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Journal of Agricultural and Veterinary Sciences
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Performance of Maize (*Zea Mays L.*) under Different Sowing Methods and Intra-Row Spacing

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Received: **Accepted:**

Abstract:
Field experiments were conducted in demonstration farm of the college of Agricultural studies, Sudan University of Science and Technology, Shambat, Khartoum North, Sudan, to study the effects of sowing methods and intra-row spacings on some agronomic characteristics of Maize crop, Hudeiba I cultivar, seasons 2019/20 and 2020/21, including plant height, stem diameter, leaf area index, number of rows/ear, number of seeds/ row, number of grains per Ear, 1000-grains weight and grain yield (t.ha^{-1}), were conducted. The experimental design was a Randomized Complete Block Design in split plot arrangement with three replications. Main plot were sowing methods (drilling, ridging and terrace). Subplots were intra-row spacing of (10, 15, 20, 25, and 30 cm). Sowing methods and intra-row spacing had significant effects on plant height, number of seeds per ear, and grain yield. Row spacing had non-significant effects on stem sickness, number of rows per cob and 1000-grain weight. Intra-row spacing at 20 cm was gave the highest grain yield (6.99 t.ha^{-1}) and the same intra-row spacing 20 cm combined with ridging sowing method were gave the maximum grain yield, so they were achieved (8.33 t.ha^{-1}). Intra-row spacing (10 cm) in combination with terrace sowing method were produced the lower grain yield (3.53 t.ha^{-1}), and intra-row spacing 10 cm with drilling sowing method were gave the highest plant height in both two seasons, they were achieved 190.13 cm. It's clear that plant height increased with decrease in intra-row spacing. Stem diameter decreased with decrease in intra-row spacing.
Keywords: Maize, intra-row spacing, Hudeiba I, grain yield, leaf area index

Introduction

Maize (*Zea mays L.*) is a member of the grass family, Poaceae (Gramineae); it's the world's widely grown highland cereal and primary staple food crop and animal feed in many developing countries (Kandil, 2014). It is the third most important staple food crop both in terms of area and production after wheat (*Triticum aestivum*) and rice (*Oryza sativa*) in the world (Yearbook, 1995). Maize demand is projected to increase by 50% worldwide` and by 93% in sub-Saharan (FAO, 2015; Temesgen, 2019). In many countries becoming the main food crop, especially part of Africa and Asia countries. Maize also known as corn, domesticated by indigenous people of South Mexico before 10,000 years ago (Ali, 2019). The rapidly increasing demand of maize is driven by increased in demand for direct human consumption in the world as a staple food crop (Ghimire *et al.*, 2007; Kandil, 2014). This made many researchers, research centers and countries focus on this crop in order to fill any potential food gap in the world, whether through direct consumption or through animal and poultry feed. Where increasing grain yield per unit area and increasing the corn are the best solution to decrease the gap between consumption and production from feed and forage. Determination of the optimum plant density and in combination with appropriate agronomic practices is an important component of crops production package for maximizing productivity. Among the good agricultural practice to achieve this goal is to define the best row and intra-row spacing. Decreasing intra-row spacing decreased the number of inflorescence per plant, leaf area, shoot dry weight and grain yield per plant but increased plant height (Kandil, 2014). Maize was non-major crop in Sudan, but in the past few years the need for it has grown, as it is used in livestock and poultry feed, in addition to use in other food industry and biofuel (ethanol). In fact, area cropped with maize amount to 126 thousand acre (121,500 Feddan) about 51000 ha^{-1}, which is 82% of that of 2013 (FAOSTAT, 2016). It's becoming the fourth importance, after rice (*Oryza sativa*) wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*) and millet (*Pennisetum glaucum*). It is grown mainly as food and feed crop (both forage and grain). Also it's of minor importance, it is only grown in River Banks, in small batches and in "Jobraka" system of farming around houses in rural areas, in irrigated schemes and in modern irrigation systems in Khartoum and River Nile States (Ali, 2019). Maize optimum cultural practices should be determined to satisfy increasing demand for the crop. Also its production is greatly affected by varying planting density than other members of the grass family because of its monoecious floral organization, its low tillering cognition to fill the gap among plants and the presence of synopsis ontogeny punctuation (Ali *et al.*, 2017).

