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Impact of various planting directions and plant densities on yield and its components in maize (*Zea mays* L.)

Ahmed M. Saad[1*] and Tarek A. Elewa[2]

[1]Deptartment of Agronomy, Faculty of Agriculture (Moshtohor), Benha University, **Egypt.**
[2]Field Crops Research Department, National Research Centre, 33 El Bohouth St., Dokki-Giza, P.O. Box, 12622, **Egypt**.

***Correspondence:** ahmed.saad@fagr.bu.edu.eg **Received:** 04 Jan. 2017 **Accepted:** 03 Feb. 2017 **Published online:** 09 Feb. 2017

Two field experiments were carried out at the Experimental Research Station, Faculty of Agriculture (Moshtohor), Benha University, Kalubia Governorate, Egypt during two summer growing seasons (2014 and 2015) to evaluate yield and its components of maize variety Hi-tech 2031 under six planting directions: straight (North-South (N-S); East-West (E-W); diagonal (North. Eastern (N.E); North. Western (N.W)); others (Perpendicular (Perp) and Circular (Circ)) using three plant population densities of 16000, 24000 and 32000 plants/feddan (one feddan = 0.42 ha). Results could be concluded as follows: Planting directions, showed that the North.Western rows orientations was superior in producing grain yield, stover yield, plant and ear height, ear weight, ear diameter, number of rows/ear, shelling percentage and cob weight with significant differences of various magnitudes. Meanwhile, the East-West sowing direction was superior for number of kernels/row and light radiation intensity. Also, the highest ear length and seed index were obtained for planting in North.Eastern direction. Plant population densities, clarified that yield and yield components characters were generally increased as plant population density increased with various variable significant differences except for ear length, ear weight, cob weight, number of kernels/row and seed index.

Keywords: Planting direction; Plant densities; Maize; Grain yield; Light intensity.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops and ranks the third after wheat and rice in Egypt and worldwide. Efforts are being done to improve maize productivity to fulfill the food requirements over the drastically expanding population. Also, it is required for several industrial purposes as starch, sweeteners, syrups, oil and its other plant byproducts and field residues as well. The traditional seed broadcasting have been identified as major reason of lower plants productivity. Mechanizations of agriculture operations have developed recently and adopted for mechanical line and /or row sowing orientations. However, there is still a lack of knowledge for the appropriate row direction required for maximum yield production. Row direction of sowing showed significant differences in canopy temperature at all of the reproductive stages. Maize plants grown in East-West rows direction produced an increase in number of grains /row and grain yield/feddan than those grown from North-South rows (Abdrabou, 1996). The North-South row direction produced significant higher values of plant heights, number of grains /ear, grain weight/ear, grain and stover yield/feddan as compared to East-West row directions, with no difference in ear length, ear diameter, number of rows/ear, number of grains/row, 100-grain weight and shelling percentage (Ismail, 1997). Researchers varied upon preferring sowing directions of crop plants in north-south or in east-west row orientation. But the inconsistent of their results could be due to the location of the farm and the other important crucial physioenviromental factors as presented earlier, which should be respected for each situation to full fill the basic requirements of each crop plant for germination, and all of the consecutive growth stages for produce the highest yield and best quality. Moreover, the geographical and topographical, soil and the other edaphic conditions could be considered in response of the effect of sowing directions for the grown crop potentialities.

In this respect, East-West seeding direction allowed more light deep in the plant canopies leading to more growth especially for C_4 plants as maize resulted in better growth and producing higher grain yield and some of its contributes as reported by Fernando et al. (2000); Ibrahim and Abd El Maksoud (2001). The effect of rows orientation was studied in respect of radiant energy use. For analysing crop radiation capture and utilization, three indices are often used: the fraction of radiation intercepted, radiation use efficiency and harvest index (Tsubo et al. 2001). High yield required production of incident radiation at the soil surface must be incorporated by crop canopy as reported by Eberbach and Pala (2005). Other scientists claimed that East-West seeding direction caused more light to penetrate and intercept in plant canopy than North-South direction. This was noticed from ground level up to 120 cm height (Abd El-Maksoud, 2008). The orientation of seeding rows affects photosynthetic efficiency and canopy temperature affects interception of solar radiation by crop canopies (Drews et al. 2009). Plant stand design in the field is an important parameter for maximizing grain yield production which internally affects many related factors such as light, water, nutrients, and weeds…etc. which are essential growth and crop production (Brant et al. 2009). A uniform distribution and proper orientation of plants over the cropped area which are needed for maximizing light interception throughout the crop profile and plant canopies to enhance photosynthetic efficiencies for all of leaves and plant foliage as well (Evers et al. 2009).

