline non sodic alluviumsoil with silt range from 49% -54%, clay range from 37% to 41% and sand range 7% to12%. The electrical conductivity (EC) decreasing with the depth, while ESP increasing with the depth for R_1 and R_2, while R_3 and R_4 are equal. Fertility level is low.The field study was carried out in one site by irrigation for two consecutive seasons during the period from September to December 2015 and 2016 respectively. The climatic data for the period from September 2015 to January 2016 and from September 2016 to January 2017 as presented in Appendix(2) showed that maximum and minimum temperature for September. and October. 2015 were greater than that of 2016, while the maximum temperature for the period Nov. 2015 follow the same trend as the period of 2016. While during Dec 2015 compared with that of 2016 the maximum temp deceased while that of minimum increased. The evaporation increase with the increase in temp. It was also noticed that the relative humidity(R.H.%)was higher during September and it started to decrease during November, and it started to increase during December. During September October the sun shine duration was low due to the presence of clouds while during November December sun light duration was higher because no cloud cover during this period.The seeds used consisted of 3 varieties namely Hudeiba-1, Hudeiba-2 and variety113 which are open pollinated varieties obtained from Agricultural Research Corporation (ARC) Maize Research Program.Land preparation was done according to ARC package**.** The land was ploughed using disc plough, then disc harrow used to break soil clouds, then leveling by the scarper to obtain a fine uniform seed bed. Then ridges 0.8 m used to make ridges, then the plough used to make three ridges 1m apart in each plot, which is known as the farmers practice in all Gash area the flat was divided into plots 3*3 meters area, and crop was sown with (20, 30 and 40 cm) between hills in all types of land preparation.All cultural practices were applied as recommended by ARC. No fertilizer and/or pesticide were applied. Hand weeding was executed thrice at 2nd, 6th and 8th weeks after planting to keep plots free of weeds. Seven irrigations were carried during the growth period with two weeks interval.

2.2. Data Collection and Analysis

After establishment population/plot was counted and registered, during growth 50% Tasslling and 50% silking were observed and registered. At harvest time the parameters measured were Plant height cm, leaf area index, and yield kg/ha. After emergence the plants were thinned to one plant/hill, resulting in about (62500, 41670 and 31250 plants/hectare respectively). A randomized complete block design (RCBD) with three replications was used to arrange the data in split split trail with the sowing method at the main plot, the spacing at the sub plot and variety at the sub-sub plot. All data were analyzed using Statistics10 Computer Based program. Means were separated using Least significant Difference (LSD), according to Gomez and Gomez [8].

3. Results and Discussion

3.1. Effect of Sowing Methods on means of Morphological and Phonological Attributes

The effect of sowing methods on means of the measured attributes as shown in table 1: Statistical analysis revealed that ridge sowing methods (SMs) affected population density (42.0) during the first season, and plant height (177.5), and flat SMs significantly affected 50% silking (57.9 days) during the second season. while ridge SM scored higher insignificant levels of plant height during the first season and leaf area index during both seasons amounted (188.7 cm plant height, 2.0 and 1.42 leaf area index). Local farmers' methods scored higher insignificant rate with respect to number of days to 50% Tasselling during both seasons amounted (59.5 and 43.3 days respectively), and number of days to 50% silking during the first season, while flat SM resulted in higher insignificant rates of seed yield during both seasons amounted (1732 and 1740 kg/ha respectively). These results are in conformity with Anjum, *et al.* [9], he reported thateconomically, maize sown on ridges under deep tillage gave maximum net income of Rs. 85162 ha$^{-1.}$.

3.2. Effect of Intra-row Spacing on means of Morphological and Phonological Attributes

The effect of intra-row spacing on means of morphological and phonological characters presented in table 1: Statistical analysis revealed that intra-row spacing significantly affected population density, plant height, 50% flowering and 50% Silking and seed yield kg/ha during the first season scoring (48.1, 191.2 cm, 59.9 days, 63.2 and 1767 kg/ha respectively) and leaf area index (LAI) during the second season scoring (1.92). Intra-row spacing of 30 cm scored higher significant levels of most measured characters (192 cm plant hight,1.92 LAI,2.27 stem diameter, 59.9 days 50% tasselling and 63.8 days to 50% Silking). 20cm intra-row spacing scored significant higher level of population density of (48.1 plants/plot) and insignificant level of seed yield/ha amounted 1765 kg/ha.