The establishment of an adequate plant density is critical for utilization of available growth factors such as water, light, nutrients and carbon-dioxide and to maximize grain yield. Decreasing the distance between neighbor rows at any particular plant population has several potential advantages. It reduces competition among plants within rows for light, water and nutrients due to a more equidistant plant arrangement (Tesfaye, 2020).

Growth and grain yield of maize is more affected by variations in hill spacing than other members of the grass family. Too wide spacing leads to low plant density per unit area and reduces ground cover, whereas too narrow spacing is related to intense competition between plants for growth factors (Tesfaye, 2020). The low yield of crops has been partly attributed to inappropriate plant density, planting time, and pest pressure (weeds, diseases and insect pests) (Gobeze *et al.*, 2012). Determination of optimum plant population, adapted varieties and appropriate agronomic practices are important components of maize production package for maximizing productivity.

Successful production of any crop depends on the application of production inputs that will support the environment as well as agricultural production, these inputs including; adapted varieties, plant population, soil tillage, fertilization, weed, insect and disease control, harvesting, marketing and financial resources. Maize crop characterized as low tillers, this poses that population density should be manipulated to compensate the spaces created by the low tillering character; therefore, studying plant densities will be vital importance. Many cultural practices like optimum sowing methods, intra-row spacing, and suitable varieties which achieve economical yield are also crucial for farmers and producers to increase their returns, change life style, and increase the investment capital of producers and investors. The increase of maize crop yield adds up to the satisfaction of the growing demand of the increasing livestock and poultry industry.

The experiments were conducted to adapt the best cultural practices that increase maize production in the Sudan, especially in Khartoum North area. Therefore, the overall objective is to study the effects of sowing methods, intra-row spacing on growth, yield and yield components of maize crop.

Materials and methods

Description of experiment:

Two experiments were conducted at experimental farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Khartoum North, Sudan, during seasons 2019/20 and 2020/21 to investigate the effects of three sowing methods (drilling, ridging and terrace) and five intra row spacings (10, 15, 20, 25 and 30 cm) on some agronomic characters of maize using the (cultivar Hudeiba I), using a Randomized Complete Block Design in a split plot arrangement, keeping sowing methods as a main plots and intra-row spacing as sub-plots, plant populations of these intra-row spacings at all sowing methods are (10.0, 6.67, 5.0, 4.0 and 3.33 plants m^{-1}) respectively (Table 1), the plot measuring size is 12 m^2 (4 rows× 3 m) with three replications (Table 1), (drilling sowing method was leveled the four ridges and seeds were sown in four lines, the terrace sowing method was combined every two ridges together to compose one terrace and seeds were sown at the sides of any terrace). The spacing of 1.0 m and 1.5 m were left between plots and blocks, respectively. The area suited in the low land, River Nile, which lies between Latitude 15˚ 40' N and longitude 32˚ 32' E, evaluation 380 m above Sea level (Gol, 2018).

Climate:

The climate according to Shambat Metrological station, described as tropical semi-arid, the maximum annual rainfall ranges between 160- 180 mm, occurring during July to September. Relative humidity ranges between 31- 51% during wet season and 12-27% during dry season. Mean maximum and minimum temperature in Khartoum North are 41.7˚C and 15.3˚C respectively. Winter season from Nov. – Mar. and is relatively cool and dry. Summer season is hot and dry.

Plant material:

The open pollinated variety of grain maize (Zea mays L.) used in this study was obtained from Agricultural Research Corporation (ARC), Hudeiba station.

