Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 04 | Issue : 03 | July-Sept. | 2015
Pages: 590-601

Impact of Various Seeding Orientation Patterns on Growth, Grain Yield and its Components of two Maize Varieties

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ABSTRACT

Experiments were designed and implemented to evaluate yield, its components and quality determinations of two maize varieties (Hi-tech 2031 and Fine seeds 101) under six planting directions (North-South (N-S), East-West (E-W), North.Eastern (N.E), North.Western (N.W), Perpendicular (Perp.) and Circular (Circ.). Two field experiments were carried out at the Experimental Research station, Faculty of Agriculture, Moshtohor, Benha University, Kalubia Governorate during two summer growing seasons (2013 and 2014). Results could be concluded as follows:

The two growing seasons showed significant differences in yield and its components for the two maize varieties (Hi-tech 2031 and Fine seeds 101). Whereas, Hi-tech 2031was superior crop as compared to Fine seeds 101 variety in grain yield, stover yield, cob yield, ear weight, ear diameter, ear length, number of kernels/ row, plant height, ear height and CP content of grain. Meanwhile, Fine seeds 101 variety was the superior crop in number of rows/ear, seed index, shelling percentage and light radiation intensity within plant canopy with significant differences of various magnitudes.

Regarding planting directions, data showed that the Circular 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 light radiation intensity with significant differences magnitudes. Meanwhile, the tallest plants were obtained when using North-South direction. Meanwhile, highest seed index produced from East-West direction. Moreover, the superior CP content and ear height were noticed for the perpendicular direction.

Key words: Maize (*Zea mays*, L) varieties, Seeding orientation patterns, yield, quality

Introduction

Maize (*Zea mays*, L) is one of the most important crops and ranks the third of the most important cereal crops after wheat and rice in Egypt and world wide. Efforts being done to improve maize productivity to fulfill the food requirements over the drastically expanding population. Moreover, it is required for several industrial purposes as starch, syrups, oil and its other plant residues and by products.

Mohamed *et al.,* (2009) reported about the importance of maize for food, feed and other purposes and for contributed with the other consumption of cereal crops to satisfy the general food consumption target.

The traditional seed broadcasting have been identified as major causes of lower productivity. Mechanizations of agriculture operations have increased recently and adopted for mechanical line or row sowing. However, there is still a lack of knowledge on proper row direction required for maximum yield of seed production (Pandey *et al.,* 2013).

Researchers varied upon judgements for 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 physioenvironmental factors as presented earlier, which should be respected for each situation to full fill the basic requirements of each crop plant to germinate, grow and produce the highest yield of best quality.

Moreover, there is no enough research information for studying the effect and functions of other un-traditional sowing direction as each of the two diagonals directions (north easteren and north western), the perpendicular and the circular row orientations. These and possible others could be well studied.

Row orientation on seed and forage yield of grasses sorghum was experimented (Nasser Shamsadin, 2008) where 4 seeding directions were tried: north-south, east-west, north easteren and north western. Results showed that planting orientation had significant effect on seed yield, weight of 1000 seeds, number of tillers, dry matter yield length and diameter of shoot. Mean comparisons, showed that a maximum and minimum amount of the prevailing mentioned traits except shoot length was obtained when using north-south orientations than for east-west direction.

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Mehasen and El-Gizawy (2010) studied the performance of 5 maize varieties (S.C. Hitec, S.C.10, T.W.C Hitec, T.W.C 329 and Giza 2) under 4 irrigation levels (100% field capacity (I1), 80% field capacity (I2), 60 % field capacity (I3) and 40 % field capacity (I4)). They found that single crosses of maize significantly surpassed other cross hybrids in growth characters, yield and yield components.

For higher yield, higher production of incident radiation at the soil surface must be incorporated by crop canopy (Eberbach and Pala, 2005). Plant stand design in the field is an important key parameter for grain yield which affect many factors such as light, water, nutrients, and weeds which are crucial for crop production (Brant *et al.,* 2009). A uniform distribution and proper orientation of plants over a cropped area are needed for greater light interception throughout the crop profile and maximum photosynthetic efficiency by all the leaves of plant (Evers *et al.,* 2009).

Preliminary data from a strip tillage study conducted in 2007,in North Dakota State Univ., suggested that row orientation (north-south vs. east-west orientations) can influence soil temperatures of strips near the seeding depth prior to planting. Most growers orient crop rows in a north-south direction, which reduced wind damage and affect soil temperature which was an unexpected discovery in 2007, resulting from preliminary soil temperature and moisture at the study locations. It was expected that temperature in strip tilled plots would be cooler than in conventionally tilled plots regardless of row orientation. In the north-south orientation, soil temperatures were 5-8 degrees warmer in strip tilled plots relative to conventionally tilled plots. However, results were confounded by the different soil types and field conditions potentially influencing soil temperature and moisture in the 2007 study (Overstreet *et al.,* 2008).

In general, canopy temperature was higher at bottom level and then declined in middle and top levels of the crop canopy at reproductive stages. This might be due to absorption of the short wave radiation at the top and middle of the crop canopy and the transmission of infra-red radiation to the bottom (Sharma and Angiras, 1996). Moreover, orientation of seeding rows affects photosynthetic efficiency and canopy temperature as it affects interception of solar radiation by crop canopy (Drews *et al.,* 2009). Row direction of sowing showed significant differences in canopy temperature at all reproductive stages (Bisheshwor *et al.,* 2013).

Row orientation significantly influenced the interception and transmission of solar radiation. He found that the daily intercepted solar radiation was higher at north- south row direction at 53 days after sowing (Talentino, 1982).