The effect of row directions of sowing on grain wheat yield was significant. In this connection, Pandey et al. (2013) reported that the grown two wheat varieties yielded about 11% higher grain yield in north-south compared with East-West sowing. Seif and Saad (2015) found that that the Circular sowing direction was superior in grain yield, stover yield, ear weight, ear diameter, ear length, number of rows/ear, number of kernels/row, shelling percentage and its even distribution of light radiation intensity with various significant magnitudes. However, the tallest plants were obtained when using North-South direction and highest seed index produced from East-West direction. Meanwhile, the superior ear height was noticed for the perpendicular sowing direction. Regarding plant densities, Burns and Abbas (2003) mentioned that grain and stover yields were increased with increasing plant densities, but, kernels weight and ear weight were declined with the extra increasing plant densities. Plant and ear height increased as planting density increased (Carena and Cross, 2003). On the other hand, ear length decreased linearly as planting density increased (Silva et al. 2007). Also, number of grains/row substantially decreased as planting density increased (Abuzar et al. 2011). Several research workers reported that increasing plant density increased grain and stover yields as reported by Dawadi and Sah (2012); Muranyi (2015).

The target of this study was to find out the impact of six planting direction patterns and three plant population densities on the productivity and performance of maize.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Research Station, Faculty of Agriculture (Moshtohor), Benha University, Egypt during two growing summer seasons (2014 and 2015). This was to investigate the performance of maize under six planting directions and three plant population densities. Growth characters yield and yield components of the tested maize variety (Hi-tech 2031) were studied. Experimental design was split- plot, where planting directions were randomly distributed in the main plots and the three plant population densities in the split-plots. Each experimental unit was 16 m^2 (4 x 4 m) of about 1/262.5 feddan area (one feddan= 0.42ha). The applied treatments were as follows:

A- Planting direction patterns:
I- Strait rows:
1. North-South (N-S). 2. East-West (E-W).
II- Diagonal rows:
1. North. Eastern (N.E). 2. North. Western (N.W).
III- Others:
1. Perpendicular (Perp). 2. Circular (Circ).

B- Plant population densities:

Three plant population densities of the assigned for this study, which were 16000, 24000 and 32000 plants/feddan, respectively. For each of the six designed seeding orientation patterns, distance between rows was 70 cm in hills of 20-25 cm apart. Thinning of plants/hill was adjusted to achieve the previously proposed number of plants/feddan.

Seeds of maize maize variety (Hi-tech 2031) were sown on May, 19th in both summer seasons. Calcium super phosphate (15.5% P_2O_5) at a rate of 150 kg/feddan was applied at the appropriate soil preparation. The other approved agronomic practices for maize production were applied properly.

Investigated parameters

For estimating growth characters a random sample of ten plants from central area of each plot was taken at 80 days after planting in each season to estimate the following parameters:

- Plant height (cm) from the soil surface up to the top of tassel.
- Ear height (cm) from the soil surface up to the base of the topmost ear.
- Light intensity (Lux): Light intensity meter (Digital Illumination meter- Lux / Foot-Candle- INS- DX-200) was used. Measurements were recorded for the top of the plants to estimate the prevailing ambient intercepted light immetion intensity. Meanwhile, another reading was recorded above soil surface. Reading was taken in luxces unit (F.C=10.7 lux). This was to determine the differences of light intensities as an approximate indicator for light intensity within plant canopies for each of the assigned treatments (Seif and Saad, 2015). Measuring the two light radiation intensity was taken at randomly selected spots within the center of each experimental unit. The two light intensities were taken at mid- day (12-noon), in clear sky, where the differences between the top of plants and above the soil surface representing the light radiation intensity within the grown plant canopies. The light intensity by means of lux meter was conducted according to Williams et al. (1965); Leach et al. (1986).

Yield and yield components:

Yield components: At harvest 10 ears were taken at random from each plot in four replications to record the following traits:
Ear weight (g).
Ear length (cm).
Ear diameter (cm).
Number of rows/ear.
Number of kernels/row.
Seed index

Grains weight per ear (g)
Shelling percentage =---------------------------- x100
Cob weight (g)
Ear weight (g)

Grain and stover yield (kg/feddan): After harvesting processing plants were sun-dried and plot yield of grain and stover yields were determined using field scale of 0.25 kg sensitivity. Grain yield were adjusted to 15.5 % moisture content.