3.3. Effect of Varieties on Means Morphological and Phonological Attributes

The effect of varieties on means of morphological and phonological attributes shown on table 1: Statistical analysis showed that varieties had significant effect on plant population during first season (39.9 plants/plot), and leaf area index (LAI) scored higher rate of (, 1.99 and1.43) during both seasons respectively. Variety 113 scored higher levels with respect of population density of (39.9/plot), tallest plants of (188.9 and 158.0), LAI during both seasons as (1,99 and 1.43), days to 50% tasselling of (59.4) and 50% and silking of (57.4 silking) and seed yield of (1683 and 1766 kg/ha) compared with other treatments. Variety Hudeiba1 scored higher rates of population density of 42.9 plants/plot, days to 50% tasselling of 42.9 days during second season while number days to 50% silking of 63.9 days during the first season. while Hudeiba2 scored high rate of number of days to 50% silking of 63.5 days during the first season.

3.4. Effect of the Interaction between SMs, Varieties and Intra-Row Spacing

Sowing methods (SM) and intra- row spacing (S)SM1* S1, affected population density and resulted in higher rate of 57.6. The combination SM2S1V3 of population density gave the highest level of the population density amount 52.3 during 2015 while during 2016 it results in48.1.The combination of SM2*S2*V3 of plant height resulted in the highest level amounted 202.9. The combination of SM2*V3*S1 gave the highest level of LAI of (1.92) during the first season. The combination of SM2*V2S2cmduring the second season (2016) SM2*V1*S2 gave significantly higher level of population density amounted 58.9 plant/plot, while the combination of SM1*V1*S1 gave the highest level of plant height amounted 182.7cm. The combination of SM3*V1*S1 of leaf area index gave the highest level LAI of 2.2 during first season. The combination of SM1*S2*V3 and SM2*S3*V3 gave the highest level of the days to 50% amounted 61 days, while the days to 50% Silking combination of SM1*S2*V3 , SM2*S3*V2. The combination of SM*S*V of seed yield kg/ha gave the highest significant interaction and resulted in 2277 kg/ha during 2015, this combination was SM3S2V3 and SM2 S3 V3. While during 2016 theSM2*S*V interaction was not significant despite this the SM2*S1*V3 scored 2187 kg/ha.

4. Conclusion

From the above discussion we can reached to the following conclusions:

1- Sowing methods affected the morphological and phonological attributes differently in such a way that ridge sowing method scored higher levels with respect to most measuredcharacters followed by flat sowing method and farmers local method was the least.

2- The response of the morphological and phonological attributes differ with the variety, variety 113 response positively with most measured morphological and phonological attributes and scored higher levels.

3- The intra-row spacing is considered to be the most determinant factor of yield, low population results in reduction of yield, while optimum population density results in satisfactory yield. 30 cm intra-row spacing result in more rates of most measured attributes.

Table-1. Morphological and Phonological attributes of ThreeMaie (Zea mays L.) varieties Affected by Sowing Methods, Intra-row Spacing on: Population density, Plant height, 50% Flowering, 50% Silking, Leaf Area Index and Stem diameter