The importance of investigating the agronomic factor and practices which affect light interception % is quite feasible. This is because the more light energy deep in the canopy, the more photosynthetic activity which leading to extra production especially for the C4 plants as maize (Gardnar (1988), Ottman and Welch (1989), Fernando, *et al*., (2000) and Ibrahim and Abd El Maksoud (2001)). Along the effect of the traditional planting directions, the north-south-oriented wheat canopy had captured light more efficiently compared to east-west orientation which subsequently increased photosynthesis rate, particularly during high zenith angles on clear days. Such higher rate of photosynthesis might have achieved in north-south orientation resulting in increased yield (Wall and Kanemasu, 1990).

The effect of row orientation was found in terms 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).

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).Similarly the east-west seeding direction allowed more light deep in the plant canopy leading to more growth especially for C4 plants as maize resulted in better growth and producing higher grain yield and some of its contributes (Gardnar (1988), Ottman and Welch (1989), Fernando *et al.,* (2000) and Ibrahim and Abd El Maksoud (2001).

North-south row directions produced significantly higher seed index, grain weight/head, grain yield and stover yield of grain sorghum as compared with east-west direction (Robinson, 1975 and Seif *et al*., 1988). Whereas, no any advantages was obtained in grain yield when sowing maize in east-west or north-south rows. Meanwhile, north-south direction outyielded east-west in stover yield (El- Murshedi, 1991). Maize plants grown in east-west direction had an increase in number of grain/row and grain yield/ feddan than those grown from north-south rows (Abdrabou, 1996). The north-south row direction produced significant higher values in 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).

Scientists were varied in preferring north-south as compared with east-west rows directions. In north-south row direction, growing plants are subjected to highest light interception compared to the east-west (Abd El-Maksoud 2008). Moreover, it was clear that row orientation did not significantly affect root yield when compared with any single tillage treatment (Overstreet *et al.,* 2008).

Regarding the perpendicular planting orientation as management practices, such as contouring, or farmer preference, crop rows may be oriented without consideration of wind erosion protection. Studies show that crops planted in rows perpendicular (normal) to wind direction give the most protection against wind erosion (Zingg *et al.,* 1952 and Skidmore *et al.,* 1966).

For wind protection, in rows oriented normally (perpendicular) to wind direction. Few studies have compared the erosion protection provided by uniformly spaced elements (plants, stubble, etc.) with the protection provided by rows perpendicular or parallel to wind direction. Wind direction varies widely - during the same wind, among winds, and at various geographical locations. Such information indicated where and when protection from wind erosion is needed and proper orientation for reducing wind erosion will be applied (Lyles and Allison, 1975).

The differences between varietal productivities depending on the general unique make up and its interaction with the prevailing environmental conditions. Significant differences in this respect were reported by El-Metwally *et al*., (2001), Ahmed and El-Sheikh (2002) and Oraby and Sarhan (2002).

The effect of variety and row directions of sowing on grain wheat yield were significant. The grown two wheat varieties yielded about 11% higher grain yield in north-south compared with east-west sowing (Bisheshwor *et al.,* 2013).

The target of this study was to find out the impact of six planting direction patterns on the productivity and performance of two common maize varieties.

Materials and Methods

Two field experiments were carried out at the Experimental Research Station, Faculty of Agriculture, Benha University during 2012/2013 and 2013/2014 seasons. This was to investigate the performance of two maize varieties under six planting directions. Growth characters, yield, yield components of the two tested maize varieties were studied. Experimental design was split- plot, where maize varieties were randomly distributed in the main plots and the six planting directions in the split- plots. Each experimental unit was 16 m^2 (4 x 4 m) of about 1/262.5 feddan area. The applied treatments were as follows:

A - Common maize varieties:

1-Hi-tech 2031. 2- Fine seeds 101.

Seeds of each of the two maize varieties were provided through Hi-Tech seed production company and Quality Techno Seeds Company. The recommended seeding rates of each of the above maize varieties were followed properly. Seeds were sown on May, 18^{th} in each of the two growing seasons. Phosphorus fertilizer was applied as calcium super phosphate (15.5% P_2O_5) at a rate of 150 kg/feddan as a basic treatment during the appropriate soil preparation and before sowing.

B- Planting direction patterns:

- Strait rows:
  1. North-South (N-S).
  2. East-West (E-W).
- Diagonal rows:
  3. North.Eastern (N.S).
  4. North.Western (N.W).
- Others:
  5. Perpendicular (Perp.).
  6. Circular (Circ.).

Data recorded:

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

1-*Plant height (cm)* from the soil surface to the top of tassel.

2- *Ear height (cm)* from the soil surface to the base of the topmost ear.

3-*Light intensity (Lux):*

Light intensity meter (Digital Illumination meter- Lux / Foot-Candle- INS- DX-200) was used for two plants measurement heights. Those were at the far top of the plants for estimating 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 (Saad *et al.,* 2010).

Measuring the two light radiation intensity were taken in randomly selected spots within the center of each experimental unit. The two light intensities were taken an hour after mid- day (12-noon), in clear days, where the differences between the top of plants and above ground representing the light radiation intensity within the grown plant canopies. The light intensity by means of luxmeter was conducted according to Williams *et al.,* 1965 and Leach, *et al.,* 1986.