Statistical analysis:

The analysis of variance for data of each of the two growing seasons were carried out according to Steel and Torrie (1981). The L.S.D. test at the 5% level was used in means comparison.

RESULTS AND DISCUSSION

Effect of planting directions:

Plant height (cm.):

It is generally noticed from Table (1) that plants of diagonal N.Western direction was the tallest which was 315.87 and 346.67cm in each of the respective two seasons, with significant differences of various magnitudes. Results clarify appreciable significant differences in plant heights among the studied planting directions with variable significant magnitudes. Plants height could be ranked in the following descending order: North. Western (315.87)>North. Eastern (312.42) ≈ North-South (312.29)> Circular (306.16) > Perpendicular (303.09) = East-West (303.09cm) in the first season, being, North. Western (346.67) > Circular (336.44) > North-South (334.44) ≈ North.Eastern (334.22) > East-West (331.90) > Perpendicular (325.78 cm) in the second season with significant differences of various magnitudes (Table 1). Almost, more or less similar results were reported by Abd El-Maksoud (2008); Seif and Saad (2015).

Ear height (cm.):
Results indicated that the diagonal North.Western seeding orientation produced the superior ear height in the two respective seasons which were 159.21 and 174.44 cm, respectively. It showed slight significant differences of ear height having the respective descending order which were: North-Western (159.21) > North-Eastern (154.10) >North-South (153.59) > Circular (152.05) > East-West (151.54) > Perpendicular (151.03cm) in the first season; being, North-Western (174.44) >North-Eastern (172.45) > Circular (171.78) > Perpendicular (170.22) > East-West (169.33) > North-South (168.78 cm) in the second season for ear height with slight significant differences (Table 1). Similar results were reported by Seif and Saad (2015) according to their different densities.

Light intensity (Lux):
Results in Table 1 exerted significant differences among the tested planting orientation patterns in light radiation intensity within maize plant canopies and edaphic conditions as well. In this respect, data of the two growing seasons clarified slight significant differences among the planting direction patterns in light intensity of maize having descending order of North-South (78010.44), Circular (75071.55), North-Western (74890.00), East-West (74666.11), Perpendicular (74179.89) and North-Eastern (73195.89 lux) in the first season; being East-West (74794.44), North-Eastern (73835.44), North-Western (73702.44), Circular (73262.22), Perpendicular (72941.89) and North-South direction (62128.22 lux) in the second season for light intensity within plant canopies. However such differences did not reach to the level of significance in the second season (Table 1). Light radiation (difference in light radiation in lux unit) from the top to the bottom of plants at noon (24.00 hr) included the light interception of plant canopies. More light radiation within maize plant canopies was estimated in each sowing orientation patterns. So, when the difference of solar light radiation from the top to the bottom of plants increased, this mean that light is of better use for plants through absorption and transmition within plant canopies for the essential requirements of light in photosynthesis and all of the metabolic and anabolic processes of photochemical reactions of plant growth; development and production. Similar results in this respect were reported by Tsubo et al. (2001); Eberbach and Pala (2005); Abd El-Maksoud (2008); Brant et al. (2009); Evers et al. (2009); Seif and Saad (2015).

Ear characters:
Results indicated that appreciable differences between each of the studied planting patterns (North-South, East-West, North.Eastern, North.Western, Perpendicular and Circular) on ear length, ear diameter, number of rows/ear, number of kernels/row (Table 1), ear weight, cob weight, shelling percentage and seed index (Table 2). Moreover, higher production of grain yield components having the respective order of the various planting directions as follow: ear length (20.62cm); ear diameter (4.95cm); ear weight (266.29g); cob weight (47.47g); number of rows/ear (12.22); number of kernels/ row (45.53) for North.Western direction; seed index (39.89) for North.Eastern direction and shelling percentage (85.31) for Circular direction in the first season; corresponding to ear length (21.95cm) for North.Eastern direction; ear diameter (5.02cm) for North.Eastern direction; ear weight (312.75g) for North.Eastern direction; cob weight (48.84g) for North-South direction; number of rows/ear (12.18) for East-West direction; number of kernels/ row (45.75) for North-South direction; seed index (44.00) for North.Eastern direction and shelling percentage (77.21) for North.Western direction in the second season; respectively, with significant differences except for each of ear diameter and shelling percentage (Tables 1 & 2). Similar results were reported by Ismail (1997); Seif and Saad (2015).