Land preparations:

Land was well prepared (soil was ploughed with disc plough to uproot the previous crop, followed by disc harrow, cross harrow, leveling and finally ridging operation), all these operations were done by tractor. After that, field was divided into plots, drilling and terrace were done manually after divided the soil. Soil of Shambat is well drained loamy clay, non-saline, non-sodic, and classified as predominantly as arid sols with pokets of Vertisols formed on old alluvium deposits, and Entisols on recent alluvium and aeolian deposits, with pH ranging from 7.71 to 7.91 (Hamadtou, 2016; Gol, 2018; Osman, 2021)

Sowing methods and time:

The experiments were sown on 4th week of Nov. during both seasons. Two seeds per hole were sown manually in the last end-Nov, thinning to a single plant per each hole was done when seedlings produced four real leaves. Sowing was done manually. Pumping water from River Nile is common; in addition, underground water used as supplementary irrigation when River pump station was failed, especially in the second season. First irrigation was given after 15 days from the sowing in the first season and 7 days in the second season (this delay is due to failure of pump station machine). For the 1st month field was shallow irrigated at 7 interval days, while after a month till to tasselling and silking irrigation 10 days interval applied deeply by furrow system, and at critical time at tasselling and silking stage field was irrigated by 5 days interval to initiate flowering and silking, most of the time irrigation has been done after noon to avoid loses of water from the field by evaporation.

Fertilization:

Phosphorus fertilizer in the form of DAP (Diammonium phosphate 18% N and 46% P_2O_5) at the recommended dose of 100.0 kg. ha^{-1} this equivalent (9 kg N and 46 kg P_2O_5) and half of recommended dose of Nitrogen fertilizer in the form of Urea 46% N 250.0 kg ha^{-1}, this equivalent (115.0 kg N) were added uniformly to all plots manually at the time of the sowing and the rest half of N-fertilizer was added after 35 days (5 weeks) from the first irrigation during both seasons.

Herbicides:

Herbicide 2-4-D (2-4-dichloro-phenoxyacetic acid) 4.0 L. ha^{-1} was applied manually by Knapsack to protect the crop from broad leaves in second season only.

Insecticides: Amidocloprid (N-{1-[(6-Chloro-3-pyridyl) methyl]-4, 5-dihydroimidazol-2-yl} nitramide) 1.50 L/ha^{-1} was applied manually by Knapsack, to control the Armyworms Mythimna Spp. (Lepidoptera: Noctuidae) appeared during both seasons.

Data Collection:Plant height (cm):

Plant height was measured from six randomly pre-tagged plants from the net plot area and then their height was measured from the soil surface to point where the tassel starts to branch with a meter rod at physiological maturity.

Stem diameter (mm):

Stem diameter was measured at 30 cm over the soil surface using the vernier caliper to determine the plant thickness and effects of sowing methods and intra-row spacing.

Leaf area (cm^2):

Leaf area per plant and leaf area index was recorded at 50% milk stage by measuring the leaf length and maximum leaf width of three leaves (top, middle, and bottom) per plant from six randomly pre-tagged plants from each net plot, the average of the three leaves was multiplied by the total number of leaves per plant and the area was adjusted by a correction factor 0.75 (i.e. 0.75× leaf length× maximum leaf width) as described by (Francis et al., 1969). The leaf area index was determined as the ratio of leaf area per plant divided by the respective ground area occupied by the plant.

Ear length:

Ear length was recorded from six pre-tagged plants and measured their ear height from attached of stalk level to the node bearing the top useful ear with a meter rod at physiological maturity.

Ear diameter:

Ear diameter was recorded also from the same six ears taken from the net plot area (The same ears from which the length was taken), and then their diameter was measured at the middle of ear with vernier caliper; the mean was recorded as an ear diameter.

Number of rows/ear:

The number of rows per ear was counted with the average number of rows in six ears **from the same six pre-tagged plants, where the number of rows from six ears was counted and divided by their number.**

Number of kernels/ row (KR):

Number of kernels per Ear (KR) was recorded from the six ears taken from the same six pre-tagged plants.

Number of kernels/ ear:

Number of kernels per ear were recorded by multiplying the total number of rows per ear and the number of kernels per row was recorded from the same six ears taken from the net plot area (The same ears from which the lengths and thickness were taken) in the net plot area after harvest and the average was recorded.

1000-kernels weight (GW)

Thousand kernels were counted from randomly taken ears after shelling by (manual counted). Then, thousand kernels weight was recorded from weighed thousand kernels using sensitive balance and adjusted to 12.5% moisture level.