Yield and yield components: The crop from each experimental unit was harvested manually using sickles when plants turned into yellow. After harvest plants were sun-dried and plot yield of grain, stover and cob yield were determined using field scale of 0.25 kg sensitivity. Grain yield were adjusted to 15.5 % moisture content, after drying the samples at 70 Ċ up to constant weight. The following yield traits were recorded and the total yield was estimated accordingly:

Yield components:

At harvest 10 ears were taken at random from each plot in four replications to record the following traits:

1- Ear weight (g). 2- Ear diameter (cm). 3- Ear length (cm).
4- Number of rows/ear. 5- Number of kernels/row. 6- Seed index

$$\text{7-Shelling percentage} = \frac{\text{Grains weight per ear (g)}}{\text{Ear weight (g)}} \times 100$$

Yields:

1- Grain yield (ton/fed). 2- Stover yield (ton/fed). 3- Cob yield (ton/fed).

Chemical analysis:

The prepared maize grain (15.5% moisture) were dried in oven an air-forced at 60-70 Ċ for 48 hours, then ground to pass through 0.5 mm sieve. From these dried samples, 0.2 g were wet digested using a mixture of sulphoric (H_2SO_4) and perchloric acids according to Jackson (1973). The digested solution was analyzed for N%.

Crude protein (CP) content:

Total nitrogen percentage was determined according to the modified micro kjeldahl method. Crude protein content was estimated by multiplying nitrogen percentage by 6.25 (A.O.A.C., 1995).

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

Yield and its components:

Yield productivity:

Grain, stover and Cob yield:

Results in Table (1) clarified appreciable differences between the two studied maize varieties under the applied planting directions.

Over the applied planting directions, results of the two growing seasons indicated significant differences in grain, stover and cob yields between the two studied maize varieties (Hi-tech 2031 and Fine seeds 101). The Hi-tech 2031 variety was superior compared to the Fine seed 101 variety in grain, stover and cob yield production with significant differences. The Hi-tech variety produced 7.12, 5.40 and 1.29 ton/fed of grain, stover and cob yield respectively, in the first season, being 6.51, 4.44 and 1.09 ton/fed for the second season, with significant difference. Meanwhile, the production of Fine seeds 101 variety for grain, stover and cob yield was 6.30, 5.02 and 0.75 ton/fed, respectively in the first season, being 4.70, 3.68 and 0.60 ton/fed in the second season, with significant differences (Table, 1).

Such obtained differences in the performance for each of the two maize varieties relies on their each specific genetical makeup and the prevailing environmental conditions. Similar results were reported by El-Metwally *et al*., (2001), Ahmed and El-Sheikh (2002), Oraby and Sarhan (2002), Mehasen and El-Gizawy (2010) and Bisheshwor *et al.,* (2013).

It generally noticed from the data of Table (1) that the other (non-traditional) row orientations (either the perpendicular or circular patterns) indicated the highest value of the studied character which were grain, stover and cob yield. These results were true except for the circular pattern in the second season for grain yield.

Also, E-W direction produced slightly but significant higher yield than N-S direction in each of the two seasons. Meanwhile, either the diagonal directions (N.E and N.W) produced slightly significant higher grain yield with relatively higher the later North.Western than the earlier North.Eastern diagonal directions in the two seasons.

It is noticed from Table (1) that the grain yield of the first season was relatively higher than the second season and partlet test of significant was not valid for processing the combined analysis for the results of each season. So, in some instances the obtained results were relatively inconsistent between the two seasons, which could be due to the expected packages of various unidentified factors.

Grain yield (ton/fed) as affected by the various 6-row orientations of seeding is being explained as follows in the following set of data generated from Table (1). It looks to be true that the perpendicular and circular planting directions were significantly higher in producing grain yield of maize compared to each of the other proposed four planting directions, followed by the two diagonal planting directions (N.Eastern and N.Western), then the two traditional planting directions (N-S and E-W).

Character	Directions / Seasons	Planting directions: Traditional N-S	E-W	Non-Traditional N.E	N.W	Perp	Circ	L.S.D
Grain	1st	6.04	6.65	6.96	6.69	6.91	7.00	0.31
yield	2nd	5.05	5.49	6.10	5.70	5.12	6.17	0.24

In comparing the highest production for perpendicular and circular sowing directions was of no significant differences were obtained in the first season, but were significant in the second season with unexpected drop in grain yield in the second season. Whereas, in the first season circular direction was of the highest effect (7.0 ton/fed) as compared with perpendicular direction (6.91 ton/fed) in the first season. So, it could be concluded that either the perpendicular or circular planting directions patterns are almost equal in preference for grain yield production of maize. But these two directions proved to be the best in maize production than the other four planting orientations (N-S, E-W, N.Eastern and N.Western).Similar results were reported by Fernando, *et al*., (2000), Ibrahim and Abd El Maksoud (2001), Abd El-Maksoud (2008) and Pandey *et al.,* (2013).

Regarding the diagonal rows orientations (N.Eastern and N.Western planting patterns), N.Western direction produced higher grain yield of maize where N.Eastern orientation in each of the two growing seasons with significant differences in the second season. So, N.Western planting direction was relatively of more effect in producing higher grain yield as compared with the N.Eastern direction. And both have the second descending ranking order than either perpendicular or circular direction.

The two traditional sowing directions, it was noticed that N-S and E-W were almost similar in their effect on grain yield. This could be due to the slightly higher grain yield in N-S direction in the first season, and for E.W direction in the second season with a difference from 8-9 % seasonal fluctuations. But again, these two traditional row orientations were almost similar in their effect on grain yield of maize, and they used to be on the third in their descending effect among the other four directions.

It could be generally concluded that the descending ranking effect of the six planting direction for grain maize productivity was as follows: circular and perpendicular > N.Eastern and N.Western > the traditional N-S or E-W rows direction of planting as it is clear for the presented set of data generated from Table (1). Similar results were reported by Nasser Shamsadin (2008) and Brant *et al.,*(2009).