Grain and stover yield:
Results of the two growing seasons indicated that the significant differences in grain and stover yields due to the applied planting directions in Table 2. The North.Western (N.W) row orientations produced the highest value of grain and stover yield with significant difference magnitudes during each of the two growing seasons. It obvious that the diagonal planting directions (North.Western & North. Eastern) significantly increased grain yield of maize as compared to each of the other proposed four planting directions during each of the two seasons. The highest production for the diagonal North.Western and North.

Table 1: Effect of seeding orientation patterns on the potentialities of plant height, ear height, light intensity, ear length, ear diameter, number of rows/ear and number of kernels/row of maize during each of the two growing seasons (2014 and 2015).

Seeding orientation patterns(O)	Plant height (cm)	Ear height (cm)	Light intensity (Lux)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	Number of kernels/row
			2014 season				
North-South (N-S)	312.29	153.59	78010.44	20.17	4.87	11.91	43.75
East-West (E-W)	303.09	151.54	74666.11	20.35	4.87	11.82	45.51
North-Eastern (N.E)	312.42	154.10	73195.89	20.53	4.91	11.87	43.27
North-Western (N.W)	315.87	159.21	74890.00	20.62	4.95	12.22	45.53
Perpendicular	303.09	151.03	74179.89	19.91	4.84	12.00	43.09
Circular	306.16	152.05	75071.55	19.71	4.82	11.60	42.30
LSD 0.05	N.S	O= 2.70	O=1117.42	O= 0.23	N.S	O= 0.23	O= 0.87
			2015 season				
North-South (N-S)	334.44	168.78	62128.22	21.82	4.95	11.60	45.75
East-West (E-W)	331.90	169.33	74794.44	21.53	5.00	12.18	45.27
North-Eastern (N.E)	334.22	172.45	73835.44	21.95	5.02	11.91	45.67
North-Western (N.W)	346.67	174.44	73702.44	21.24	4.98	11.95	44.20
Perpendicular	325.78	170.22	72941.89	21.13	4.93	12.03	44.64
Circular	336.44	171.78	73262.22	21.62	4.91	11.75	45.40
LSD 0.05	O= 5.60	N.S	N.S	O= 0.13	N.S	O= 0.15	N.S

Table 2: Effect of seeding orientation patterns on the potentialities of grain yield, stover yield, ear weight, cob weight, shelling percentage and seed index of maize during each of the two growing seasons (2014 and 2015).

Seeding orientation patterns(O)	Ear weight (g)	Cob weight (g)	Shelling %	Seed index	Grain yield (kg/feddan)	Stover yield (kg/feddan)
			2014 season			
North-South (N-S)	246.58	44.91	81.76	39.55	3002.54	4701.67
East-West (E-W)	253.64	44.78	83.48	39.22	3271.42	4663.75
North-Eastern (N.E)	249.07	44.18	83.40	39.89	3459.64	4967.08
North-Western (N.W)	266.29	47.47	81.50	39.78	3416.72	5270.42
Perpendicular	242.42	43.09	82.64	39.00	3353.21	5005.00
Circular	232.89	41.98	85.31	39.44	3410.20	5156.67
LSD 0.05	O= 9.70	O= 1.94	N.S	N.S	N.S	O=244.35
			2015 season			
North-South (N-S)	301.44	48.84	76.05	43.22	3411.88	5810.00
East-West (E-W)	302.84	47.69	74.58	43.22	3336.97	5950.00
North-Eastern (N.E)	312.75	47.56	74.87	44.00	3226.83	6416.67
North-Western (N.W)	298.13	46.00	77.21	43.22	3472.89	6020.00
Perpendicular	298.73	45.91	73.65	43.77	3044.64	5996.67
Circular	306.18	47.53	73.42	43.22	2934.98	5646.67
LSD 0.05	N.S	N.S	N.S	N.S	O= 242.25	O= 314.08