Grain yield (GY):

Grain yield per plot was recorded using electronic balance and then adjusted to 12.5% moisture and converted to hectare basis. The trend of data collected during two seasons was found similar, so the data was averaged.

Statistical analysis:

The data was subjected to analysis of variance (ANOVA) using Statistical Analysis System (Statistix10, 2013) version 10.0.1.5 Software using proc GLM procedure. LSD was used to separate significantly differing treatment means after treatment effects were found significant at $P \leq 0.05$

Results and Discussions: Analysis of variance showed a significant differences among sowing methods,. intra-row spacing and interactions of both variables were obtained from leaf area index (LAI), number of kernels per row, and grain yield in the combined results of two years, all results were shown in (Tables 2- 4).

Plant height (cm):

Analysis of variances of plant height showed no significant affected due to the main effects of sowing method, but highly significant at (P>01) of intra-row spacing and significant at (P>05) of combined analysis of sowing methods with intra-row spacing, the highest plant height 190.13 and 181.73 cm were obtained from an interactions of drilling and ridging sowing methods with 10 cm intra-row spacing, respectively, while the lowest 139.20 and 134.20 cm were recorded from interactions of terrace sowing method combined with 25 cm intra-row spacing followed by interactions of drilling sowing method combined with 30 cm intra-row spacing, (Table 2).

Plant height was increased with decreased of intra-row spacing (increase in plant population from 3.33 to 10.0 plants.m-1), and these might be due to competition among plants about growth factors (moisture, nutrients, solar radiation and wind), these results agreement with (Gondal et al., 2017), they found that plant height was increased with increasing seed rate and decreasing row spacing. (Snider et al., 2012), reported that the effects of seeding rate on the plant height to be significantbut contrasting effects at different sites. The intra-row spacing of 10 cm was resulted in highest plant height among all intra-row spacings and interactions among sowing methods; the lower plant height (134.20 cm) was obtained from drilling sowing method and interaction with 30 cm intra-row spacing. Also (Azam et al., 2007), reported that various varieties of maize have genotypic differences for plant height where the tallest plant height (145 cm) was recorded for variety Cargill 707 and the shortest plant height (134 cm) was recorded for variety Baber.

Stem diameter (mm):

Analysis of variances of stem diameter showed significantly (p>01) affected by intra-row spacing but sowing methods and interaction between sowing methods and intra-row spacing had no significant effects. The highest stem diameter (20.3 mm) was determined at interaction of drilling sowing method with 30 cm intra-spacing, while the lowest stem diameter (15.3 mm) was recorded at interaction of drilling and ridging sowing methods with 15 cm intra-row spacing. 30 cm intra-row spacing was resulted the maximum (19.9 cm) stem thickness over the all other intra-row spacings (Table 2). These results may due to the fact that higher seed rate directly results in higher stems density and a higher stem density resulting in decrease in stem diameter due to the obvious interplant competition due to narrower of holes between plant to plant. These results were in line with (Schmitt and Wulff, 1993; Werf et al., 1995) they reported that increase in seed rate from 5 kg ha^{-1} to 15 kg ha^{-1} resulted in a significant decrease in stem diameter while increased the stem density. Higher plant density produces thin stemmed plants that tend to lodge (Kashiwagi et al., 2008; Venuto and Kindiger, 2008). **Leaf area index:**

Analysis of variance showed a highly significant at ($P < 0.01$) affected by way of sowing methods and significant at ($P > 0.05$) affected by two ways (intra-row spacing and interactions of sowing method with intra-row spacing). Therefore, analysis and combined analysis of variance depicted that the maximum leaf area index (8.33 and 7.27) were obtained from interactions of the intra-row spacing 20 cm× ridging sowing method and intra-row spacing 20 cm with drilling sowing method respectively (5.0 stalk. m^{-1} plant density), whereas the minimum leaf area index (3.53 and 3.93) were attained from combination of the terrace sowing method× 10 cm intra-row spacing (10.0 stalk. m^{-1} plant density) and terrace sowing method combined with 30 cm sowing method, respectively (Table 2).