Regarding, stover yield results in Table (1) showed that circular (5.45) and perpendicular (5.47ton/fed) planting orientation were closely similar in the first season. While, the circular pattern (4.64) was significantly higher than perpendicular pattern (3.7 ton/fed) in the second season (Table 1).

Table 1: The impact of traditional and non-traditional planting directions on grain, stover and cob yields of maize varieties during each of the two growing seasons (2013 and2014).

Variety (V)	Planting directions(D)	Grain yield (ton/fed) 1st season	Grain yield 2nd season	Stover yield (ton/fed) 1st season	Stover yield 2nd season	Cob yield (ton/fed) 1st season	Cob yield 2nd season
Hi-tech 2031	North-South (N-S)	7.26	5.76	5.03	4.72	1.28	0.95
	East-West (E-W)	6.30	6.24	4.86	4.37	1.14	1.07
	North. Eastern (N.E)	6.82	7.12	5.29	4.07	1.27	1.24
	North. Western (N.W)	7.09	7.66	5.42	4.55	1.28	1.29
	Perpendicular (Perp)	7.70	6.92	6.12	4.02	1.42	1.12
	Circular (Circ)	7.53	5.36	5.64	4.90	1.34	0.91
Mean		7.12	6.51	5.40	4.44	1.29	1.09
Fine seeds 101	North-South (N-S)	6.04	4.34	5.03	3.59	0.72	0.56
	East-West (E-W)	5.77	4.75	5.64	3.50	0.69	0.59
	North. Eastern (N.E)	6.56	4.27	4.55	3.37	0.76	0.59
	North. Western (N.W)	6.82	4.54	4.86	3.89	0.79	0.57
	Perpendicular (Perp)	6.12	5.42	4.81	3.37	0.74	0.70
	Circular (Circ)	6.47	4.88	5.25	4.37	0.79	0.60
Mean		6.30	4.70	5.02	3.68	0.75	0.60
Strait directions	North-South (N-S)	6.65	5.05	5.03	4.16	1.00	0.75
	East-West (E-W)	6.04	5.49	5.25	3.94	0.91	0.83
Diagonal directions	North. Eastern (N.E)	6.69	5.70	4.92	3.72	1.01	0.91
	North. Western (N.W)	6.96	6.10	5.14	4.22	1.03	0.93
Other directions	Perpendicular (Perp)	6.91	6.17	5.47	3.70	1.08	0.91
	Circular (Circ)	7.00	5.12	5.45	4.64	1.06	0.75
Mean		6.71	5.60	5.21	4.06	1.01	0.85
LSD at: 5% for:		V= 0.29 D= 0.31 Vd= 0.44	V= 0.18 D= 0.24 Vd= 0.34	V= N.S D= 0.22 Vd= 0.31	V= 0.19 D= 0.20 Vd= N.S	V= 0.07 D= 0.06 Vd= N.S	V= 0.03 D= 0.05 Vd= 0.07

Character	Directions / Seasons	Planting directions: Traditional N-S	Traditional E-W	Non-Traditional N.E	Non-Traditional N.W	Non-Traditional Perp	Non-Traditional Circ	L.S.D
Stover yield	1st	5.25	5.03	5.14	4.92	5.47	5.45	0.22
	2nd	4.16	3.94	4.22	3.72	4.64	3.70	0.20

The N.Western planting direction produced significantly higher stover yield than the N.Eastern direction for each of the two growing seasons. Meanwhile, the two traditional orientations (N-S and E-W), the E-W direction slightly significant increased stover yield in the first season, and almost similar in production for the second season as compared with N-S planting directions (Table 1).

However, it could be generally noticed that the perpendicular and circular directions were the highest in stover yield of maize followed by the traditional orientations (N-S and E-W), then the diagonal orientations.

Similar results were reported by Zingg *et al.,* (1952), Skidmore *et al.,* (1966) and Lyles and Allison (1975).

This information could be detected from the following set of the comparable data of grain yield for maize, which generated from Table (1) as follows:

Concerning cob yield, it looks to be true that the cob yield of maize was not significant among the whole planting directions except for the perpendicular pattern which was significantly higher than the circular orientations in the second season. Similar results were reported by Zingg *et al.,* (1952), Skidmore *et al.,* (1966) and Lyles and Allison (1975).

In respect of the interaction effect of the grown maize varieties and the proposed planting directions for the studied yield (grain, stover and cob yield) are presented in Table (1). Highest grain yield of maize was obtained for Hi-tech maize variety planted in perpendicular direction (7.70 ton/fed) in the first season, and in N.Western direction in the second season (7.66 ton/fed).Also, the heaviest stover yield (6.12 ton/fed) was obtained for the same maize variety planted in the perpendicular direction in the first season and circular direction in the second season (4.90 ton/fed). Meanwhile, the higher cob yield (1.42 ton/fed) was obtained from the same above maize variety planted in the perpendicular direction in the first season and in the N.Western direction (1.29 ton/fed) in the second season. Moreover, lowest values of the above studied traits were recorded for the interaction of Fine-Seeds 101 variety and its relevant planting patterns as presented in Table (1).

Studied Yield Components:

Ear specifications:

Over the applied planting directions, results indicated appreciable differences between each of the two studied maize varieties (Hi-tech 2031 and Fine seeds 101) in ear weight, ear diameter, ear length (Table 2), number of rows/ear, number of kernels/ row and shelling percentage (Table 3).