Eastern sowing directions without significant differences. Results indicated that either the North.Western or North. Eastern planting directions patterns are the best in maize production than each of the other four planting orientations (N-S, E-W, Circular and Perpendicular). Almost similar results were reported by Fernando et al. (2000), Ibrahim and Abd El Maksoud (2001); Abd El-Maksoud (2008); Pandey et al. (2013); Seif and Saad (2015) in this

respect. Concerning the two traditional straight rows orientations (N-S and E-W planting patterns), E-W direction produced slightly higher grain yield of maize than N-S orientation in each of the two growing seasons without significant differences. So, E-W planting direction was relatively of more effect in producing higher grain yield as compared with the N-S direction. And both have the second descending ranking order than either of the diagonal direction N.Western or N. Eastern direction.
Regarding the other planting directions, it was noticed that Perpendicular and Circular planting direction were almost similar in their effect on grain yield with slightly higher grain yield in Perpendicular direction in the second season, and for Circular direction in the first season with a difference of about 1 % in seasonal fluctuations. But again, these two other row orientations were almost similar in their effect on grain yield of maize, and they used to be the third in their descending ranking effect among the other four planting directions. It could be generally concluded that the descending ranking effect of the six planting direction for grain maize productivity was as follows: the diagonal North.Western and North. Eastern directions > the traditional straight sowing directions N-S or E-W > perpendicular and circular sowing directions of planting as presented in Table 2. These results may be due the more even distribution of the required micro environmental factors for the essential requirements of the macro and micro physiological factors for growth and development surround and within plant canopies. Similar results were reported by Brant et al. (2009).

Stover yield:
Results of the stover yield are presented in Table 2 showed that the diagonal North.Western (5270.42) and North. Eastern (4967.08 kg/fed) planting orientation were almost similar in their effect during the first season. While, the North. Eastern pattern (6416.67) was significantly produced higher stover yield than North.Western pattern (6020 kg/feddan) in the second season (Table 2). It is noticed that Perpendicular planting direction produced higher stover yield than the Circular orientation direction. This result was true in the two seasons with significant differences in the second season. This result may indicate that the better planting distribution for the perpendicular planting direction more favorable for better stover production as compared with the circular direction.

Effect of plant densities:
Plant height (cm.):
Results in Table 3 indicated that plant heights of maize were substantially increased as plant density increased with significant differences in the first season. As plant population density increased from 16000 to 24000 and up to 32000 plants/feddan, plant heights were substantially increased with a respective height of 298.10, 310.48 and 317.85 cm in the first season. Corresponding to 328.22, 333.44 and 343.05 cm in the second season, respectively. It looks to be true that the total increase in heights of maize plants was due to increasing seeding rate (from 16000 to 24000 and up to 32000 plants/fed) was more pronounced in subsequent magnitudes during the second than the first season. These results may be due to the high competition for the absorbing incident light mainly, which force plants for elongation research for extra needed light for their necessary requirements. Other environmental and edaphic conditions could be involved in growth and developments of plants. Similar results were reported by Carena and Cross (2003).

Ear height (cm):
Data in Table 3 indicate clearly that ear heights of maize increased as plant densities increased with slight significant differences. As plant population density increased from 16000 to 24000 and up to 32000 plants/feddan, ear height was substantially increased with a respective height of 147.97, 154.61 and 158.19 cm in the first season, and 165.22, 171.05 and 177.22 cm in the second season respectively with significant differences in the first season. Similar results were reported by Carena and Cross (2003).

Light intensity (Lux):
Difference in light radiation intensity substantially increased as plant densities increased with significant differences of different magnitudes. As plant density increased from 16000 to 24000 and up to 32000 plants/feddan, light intensity difference was substantially increased with a respective production of 73154.39, 75078.78 and 76773.78 lux in the first season; being 67166.72, 71431.39 and 76734.22 lux in the second season respectively with significant differences (Table 3). Among the performance and potentiality of the grown plants are the impacts of the

physioenviromental factors which affect the photosynthesis and respiration processes involved in the metabolism and catabolism processes in crop plants.

Ear characters:

Regarding plant densities it was noticed that, each of the studied ear characters (ear length, ear diameter, ear weight, cob weight, number of kernels/row, seed index and shelling percentage), indicate substantially decrease as seeding rate increased with significant differences except for ear diameter and shelling percentage did not exert significant differences during each of the two growing seasons. Whereas, number of rows/ear increased as seeding rate increased with significant differences (Tables 3&4). Similar results were reported by Silva et al. (2007) and Abuzar et al. (2011).

Grain and stover yield:

Results in Table 4 clarify that grain yield was generally increased as plant population density increased with significant differences of various magnitudes. The respective grain yield was 3007.77, 3375.15 and 3573.94 kg/feddan in the first season, being 2988.19, 3309.49 and 3416.43 kg/feddan in the second season as plant population density increased from 16000 to 24000 and up to 32000 plants/feddan (Table 4). This result clearly indicates that the higher plant population density is more productive than the lower densities. Such result could be due to the more efficient physiochemical processes due to creating better microenvironment within plant canopies in respect of light intensity and distribution within plant canopies, temperature and humidity under the hot-dry summer conditions and convenient edaphic conditions, better soil microflora. These results confirm what were reported by Burns and Abbas (2003), Dawadi and Sah (2012) and Muranyi (2015).