In this study, it’s clear that leaf area index was increasing with increasing the intra-row spacing till to 20 cm intra-row spacing and decreasing again, the possible reasons for the highest leaf area for ridging sowing method at the medium intra-row spacing (20 cm) might be due to the optimum conditions and ability of plant to uptake its sufficient needs from soil solution and solar radiation interception. These results were agreed with (Ngugi et al., 2013), he mentioned that lower plant population got more nutrients and water compared to higher population, thus contributed increased leaf area unlike high plant population density that reduced low leaf area of maize decreased. Similarly (Tesfaye, 2020), reported that the main effects of both intra, inter-row spacing and their interactions on leaf area were significant ($P < 0.05$), also he found that the leaf area per plant was increased with increasing inter and intra-row spacing.(Borrás et al., 2003; Ali et al., 2017) reported that a less leaf area index (LAI) duration could be resulted in response to increased plant population in the field due to more leaf senescence rate during grain filling. (Ali et al., 2017) mentioned that photosynthetic efficiency, growth and development in maize are greatly related to the effect of canopy architecture on the vertical distribution of light within the plants canopy. The optimum plant density is one of the ways of increasing the capture of solar radiation within the canopy. However, the efficiency of the conversion of intercepted solar radiation decreases with a high plant population density because of mutual shading in the plants in the field (Zhang et al., 2006; Ali et al., 2017).

Number of rows per Ear:

The effects of sowing methods (SMs) and intra-row spacing on means of number of rows per ear were presented in (table 3). Statistical analysis showed no significant differences among the number of rows per ear affected by sowing methods and intra-row spacing.The maximum number of rows/ear (14.27) were recorded from the interactions of ridging sowing method with 20 cm intra-row spacing, followed by the interaction of terrace sowing method with 30 cm intra-row spacing, was achieved (14.07 cm). These results were agreed with (Ibrahim et al., n.d.) found that the ridging sowing method scored higher rates of ear number , number of seeds/ ear, number of seeds per row and hay yield, also mentioned that the increase in intra-row spacing from 20 cm to 25 cm significantly increase number of row/ ear, 100 seed weight and grain yield.

Number of kernels per row:

The effects of sowing methods and intra-row spacing on number of kernels per row were presented in (table 3). Statistical analysis showed highly significant differences among mean of number of kernels per row and it was affected by three ways of sowing methods, intra-row spacing and interactions of SMs with intra row spacings. However, 20 cm intra-row spacing was achieved the highest number of kernels per row (30.52) while the 30 cm intra-row spacing was scored the lowest number of kernels per row (25.93). Moreover ridging sowing method (SM2) scored the higher level of kernels per row and achieved the 29.35 over the drilling and terrace sowing methods and they were achieved 26.78 and 26.24 respectively. The interaction effects of these cultural practices, ridging sowing methods with 20 cm intra-row spacing were achieved the highest number of kernels per row, achieved 33.93 while the lowest number of kernels per row were achieved by drilling and terrace sowing method methods with (25 and 30 cm) intra-row spacing respectively, they were scored 25.27 number of kernels per row. These results may due to the optimum conditions of the 20 cm intra-row spacing with ridging sowing method, crop was uptake the sufficient required from the soil nutrients and moisture and optimum distance between plants to intercepts their needs from solar radiation for good photosynthetic.

Number of kernels per ear:

Number of kernels per ear contributes to the economic yield and represents the productive efficiency of any cereal crop or crop variety (Kebede, 2019).Number of kernels per ear was highly significant ($p < 0.01$) affected by the main effects of intra-row spacing, significant ($P > 0.05$) affected by sowing methods (SMs) and there was no significant effects by interactions among the experimental variables. Highest number of kernels per year (484.14, 399.03) was recorded at interactions of ridging sowing with 20 cm intra-row spacing and however followed by drilling sowing interacted with the 20 cm intra-row spacing, while the lowest number of kernels per ear (313.85, 335.30) were recorded under interactions of terrace sowing method with 25 cm and 15 cm intra-row spacing, respectively (Table 3), This variation might be due to the fact that widely spaced plants encountered less interplant competition than closely spaced plants and thus exhibited better growth that contributed to more number of kernels per ear. These results were agreed with (Mukhtar et al., 2012) reported that wider spacing (17.50 cm) produced higher number of kernels per ear (717.00) while narrower spacing (10 cm) gave lower number of grains (540.30). In same line also (Eskandarnejada, 2013) reported that wide inter-row spacing of 30 cm produced more number of kernels per ear than that 20 cm plant spacing.