Results of the two growing seasons showed significant differences in the previous studied parameters between the two maize varieties (Hi-tech 2031 and Fine seeds 101). Whereas, Hi-tech 2031was superior than Fine seeds 101 variety in ear weight, ear diameter, ear length (Table 2), number of rows/ear, number of kernels/ row except shelling percentage (Table 3), whereas Fine seeds 101 was higher than Hi-tech variety with significant differences.

Moreover, higher production of yield components having the respective order: ear weight (362.89), ear diameter (5.46), ear length (22.80), number of rows/ear (12.24), number of kernels/ row (46.21) and shelling percentage (81.90) in the first season, being ear weight (221.44), ear diameter (4.94), ear length (19.86), number of rows/ear (11.67), number of kernels/ row (41.46) and shelling percentage (83.18) in the second season for Hi-tech variety, respectively. Meanwhile, Fine seeds variety produced ear weight (297.44), ear diameter (5.16), ear length (21.31), number of rows/ear (12.11), number of kernels/ row (42.70) and shelling percentage (88.13) in the first season, corresponding ear weight (195.72), ear diameter (4.68), ear length (18.36), number of rows/ear (12.13), number of kernels/ row (38.22) and shelling percentage (87.17) in the second season for fine seeds variety, respectively, with significant differences (Tables 2 & 3).

The noticed differences in yield between the two studied maize varieties were also due to the special unique features of their genetical make up under the prevailing environmental conditions of this study with various magnitudes. Similar results were reported by El-Metwally *et al*., (2001), Ahmed and El-Sheikh (2002).

Ear weight: the E-W planting direction produced slightly heavier ear weight of maize as compared to N-S direction with significant differences in the second season, but not in the first season where the difference was not significant (Table 2).

Similar trend was noticed for N.Eastern and N.Western directions in favour of the first than the second one. The perpendicular planting direction produced heavier ear weight (215.6 g) than the circular direction (191.9 g) with significant difference during the second growing season as it is clear in Table (2).

Table 2: The impact of traditional and non-traditional planting directions on the ear weight, ear diameter and ear length of maize varieties during each of the two growing seasons (2013 and 2014).

Variety (V)	Planting directions(D)	Ear weight (g)		Ear diameter (cm)		Ear length (cm)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Hi-Tech 2031	North-South (N-S)	345.27	183.13	5.47	4.80	22.40	19.13
	East-West (E-W)	365.27	232.73	5.53	4.87	23.67	20.40
	North. Eastern (N.E)	362.47	244.93	5.50	5.20	22.67	21.20
	North. Western (N.W)	364.47	224.07	5.27	5.00	22.93	18.73
	Perpendicular (Perp)	353.80	216.40	5.43	4.93	22.07	19.40
	Circular (Circ)	386.07	227.40	5.53	4.87	23.07	20.27
Mean		362.89	221.44	5.46	4.94	22.80	19.86
Fine seeds 101	North-South (N-S)	276.73	200.20	4.93	4.80	20.20	19.00
	East-West (E-W)	288.73	202.73	5.13	4.67	21.53	19.00
	North. Eastern (N.E)	302.07	199.33	5.13	4.80	21.53	17.27
	North. Western (N.W)	293.87	200.73	5.20	4.67	20.93	19.00
	Perpendicular (Perp)	315.60	167.47	5.33	4.53	21.93	17.40
	Circular (Circ)	307.67	203.87	5.20	4.80	21.73	18.47
Mean		297.44	195.72	5.16	4.68	21.31	18.36
Strait directions	North-South (N-S)	311.00	191.67	5.20	4.80	21.30	19.07
	East-West (E-W)	327.00	217.73	5.33	4.77	22.60	19.70
Diagonal directions	North. Eastern (N.E)	332.27	222.13	5.32	5.00	22.10	19.23
	North. Western (N.W)	329.17	212.40	5.23	4.73	21.93	18.87
Other directions	Perpendicular (Perp)	334.70	191.93	5.38	4.73	22.00	18.40
	Circular (Circ)	346.87	215.63	5.37	4.83	22.40	19.37
Mean		330.17	208.61	5.30	4.81	22.05	19.11
LSD at: 5% for:		V= 15.25 D= 20.66 Vd= N.S	V= 9.96 D= 9.28 Vd= 13.13	V= N.S D= 0.07 Vd= 0.10	V= N.S D= N.S Vd= N.S	V= N.S D= 0.46 Vd= 0.65	V= 0.38 D= N.S Vd= 0.92

Table 3: The impact of traditional and non-traditional planting directions on number of rows/ear, number of kernels/row and shelling percentage of maize varieties during each of the two growing seasons (2013 and 2014).