Stover yield:

The impacts of maize plant population densities (over the planting orientation patterns) for stover production are presented in Table 4. Results indicated that stover yield of maize, substantially increased as seeding rates increased with significant differences of various magnitudes. As plant density increased from 16000 to 24000 and up to 32000 plants/feddan, stover yield was substantially increased producing a respective production of 4455.21, 5014.79 and 5412.29 kg/feddan in the first season, being 5693.33, 5981.67 and 6245.0 kg/feddan, respectively in the second season with significant differences (Table 4). It looks to be true that the total increases in stover yield may be due to the increase in plant density from 16000 to 24000 and up to 32000 plants/feddan. This trend was more pronounced in subsequent magnitudes during the second than the first season. The obtained increase in stover yield of maize due to its substantial increase in population density per unit of land means more number of plants with more columns that represent the increase of stover yield. It could be of light within per columns but its greater number of unit area exerts much more weight compensating of stover yield in such case. Such results are in agreement with those obtained by Dawadi and Sah (2012) and Muranyi (2015).

Interactions effect:

Results in Table 5 clarified the interaction effect of the proposed planting direction patterns and plant density for plant heights was only significant in the first season. The tallest plants of maize (328.9 cm) were obtained for the Circular direction pattern when planted at the highest plant density (32000 plants/feddan), meanwhile, the shortest plants (273.7 cm) were obtained from the Circular direction, planted at the lowest plant density (16000 plants/feddan) in the first season. It is well noticed that maize plants trend to be taller at the highest densities could be due to the relative competition for growth factors in a convenient environmental conditions within the plant canopies of maize and the better edaphic conditions as well. Along the same line, for ear heights was significant only in the second season. The tallest ear height were obtained when plants grown in North.Western direction with the highest plant population density (32000 plants/feddan) in the second season (Table 5).

Results for the studied ear characters indicate that the highest value was of ear length (22.73cm) for East-West direction planted at the lowest density (16000 plants/feddan); ear weight (285.13g) for North.Western direction planted at the lowest density (16000 plants/feddan); cob weight (55.33g) for East-West direction planted at the lowest density (16000 plants/feddan); number of rows/ear (12.53) for North.Western direction planted at the highest plant density (32000 plants/fed). Finally, highest number of kernels/ row and seed index were 47.86 and 45.67, respectively for Circular direction planted at the

Table 3: Effect of plant densities on the potentialities of plant height, ear height, light intensity, ear length, ear diameter, number of rows/ear and number of kernels/row of maize during each of the two growing seasons (2014 and 2015).

Density (D) plants/feddan	Plant height (cm)	Ear height (cm)	Light intensity (Lux)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	Number of kernels/row
			2014 season				
16000	298.10	147.97	73154.39	20.85	4.93	11.58	45.04
24000	310.48	154.61	75078.78	20.32	4.90	11.93	44.00
32000	317.85	158.19	76773.78	19.48	4.80	12.20	42.68
Mean	308.81	153.59	75002.32	20.21	4.87	11.90	43.91
LSD 0.05	D= 5.93	D= 6.62	D=598.59	D= 0.18	N.S	D= 0.15	D= 0.71
			2015 season				
16000	328.22	165.22	67166.72	21.98	5.04	11.63	46.75
24000	333.44	171.05	71431.39	21.82	4.97	11.87	44.90
32000	343.05	177.22	76734.22	20.85	4.89	12.21	43.81
Mean	334.90	171.16	71777.44	21.55	4.96	11.90	45.15
LSD 0.05	N.S	N.S	D=3965.68	D= 0.35	N.S	D= 0.13	D= 0.70

Table 4: Effect of plant densities on the potentialities of grain yield, stover yield, ear weight, cob weight, shelling percentage and seed index of maize during each of the two growing seasons (2014 and 2015).