1000- kernels weight:

The effects of sowing methods and intra-row spacing on means of 1000-kernel weight were shown in (Table 4). Main effects of intra-row spacing were highly significant ($P < 0.01$) on thousand kernel weight. However, the sowing methods and their interactions were not significant. The highest thousand kernels weight (325.72 g) was recorded at the 20 cm intra-row spacing, whereas, the lowest (235.0 g) was recorded at the 25 cm intra-row spacing. The highest 1000-grain weight 358.0 g was recorded at interaction of 20 cm intra-row spacing combined with ridging sowing method. The parameter of increase in 1000-grain weight was reflected in the grain yield increase confirming its contributive factor for grain yield. Thousand kernel weights was increased with increasing of intra-row spacing till to 20 cm and decreased again, this might be due to optimum condition to assimilate partitioning between higher numbers of kernels used in connection with the decreased interplant competition that lead to increased plant capacity, for utilizing the environmental inputs (solar radiation interception, wind and soil aeration) addition to agronomic practices with additives like fertilizers and water in building great amount of metabolites to be used in developing new tissues and increasing its yield components. These results were agreed with (Kandil et al., 2017), Reported that maize hybrids i.e. varieties have different response to agronomic characters and grain yield. Also (ALias and Lshaque, 2010; El-Metwally et al., 2011) showed a significant difference between plant heights, number of ears/ plant, LAI, number seeds/ row, grain weight/ ear and grain yield. (Fernandez et al., 2012) reported that the single-row planting at low plant population produced the highest grain weight.

Grain yield:

Grain yield was showed in (Table 4). Statistical analysis showed a significantly ($p > 0.05$) affected by the interactions of sowing method with intra-row spacing. Accordingly, the highest grain yield (8.33 ton. ha-1) was obtained in combination of ridging method with 20 cm intra-row spacing, while the lowest grain yield (3.53 ton. ha-1) was obtained from terrace sowing method in combination with narrowest intra-row spacing 10 cm.The possible reason for the lowest grain yield at narrowest spacing might be due to the presence of competition of plants per unit area for solar radiation interception, moisture, available nutrients and other sources in the soil. This indicated that high plant population per unit area that could not get better available growth factors like moisture, nutrients, light, and space could not offset the grain yield obtained from high plant population per unit area. Previous research reveals indicated that plants grown on wider spacing absorb more nutrients and solar radiation for improved photosynthesis and hence produce better grain yield on an individual basis, but yield per unit area reduced due to a thin and low plant stand on unit area. (Ibrahim and Elhassan, 2019), Mentioned in the conclusion study that among the three sowing methods ridge method scored the highest rates of the majority of the measured characters. As far as the Intra-row spacing 30 cm and 40 cm scored the highest levels of almost all measured characters.

Within the three varieties used, the variety113 gave highest levels of all measured attributes. The combination of (drilling) Flat× 40 cm× V113 and (drilling) Flat ×30 cm× V113 of the interaction between the three treatments during the first season and the combination of (drilling) Flat× 20 cm V113 during the second season gave highest levels of yield in Kg.ha-1 (Ibrahim et al., 2019.).

Conclusion and Recommendation

From these findings, we are recommending following ridging sowing method and 20cm intra-row spacing in this area and variety.

Table 1: Combination Treatments and Descriptions

No	SM× Intra-row spacing	Plot area (m^2)	Plant density/ m^{-1}
1	SM1 IRSP1	12 m^2	10.0
2	SM1 IRSP2	12 m^2	6.67
3	SM1 IRSP3	12 m^2	5.00
4	SM1 IRSP4	12 m^2	4.00
5	SM1 IRSP5	12 m^2	3.33

SM= Sowing Methods (1= Drilling (Flat), 2= Ridging, 3= Terrace), IRSP = Intra-row Spacing (1= 10, 2= 15, 3= 20, 4= 25 and 5= 30 cm).