Variety	Planting directions(D)	Number of rows/ear		Number of kernels/row		Shelling percentage	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Hi-Tech 2031	North-South (N-S)	12.13	11.73	45.33	40.07	82.33	83.57
	East-West (E-W)	12.13	11.73	47.27	41.93	81.97	82.90
	North. Eastern (N.E)	12.13	11.73	46.80	44.33	81.41	82.62
	North. Western (N.W)	12.40	11.73	46.33	41.87	81.94	83.18
	Perpendicular (Perp)	12.40	11.47	42.73	38.80	81.52	83.77
	Circular (Circ)	12.27	11.60	48.80	41.73	82.26	83.06
Mean		12.24	11.67	46.21	41.46	81.90	83.18
Fine seeds 101	North-South (N-S)	12.00	12.00	41.27	38.33	88.10	87.11
	East-West (E-W)	11.47	11.73	41.33	39.07	88.01	87.60
	North. Eastern (N.E)	12.13	12.13	44.00	36.67	88.50	86.10
	North. Western (N.W)	12.13	12.40	44.13	38.87	88.48	87.44
	Perpendicular (Perp)	12.80	12.13	42.00	36.67	87.90	87.05
	Circular (Circ)	12.13	12.40	43.47	39.73	87.82	87.74
Mean		12.11	12.13	42.70	38.22	88.13	87.17
Strait directions	North-South (N-S)	12.07	11.87	43.30	39.20	85.13	85.34
	East-West (E-W	11.80	11.73	44.30	40.50	84.99	85.25
Diagonal directions	North. Eastern (N.E)	12.13	11.93	45.40	40.50	84.96	84.36
	North. Western (N.W)	12.27	12.07	45.23	40.37	85.21	85.31
Other directions	Perpendicular (Perp)	12.60	11.80	42.37	37.73	84.71	85.41
	Circular (Circ)	12.20	12.00	46.13	40.73	85.04	85.40
Mean		12.17	11.90	44.45	39.83	85.00	85.18
LSD at: 5% for:		V= N.S D= 0.32 Vd= N.S	V= N.S D= N.S Vd= N.S	V= 0.50 D= 1.07 Vd= 1.52	V= 0.98 D= N.S Vd= N.S	V= 0.28 D= N.S Vd= N.S	V= 1.10 D= N.S Vd= N.S

According to the interaction effect of ear weight of maize varieties and the applied planting patterns (Table 2) showed that the highest ear weight of maize was for the circular planting orientation in the first season (386.07 g) and for the N.Eastern direction in the second season (244.93 g). Similar results were reported by Zingg *et al.,* (1952), Skidmore *et al.,* (1966) and Lyles and Allison (1975).

Regarding the studied ear specifications (ear length, ear diameter, number of row /ear and number of kernels/row), results indicated that the various seeding directions slightly affected such traits in the first season. But differences did not reach the level of significant in the second season (Table 2 & 3). This is because the inconsistent of the obtained results and the higher magnitudes of the studied traits for the first than the second season and the ranges of the results were extremely narrow for these traits.

However, it general noticed that ear length was significantly higher for E-W than in N-S orientation in the first season, but kept the same in the second. Meanwhile, N.Eastern direction tended to induced relatively more ear length than for the N.Western direction during the two seasons without significant differences.

Also, the circular direction tended to produce slightly taller ear length compared to the perpendicular direction in the two seasons as insignificantly effect.

The interaction effect of Hi-tech maize varied significantly produces the longer ear length when grown in E-W direction (Table 2).

Ear diameter: The impact of planting directions of maize ear diameter was barley significant when comparing between N-S and E-W directions which was higher for E-W (5.33 cm) than N-S (5.20 cm) orientation, and between N.Eastern (5.32 cm) and N.Western (5.23 cm) direction in the first season (Table 2).

Number of rows /ear of maize were significantly higher for the perpendicular (12.6 row/ear) than for the circular direction (12.2 row/ear) in the first season, whereas the differences were not significant in the second season.

Number of kernels /row: The circular planting direction (46.13) was relatively higher than the perpendicular direction (42.37) in number of kernels /row in the first season (Table 3). Meanwhile, the seeding orientations did not significantly affected on the number of kernels/row. Similar results were reported by Overstreet *et al.,* (2008) and Evers *et al.,* (2009).

Shelling percentage: No significant differences for the studied traits in relation to the either maize varieties or planting direction patterns or their interactions. This result was true for each of the grown seasons (Table 2). On the other hand, results did not show any significant effect to the grown direction patterns due to the inconsistent data of no specific trend.

Plant height:

Over the applied planting directions, it is generally noticed from Table (4) that plants of Hi-tech 2031 maize variety was the taller which were 320.50 and 277.67cm, being 301.67 and 248.33cm for Fine seeds 101 variety in each of the respective two seasons, with significant differences of various magnitudes.

It looks to be true that plant height acted in a similar manner for each of the two growing seasons. Such noticed differences in yield between the two studied maize varieties were also due to the special unique features of their genetical make up under the prevailing environmental conditions of this study. Similar results were reported by Oraby and Sarhan (2002) and and Bisheshwor *et al.,* (2013).

The N-S planting direction produced maize plants of tallest heights (268.33 cm) as compared with the E-W direction (258.33 cm) with significant difference in the second season. Also, N.Eastern direction significantly produced taller plants (267cm) as compared with N.Western direction (254cm). Similar results were reported by Sharma and Angiras (1996) and Drews *et al.,* (2009).

Ear height:

Results in Table (4) presented significant differences among the two maize varieties under the various planting directions during each of the two grown seasons.

Results indicated that Hi-tech 2031 variety produce the tallest plants in the two respective seasons which were 320.50, 277.67cm, and 301.67, 248.33cm for the shorter variety (Fine seeds 101). It looks to be true that plant height acted in a similar manner for each of the two growing seasons. Such noticed differences in yield between the two studied maize varieties were also due to the special unique features of their genetical make up under the prevailing environmental conditions of this study with various magnitudes. Similar results were reported by El-Metwally *et al*., (2001), Ahmed and El-Sheikh (2002).

Regarding planting directions, it showed slight significant differences of ear height having the respective descending order which was of Perpendicular $_{(148.50)}$ > Circular $_{(147.67)}$ = North-South $_{(147.67)}$ >East-West$_{(147.33)}$ > North-Western $_{(147.17)}$ > North-Eastern $_{(146.50\ cm)}$ in the first season, being, North-South $_{(133.67)}$ > Perpendicular $_{(133.33)}$ > North-Eastern $_{(130.67)}$ > Circular $_{(130.33)}$ > North-Western $_{(129.00)}$ > East-West $_{(126.50\ cm)}$ in the second season for ear height with significant differences (Table, 4).