Density (D) plants/feddan	Ear weight (g)	Cob weight (g)	Shelling %	Seed index	Grain yield (kg/feddan)	Stover yield (kg/feddan)
			2014 season			
16000	261.53	46.99	84.06	41.22	3007.77	4455.21
24000	249.39	44.51	83.00	39.05	3375.15	5014.79
32000	235.52	41.70	81.97	38.16	3573.94	5412.29
Mean	248.81	44.40	83.01	39.48	3318.95	4960.76
LSD 0.05	D= 6.77	D= 1.04	N.S	D= 0.85	D = 153.73	D=272.04
			2015 season			
16000	316.95	50.19	76.77	44.78	2988.19	5693.33
24000	306.34	46.66	75.00	43.67	3309.49	5981.67
32000	286.74	44.93	73.11	41.83	3416.43	6245.00
Mean	303.34	47.26	74.96	43.43	3238.03	5973.33
LSD 0.05	D= 7.94	D= 1.39	N.S	D= 0.85	N.S	N.S

Table 5: Interaction effect between seeding orientation patterns and plant densities on the potentialities of plant height, ear height, light intensity, ear length, ear diameter, number of rows/ear and number of kernels/row of maize during each of the two growing seasons (2014 and 2015).

Seeding orientation patterns(O)	Density (D) plants/fed	Plant height (cm)	Ear height (cm)	Light intensity (Lux)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	Number of kernels/row
				2014 season				
North-South	16000	305.90	148.73	75830.00	20.47	4.93	11.47	43.33
	24000	312.03	154.10	78425.00	20.17	4.87	12.00	43.00
	32000	318.93	157.93	79776.33	19.87	4.80	12.26	44.93
East-West	16000	300.53	146.43	72561.67	21.00	4.93	11.47	47.13
	24000	302.06	151.80	74930.00	20.80	4.87	11.86	47.73
	32000	306.67	156.40	76506.67	19.27	4.80	12.13	41.67
North-Eastern	16000	302.83	150.27	70916.67	21.20	5.00	11.47	45.00
	24000	315.01	154.10	73757.67	20.60	4.93	11.87	44.27
	32000	319.32	157.93	74913.33	19.80	4.80	12.27	40.53
North-Western	16000	312.80	155.63	71893.33	21.60	5.00	12.00	47.13
	24000	316.63	161.00	74403.33	20.40	5.00	12.13	43.40
	32000	318.17	161.00	78373.33	19.86	4.87	12.53	46.06
Perpendicular	16000	292.87	147.97	73846.67	20.87	4.93	11.87	45.67
	24000	301.30	148.73	74166.67	20.20	4.87	12.00	43.26
	32000	315.10	156.40	74526.33	18.67	4.73	12.13	40.33
Circular	16000	273.70	138.77	73878.00	20.00	4.80	11.20	42.00
	24000	315.87	157.93	74790.00	19.73	4.87	11.73	42.33
	32000	328.90	159.47	76546.67	19.40	4.80	11.86	42.57
LSD 0.05		OD= 14.52	N.S	N.S	OD= 0.45	N.S	OD= 0.37	OD= 1.74
				2015 season				
North-South	16000	330.00	166.00	55873.33	22.47	5.00	11.47	47.26
	24000	334.00	167.67	59399.33	21.87	4.96	11.47	45.60
	32000	339.33	172.66	71112.00	21.13	4.90	11.87	44.40
East-West	16000	320.67	162.00	67486.67	22.73	5.07	11.73	46.20
	24000	328.00	168.00	75613.33	21.33	5.00	12.27	45.00
	32000	347.00	178.00	81283.33	20.53	4.93	12.53	44.60
North-Eastern	16000	328.67	166.67	69157.33	21.87	5.09	11.47	47.00
	24000	330.67	172.67	74360.00	21.73	5.05	11.87	45.13
	32000	343.33	178.00	77989.00	22.27	4.93	12.40	44.87
North-Western	16000	339.33	166.67	71049.00	21.80	5.07	11.60	45.20
	24000	349.33	173.33	73391.67	21.60	5.00	12.00	44.40
	32000	351.33	183.33	76666.67	20.33	4.87	12.27	43.00
Perpendicular	16000	321.33	165.33	69165.33	21.73	5.00	11.87	47.00
	24000	325.33	172.00	73243.33	22.00	4.93	11.87	44.07
	32000	330.67	173.33	76417.00	19.67	4.87	12.36	42.86
Circular	16000	329.33	164.67	70268.67	21.27	5.00	11.67	47.86
	24000	333.33	172.66	72580.67	22.40	4.90	11.73	45.20
	32000	346.67	178.00	76937.33	21.20	4.83	11.87	43.13
LSD 0.05		N.S	OD= 3.90	OD=4771.63	OD= 0.86	N.S	OD= 0.33	OD=1.72

Table 6: Interaction effect of seeding orientation patterns and plant densities on the potentialities of grain and stover yields, ear weight, cob weight, shelling percentage and seed index of maize during each of the two growing seasons (2014 and 2015).