	Population D		**Plant Height cm)(**		**Leaf Area Index**		**days to50% tasselling**		**days to 50% Silking**		**Seed Yield (kg/ha)**	
season	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Ridge	42.0	39.8	188.7	177.5	2.00	1.42	59.1	41.7	63.2	56.4	1547	1578
Flat	39.9	49.7	184.7	125.7	1.92	1.35	59.2	41.8	63.1	57.9	1732	1740
F.M.	31.2	37.7	186.2	167.2	198	1.37	59.5	43.3	63.5	56.3	1626	1578
LSig	*	Ns	Ns	*	NS	NS	NS	Ns	Ns	*	NS	NS
LSDR	2.71	-	-	3.91	-	-	-	-	-	1.29	-	-
LSDFL	2.89	7.94	9.83	1.58	-	0.07	0.97	2.37	0.99	1.33	164.3	319.
LSDF	-	-	-	-	-	-	-	-	-	-	-	-
20 cm	48.1	40.5	178.5	155.9	1.88	1.28	58.2	42.6	62.0	57.1	1767	1595
30cm	36.1	45.2	189.8	158.9	2.06	1.92	59.9	42.2	63.8	56.8	1640	1637
40cm	28.5	41.5	191.2	156.4	1.95	0. 98	59.8	42.4	63.9	56.8	1500	1684
LSig	*	Ns	*	NS	NS	***	*	Ns	*	Ns	**	NS
Hud-1	37.4	-	184.2	-	-	1.36	59.	-	62.9	-	1568	-
Hud-2	36.8	41.8	185.3	157.7	1.97	1.35	59.5	42.1	63.5	56.7	1654	1625
Vari 113	39.9	42.5	188.9	158.0	1.99	1.43	59.4	42.2	63.3	57.1	1683	1766
LSig	*	Ns	Ns	NS	*	*	Ns	Ns	Ns	Ns	NS	NS
Hud-1	37.4	42.9	184.2	155.6	1.93	1.36	59.	42.9	62.9	56.9	1568	1525
R*V	Ns	Ns	NS	NS	NS	NS	Ns	Ns	Ns	Ns	NS	NS
LSD	-	-	-	-	-	-	-	-	-	-	-	-
R*S	Ns	Ns	Ns	Ns	NS	NS	Ns	Ns	Ns	Ns	*	NS
LSD	5.28	8.165	15.19	1.07	0.20	1.42	1.50	3.03	1.47	2.11	270.0	469.
V*S	Ns	Ns	Ns	Ns	NS	1.35	NS	Ns	Ns	Ns	*	NS
LSD	-	-	-	-	-	1.37	-	-	-	-	270.0	-
R*S*v	Ns	*	NS	NS	NS	NS	Ns	Ns	Ns	Ns	*	NS
LSD	-	14.14	-	-	-	-	-	-	-	-	467.7	-.

SM= Sowing method, Kg/ha= Kilogram/ hectare,, FM=Farmer' Practice, Lsig=Level of significant ns=not significant, *,**,*** significant to highly significant, LSD $_{0.05}$= Least significant difference at (P=0.05), R*V=interaction between sowing method and variety, V*S= interaction between variety and Intra-row spacing, P*V*S= interaction between sowing method , variety and Intra-row spacing

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Appendix-1. Gash Soil Analysis

Soil name	PH	EC Dl/m-1	SAR %	ESP %	OC %	N Ppm	P Ppm	K ppm	Sand ppm	Clay ppm	Silt Ppm
R1	8.1	o.83	1.2	1.9	0.20	340	2.4	37.5	9	37	54
R2	7.8	o.80	1.6	2.3	0.05	215	2.3	31.3	11	35	54
F1	7.9	1.1	2.1	3.0	0.05	401	2.3	37.3	12	39	49
F2	7.5	0.84	2.1	3.0	0.73	211	2.3	12.5	7	41	52

EC-Electrical conductivity, SAR=Sodium Absorption Ratio, ESP=Sodium exchangeable %, OC=Organic Carbon

Appendix-2. Climatic Data from September to January for 2015 and 2016 Season: min., maxi and mean temperature, R.H.%, Evaporation (Piche mm), R.F mm, Sunshine/day, Hours of Sunshine, Wind direction and speed

Month	Maxi. Temp.	Mini. Temp.	Mean Temp.	Mean RH%	Evap Piche mm	Rain Fall Mm	Sunshi -ne D.	Sunsh Hours /day	Wind Direct Ion	Wind Speed Knots
Sept 2015	38.3	25.1	31.7	47	10.1	2.5	79	9.7	S	0.3
Sep. 2016	35.7	23.8	29.8	59	-	2.0	-	-	S..SW	03
Oct 2015	39.9	26.0	33.2	37	13.0	2.5	79	10.1	A.D.	03
Oct 2016	39.1	24.9	32.1	41	-	13.9	-	-	A.D	03
Nov 2015	38.1	23.5	30.9	37	12.9	0	92	10.5	N. N	03
Novr2016	38.1	23.0	30.8	33	-	Nil	-	-	E	03
Dec 2015	32.9	18.3	25.5	45	10.1	0	86	09.6	N.NW	03
Dec 2016	36.3	21.3	28.7	45	-	Nil	92	10.5	N.,NE	03
Jan 2016	34.1	16.9	26.0	42	11,4	Nil	90	10.1	N.	0.3
Jan 2017	33.4	16.6	29.8	42	10.7	Nil	86	9.8	NW	0.3

Source: Metrology department Kassala,Sudan