Ear heights of maize plants were higher in N-S direction (133.67cm) than in E-W direction (126.50cm) and from N.Western to N.Eastern direction and from perpendicular to circular direction with no significant differences in the last two comparisons in the second season.

The interaction effect of Hi-tech maize variety significantly produces the higher ear height when grown in N.Western direction in the first season (Table 2).

Seed index:

Significant differences of seed index were obtained between the two studied maize varieties and the applied planting directions during each of the two growing seasons (Table 4).

Over the applied planting directions, results of the two growing seasons indicated significant differences in seed index between the two studied maize varieties (Hi-tech 2031 and Fine seeds 101). Fine seeds 101was superior crop as compared to Hi-tech 2031variety in seed index with slight significant difference. Whereas, Fine seeds 101 and Hi-tech 2031varieties produced seed index of 50.44 and 47.00 respectively in the first season, being 46.93 and 45.80 in the second season, with slight significant difference (Table 4). Similar results were reported by Oraby and Sarhan (2002) and and Bisheshwor *et al.,* (2013).

Results indicated that E-W plant directions produced higher (49.50) maize seed index than N-S direction (47.83) in the first season, being 51.80 and 44.00 in the second season with significant differences.

The N.Eastern direction produced higher seed index of 49.33 than for N.Western direction of 47.67 with significant difference in the first season. Similar trend was noticed for the second season without significant difference.

Also, circular planting direction produced higher seed index than for perpendicular orientation which was 49.17 and 48.83 respectively in the first season, being 45.60 and 43.60 in the second season with significant difference in the second season (Table 4).

Table 4: The impact of traditional and non-traditional planting directions on Plant height, Ear height and Seed index of maize varieties during each of the two growing seasons (2013 and 2014).

Variety (V)	Planting directions(D)	Plant height (Cm)		Ear height(Cm)		Seed index	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Hi-Tech 2031	North-South (N-S)	320.67	290.00	151.33	142.67	46.67	42.40
	East-West (E-W)	328.00	267.33	152.67	130.67	46.67	48.80
	North. Eastern (N.E)	328.67	288.00	153.33	136.67	47.67	46.80
	North. Western (N.W)	317.00	270.00	154.33	134.00	46.00	45.60
	Perpendicular (Perp)	316.17	276.67	151.67	139.33	48.00	45.60
	Circular (Circ)	312.00	274.00	148.67	134.67	47.00	45.60
Mean		320.50	277.67	152.00	136.33	47.00	45.80
Fine seeds 101	North-South (N-S)	301.67	246.67	144.00	124.67	49.00	45.60
	East-West (E-W)	304.67	249.33	142.00	122.33	52.33	54.80
	North. Eastern (N.E)	295.67	246.00	139.67	124.67	51.00	48.00
	North. Western (N.W)	298.67	238.00	140.00	124.00	49.33	46.00
	Perpendicular (Perp)	306.00	252.00	145.33	127.33	49.67	41.60
	Circular (Circ)	303.67	258.00	146.67	126.00	51.33	45.60
Mean		301.67	248.33	142.94	124.83	50.44	46.93
Strait directions	North-South (N-S)	311.17	268.33	147.67	133.67	47.83	44.00
	East-West (E-W)	316.17	258.33	147.33	126.50	49.50	51.80
Diagonal directions	North. Eastern (N.E)	312.17	267.00	146.50	130.67	49.33	47.40
	North. Western (N.W)	307.83	254.00	147.17	129.00	47.67	45.80
Other directions	Perpendicular (Perp)	311.33	264.33	148.50	133.33	48.83	43.60
	Circular (Circ)	307.83	266.00	147.67	130.33	49.17	45.60
Mean		311.08	262.99	147.47	130.58	48.72	46.36
LSD at: 5% for:		V= 10.18 D= N.S Vd= N.S	V= 4.84 D= 5.63 Vd= 7.96	V= 2.38 D= N.S Vd= 1.72	V= 3.67 D= 3.47 Vd= N.S	V= 1.03 D= 0.86 Vd= 1.22	V= N.S D= 1.91 Vd= 2.70

The recorded significant interaction effect of planting orientations and the grown maize varieties indicated that the highest seed index of maize was obtained for Fine seeds 101variety grown in E-W direction in the first (52.33) and second seasons (54.80).

Light intensity (Lux):

Over the proposed sowing directions, results in Table (5) did not exert significant differences between each of the two studied maize varieties in light radiation intensity between plant canopies, as presented in Table (5).

The Fine seeds 101 variety was superior as compared with Hi-tech 2031 variety in light radiation intensity. Moreover, the second season gave higher intensity of light having the respective order: 69252.28 and 67298.83 lux in the first season, being 73775.00 and 69286.11 lux in the second season for Fine seeds 101 and Hi-tech 2031 variety, respectively without significant differences (Table 5). This is may be due to the detected plant heights variabilities. Similar results were reported by El-Metwally *et al*., (2001), Ahmed and El-Sheikh (2002).

In this respect, data of the two grown seasons clarified that slight significant differences among the planting directions in light intensity of each maize varieties having descending order of North-South (72476.83), Circular (69546.17), East-West (68561.67), Perpendicular (68290.00), North-Eastern (66523.33) and North-Western (64255.00 lux) in the first season, being East-West (76421.67), Circular (73898.33), North-Western (73826.67), North-South (72841.67), North-Eastern (67083.33) and Perpendicular direction (65111.67 lux) in the second season for light intensity with significant differences in the second season (Table 5).