Table 2: Effects of sowing methods and intra-row spacing on growth parameters (PH, SD and LAI) of maize

Treatments	Plant height (cm)	Stem diameter (mm)	LAI (cm)
IRSP1 (10 cm)	179.76a	15.7c	4.74d
IRSP2 (15 cm)	170.62ab	15.6c	5.70c
IRSP3 (20 cm)	164.30b	16.1c	6.99b
IRSP4 (25 cm)	151.31c	18.5b	5.07ab
IRSP5 (30 cm)	145.96c	19.9a	4.86a
LSD (0.05)	4.19**	0.04**	0.07*
SM1 (drilling)	165.11a	17.1a	3.63ab
SM2 (ridging)	171.28a	17.1a	3.99a
SM3 (terrace)	150.77a	17.3a	3.28b
LSD (05)	10.86ns	0.06ns	0.14**
SM1 IRSP1	190.13	15.7	5.13
SM1 IRSP2	166.40	15.3	5.93
SM1 IRSP3	181.10	16.3	7.27
SM1 IRSP4	153.73	17.7	4.80
SM1 IRSP5	134.20	20.3	5.03
SM2 IRSP1	181.73	15.7	5.57
SM2 IRSP2	180.20	15.3	6.40
SM2 IRSP3	172.33	1.60	8.33
SM2 IRSP4	161.00	18.7	4.83
SM2 IRSP5	161.13	19.7	5.60
SM3 IRSP1	167.40	15.7	3.53
SM3 IRSP2	165.27	16.0	4.77
SM3 IRSP3	139.47	16.0	5.37
SM3 IRSP4	139.20	19.3	4.57
SM3 IRSP5	142.53	19.7	3.93
LSD (0.05)	7.74*	0.06ns	0.13*

IRSP = Intra-row Spacing (10, 15, 20, 25 and 30 cm), SM= Sowing Methods (1= Drilling (Flat), 2= Ridging, 3= Terrace), * Significant at 0.05%, ** significant at 0.01%., N.S. Not significant, LSD: Least Significant Different.

Table 3: Effects of sowing methods and intra-row spacing on yield components (RE, KR and KE) of maize

Treatments	Number of rows/ear	Number of kernels/row	Number of kernels/ Ear
IRSP1 (10 cm)	13.50a	26.98bc	363.86b
IRSP2 (15 cm)	12.96a	27.44b	355.81b
IRSP3 (20 cm)	13.51a	30.52a	414.22a
IRSP4 (25 cm)	12.91a	26.36cd	339.98b
IRSP5 (30 cm)	13.87a	25.93d	359.40b
LSD (0.05)	0.25ns	0.33**	10.15**
SM1 (drilling)	13.40a	26.78b	358.26
SM2 (ridging)	13.49a	29.35a	397.05
SM3 (terrace)	13.15a	26.21b	344.65
LSD (05)	0.33ns	0.33**	10.51*
SM1 IRSP1	13.00	27.20	353.27
SM1 IRSP2	12.67	27.67	350.90
SM1 IRSP3	13.40	29.77	399.03
SM1 IRSP4	13.93	25.27	351.90
SM1 IRSP5	14.00	24.00	336.20
SM2 IRSP1	13.60	27.87	379.03
SM2 IRSP2	13.47	28.33	381.23
SM2 IRSP3	14.27	33.93	484.14
SM2 IRSP4	12.60	28.07	354.20
SM2 IRSP5	13.53	28.53	386.63
SM3 IRSP1	13.87	25.87	359.27
SM3 IRSP2	12.73	26.33	335.30
SM3 IRSP3	12.87	27.87	359.47
SM3 IRSP4	12.20	25.73	313.83
SM3 IRSP5	14.07	25.27	355.37
LSD (0.05)	0.56ns	0.50**	18.21ns

IRSP = Intra-row Spacing (10, 15, 20, 25 and 30 cm), SM= Sowing Methods (1= Drilling (Flat), 2= Ridging, 3= Terrace), * Significant at 0.05%, ** significant at 0.01%., N.S. Not significant, LSD: Least Significant Different.