Seeding orientation patterns(O)	Density (D) plants/fed.	Ear weight (g)	Cob weight (g)	Shelling %	Seed index	Grain yield (kg/feddan)	Stover yield (kg/feddan)
			2014 season				
North-South	16000	251.47	46.00	82.20	40.33	2510.93	4208.75
	24000	244.47	44.67	81.95	39.67	3067.87	4891.25
	32000	243.80	44.06	81.15	38.67	3428.81	5005.00
East-West	16000	269.33	48.20	84.66	41.67	2748.79	4322.50
	24000	264.47	45.00	83.26	38.33	3329.31	4636.25
	32000	227.13	41.13	82.53	37.66	3736.15	5032.50
North-Eastern	16000	261.73	46.07	84.63	40.66	3186.66	4550.00
	24000	248.27	45.53	83.81	39.67	3328.67	5005.00
	32000	237.20	40.93	81.76	39.33	3863.58	5346.25
North-Western	16000	285.13	52.53	82.46	42.00	3237.82	4550.00
	24000	255.33	46.80	81.57	40.00	3482.42	5573.75
	32000	258.40	43.07	80.46	37.33	3529.92	5687.50
Perpendicular	16000	262.67	46.53	82.93	41.67	3156.54	4663.75
	24000	243.73	43.40	82.20	37.66	3465.98	5005.00
	32000	220.87	39.33	82.81	37.66	3437.12	5346.25
Circular	16000	238.87	42.60	87.52	41.00	3205.88	4436.25
	24000	234.07	41.67	85.24	39.00	3576.64	4977.50
	32000	225.73	41.67	83.16	38.33	3448.09	6056.25
LSD 0.05		OD= 16.60	OD= 2.55	N.S	OD=2.07	OD= 376.56	N.S
			2015 season				
North-South	16000	305.53	51.87	77.66	44.00	3194.66	5600.00
	24000	303.20	48.93	75.84	43.33	3417.66	5740.00
	32000	295.60	45.73	74.64	42.33	3623.31	6090.00
East-West	16000	322.53	55.33	76.46	44.33	2851.81	5680.00
	24000	295.40	44.27	74.39	43.67	3543.23	6010.00
	32000	290.60	43.47	72.89	41.66	3615.89	6160.00
North-Eastern	16000	322.27	48.40	76.20	45.00	2981.52	6160.00
	24000	320.73	47.73	74.75	44.66	3285.17	6300.00
	32000	295.27	46.53	73.65	42.33	3413.89	6790.00
North-Western	16000	317.80	48.33	79.95	44.00	3332.97	5650.00
	24000	303.53	46.07	77.43	43.67	3507.27	6090.00
	32000	273.07	43.60	74.23	42.00	3578.44	6320.00
Perpendicular	16000	317.73	47.53	75.77	45.67	2773.50	5610.00
	24000	302.33	45.87	74.45	43.33	3103.70	6080.00
	32000	276.13	44.47	70.73	42.33	3256.72	6300.00
Circular	16000	315.87	49.67	74.58	45.67	2794.70	5460.00
	24000	312.87	47.13	73.16	43.67	2999.92	5670.00
	32000	289.80	45.80	72.51	40.33	3010.33	5810.00
LSD 0.05		N.S	OD=3.4	N.S	OD=2.07	N.S	N.S

lowest density (16000 plants/feddan) with significant differences of various magnitudes (Tables 5&6). The interaction effect between the planting directions and plant densities on grain yield was significant in the first season (Table 6). Highest grain yield of maize (3863.58 kg/feddan) was obtained for the North. Eastern direction when planted with the highest plant density

(32000 plants/feddan) in the first season, while the lowest grain yield (2510.93 kg/feddan) was obtained for the North. South direction, planted with the lowest plant density (16000 plants/feddan) in the first season. Further studies with more modifying for this preliminary study are require to obtain more accurate and precise results to be recommended and applied for maximizing yield and quality of maize.

CONCLUSION

It can be concluded that, Highest grain yield of maize was obtained for the North. Eastern direction when planted with the highest plant density (32000 plants/feddan), while the lowest grain yield was obtained for the North. South direction, planted with the lowest plant density (16000 plants/feddan).

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