Light radiation (difference in light radiation in lux unit from the top to the bottom of plants at noon (24.00 hr). This included the light interception of plant canopies. More light radiation within maize plant canopies was estimated in each sowing orientation patterns. More light interception where noticed for E-W (76421lux) than for N-S (72841lux) planting orientation, and from N.Eastern (67083lux) than for N.Western (73826lux) and from perpendicular (65111lux) to circular orientation (73898lux).So, when the difference of solar light radiation from the top to the bottom of plants increased, this mean that light is in better use to plants through absorption and transmition within plant canopies for better use in the photochemical reactions and photosynthesis of plant growth and development. Similar results were reported by Tsubo *et al.,* (2001), Eberbach and Pala (2005), Abd El-Maksoud (2008), Brant *et al.,* (2009) and Evers *et al.,* (2009).

Among the performance and potentiality of the grown crops are the impact of the physioenviromental factors which affect the photosynthesis and respiration processes involved in the metabolism and catabolism processes in crop plants. The final products are the crop yielding capabilities and quality. So, planting directions or row orientations of plants could be an important crucial factor in this respect. This is for its impact on the most of the important surrounded environmental and biotic factors with their variable circumstances.

Nutritive value:

Crude protein (CP) content:

It should be known that the presented crude protein content was determined for the grain yield during each of the two growing seasons (Table 5).

Results in Table (5) showed significant differences in CP content between the two maize varieties (Hi-tech 2031 and Fine seeds 101). The Hi-tech 2031was superior variety as compared to Fine seeds 101 in CP content with significant differences. Whereas, Hi-tech 2031and fine seeds 101 varieties produced 8.50 and 8.18 % CP content respectively in the first season, being 8.86 and 8.37 in the second season, with significant difference (Table 5). Similar results were reported by Oraby and Sarhan (2002) and and Bisheshwor *et al.,* (2013).

Results in Table (5) indicated that CP content of maize grains was significant higher for E-W planting direction compared to the N-S direction. This was true in each of the two growing seasons. Also, the perpendicular planting orientation induced significant higher CP content of grains more than the circular orientation of planting in the first season, whereas there was no significant difference between these two planting methods (perpendicular and circular) in the second season. The diagonal planting directions of N.Western produce slightly higher CP content than N.Eastern direction.

The range of protein content of maize grains according to the planting orientation methods was quite narrow (7.82-8.84%) but in favour to E-W (8.56), N.Western (8.67%) and perpendicular (8.68%) compared with the other directions. Similar results were reported by Overstreet *et al.,* (2008) and Bisheshwor *et al.,* (2013).

Table 5: The impact of traditional and non-traditional planting directions on light intensity and CP content of maize varieties during each of the two growing seasons (2013 and 2014).

Variety (V)	Planting directions(D)	Light intensity (Lux)		CP content (%)	
		1st season	2nd season	1st season	2nd season
Hi-tech 2031	North-South (N-S)	71453.33	73066.67	7.82	8.76
	East-West (E-W)	67540.00	77663.33	8.29	8.45
	North. Eastern (N.E)	66866.67	60826.67	8.45	9.07
	North. Western (N.W)	59710.00	73306.67	9.22	9.22
	Perpendicular (Perp)	67336.67	57353.33	9.22	9.22
	Circular (Circ)	70885.67	73500.00	8.13	8.45
Mean		67298.83	69286.11	8.50	8.86
Fine seeds 101	North-South (N-S)	73500.33	72616.67	7.82	8.45
	East-West (E-W)	69583.33	75180.00	8.45	9.22
	North. Eastern (N.E)	66180.00	73340.00	8.13	8.45
	North. Western (N.W)	68800.00	74346.67	8.45	7.82
	Perpendicular (Perp)	69243.33	72870.00	8.45	7.82
	Circular (Circ)	68206.67	74296.67	7.82	8.45
Mean		69252.28	73775.00	8.18	8.37
Strait directions	North-South (N-S)	72476.83	72841.67	7.82	8.60
	East-West (E-W)	68561.67	76421.67	8.29	8.83
Diagonal directions	North. Eastern (N.E)	66523.33	67083.33	8.29	8.76
	North. Western (N.W)	64255.00	73826.67	8.83	8.52
Other directions	Perpendicular (Perp)	68290.00	65111.67	8.84	8.52
	Circular (Circ)	69546.17	73898.33	7.98	8.45
Mean		68275.50	71530.56	8.34	8.61
LSD at: 5% for:		V= N.S D= N.S Vd= N.S	V= N.S D= 2760.95 Vd= 3904.57	V= 0.09 D= 0.25 Vd= 0.35	V= N.S D= 0.18 Vd= 0.26

The significant interaction effect of planting orientations and the grown maize varieties indicated that the highest CP content of maize grains was obtained for Hi-tech variety grown in either N.Western or perpendicular directions (9.22%) during each of the two growing seasons (Table 5).

Regarding planting directions, results showed that appreciable significant differences among directions of CP content whereas the respective descending order was of Perpendicular $_{(11.79)}$ = North-Western $_{(11.79)}$ > East-

West$_{(9.78)}$ = North-Eastern $_{(9.78)}$ > Circular $_{(8.63)}$ >North-South $_{(8.06\%)}$ in the first season, corresponding, East-West $_{(11.79)}$ > North-Eastern $_{(11.51)}$ > North-South $_{(10.93)}$ > Perpendicular $_{(10.64)}$ = North-Western $_{(10.64)}$ > Circular$_{(10.36\%)}$ in the second season for CP content with significant differences (Table, 5).

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