Table 4: Effects of sowing methods and intra-row spacing on yield components (1000 Kernels weight and grain yield) of maize

Treatments	1000-Kernels. wt (g)	Yield. T.ha-1
IRSP1 (10 cm)	236.7b	4.74c
IRSP2 (15 cm)	242.44b	5.70b
IRSP3 (20 cm)	325.72a	6.99a
IRSP4 (25 cm)	235.00b	5.07c
IRSP5 (30 cm)	243.00b	4.86c
LSD (0.05)	8.22**	0.15**
SM1 (drilling)	252.90a	5.63b
SM2 (ridging)	265.20a	6.35a
SM3 (terrace)	251.60a	4.43c
LSD (05)	7.39ns	0.07**
SM1 IRSP1	237.67	5.13
SM1 IRSP2	245.33	5.93
SM1 IRSP3	324.50	7.27
SM1 IRSP4	218.33	4.80
SM1 IRSP5	238.67	5.03

SM2 IRSP1	240.67	5.57
SM2 IRSP2	240.67	6.4
SM2 IRSP3	358.00	8.33
SM2 IRSP4	245.33	5.83
SM2 IRSP5	241.33	5.60
SM3 IRSP1	231.67	3.53
SM3 IRSP2	241.33	4.77
SM3 IRSP3	294.67	5.37
SM3 IRSP4	241.33	4.57
SM3 IRSP5	249.00	3.93
LSD (0.05)	12.79ns	0.26*

IRSP = Intra-row Spacing (10, 15, 20, 25 and 30 cm), SM= Sowing Methods (1= Drilling (Flat), 2= Ridging, 3= Terrace), * Significant at 0.05%, ** significant at 0.01%., N.S. Not significant, LSD: Least Significant Different.

Acknowledgement:
The authors gratefully acknowledge to the management team of the College of Agricultural Studies, Sudan University of Science and Technology for their unlimited support in accomplishing this work through two consecutive years.

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أداء الذرة (Zea Mays) تحت تأثير طرق البذر المختلفة والتباعد بين الصفوف

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المستخلص:

أجريت تجربة في المزرعة التجريبية بكلية الدراسات الزراعية، جامعة السودان للعلوم والتكنولوجيا، شمبات خلال مواسم 20/201 و 21/2020 لقياس تأثيرات طرق الزراعة والمسافات بين النباتات على عدد من الصفات الفلاحية لمحصول الذرة الاشامية (الصنف حيبة 1)، تضمنت: طول النبات، سمك الساق، دليل مساحة سطح الورقة، عدد الصفوف في الكوز، عدد الحبوب في الصف، عدد البذور في الكوز، وزن الـ 1000 حبة وإنتاجية الحبوب (طن/ هكتارٍ)، باستخدام الصنف: حديبة 1، تم استخدام تصميم القطاعات العشوائية الكاملة بتصميم القطع المنشقة بثلاثة مكررات، حيث كانت طرق الزراعة (الخطوط، السراب والمصاطب) تمثل القطع الرئيسية ومسافات الزراعة (10، 15، 20، 25 و30 سم) تمثل القطع الفرعية، أعطت النتائج تأثيراً معنوياً على طول النبات، عدد الحبوب في الصف وإنتاج الحبوب (طن/ هكتار) بينما لا توجد فروق معنوية في قياسات سمك الساق، عدد الصفوف في الكوز ووزن الـ 1000 حبة، مسافة الزراعة 20 سم أعطت أعلى إنتاجية للحبوب (6.99 طن/ هكتار) مقارنة مع بقية المسافات وكذلك نفس هذه المسافة مع طريقة الزراعة بالسراب أعطت أعلى إنتاجية للحبوب، حيث بلغت (8.33 طن للهكتار)، أما مسافة الزراعة 10 سم مع طريقة الزراعة على المساطب فقد أعطت أقل إنتاجية للحبوب، حيث بلغت (3.53 طن للهكتار) بينما مسافة الزراعة 10 سم مع طريقة الزراعة بصفوف أعطت أعلى طول للنبات (190.13 سم)، من الواضح أن طول النبات يزيد كلما قلت مسافات الزراعة، كذلك سمك الساق يقل كلما كانت مسافات الزراعة أقل.