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Effect of planting dates, planting patterns and nitrogen fertilization on earliness and some yield characteristics of cotton

Bakheit B. R.[a], Awadalla A.[b], Hamoda S. A. F.[c], Omar Azza O. M.[c*]

[a]*Agronomy Department, Faculty of Agriculture, Assiut University, Assiut, Egypt*
[b]*Agronomy Department, Faculty of Agriculture, Aswan University, Aswan, Egypt*
[c]*Agronomy Research Section, Cotton Research Institute, Agricultural Research Center, Giza, Egypt*

Abstract

The two succeded experiments were carried out conducted in El-Mattana Agricultural Research Station, Luxor governorate, Upper Egypt during two growing seasons (2019 and 2020) to measure the response of variety Giza 98 cotton as a new variety towards planting date (15th March and 15th April), planting pattern (30 cm distance between 2 hills and 70 cm ridge width (P1), 35 distance between 2 hills and 70 cm ridge width (P2),30 cm distance between 2 hills and 140 cm raised bed width (P3), and 35 cm distance between 2 hills and 140 cm raised bed width (P4)) and nitrogen fertilizer levels (45, 60 and 75 Kg N /feddan) (feddan = 4200 m² = 0.420 hectares = 1.037 acres) under Upper Egypt condition. Under 30 cm distance between 2 hills and 70 cm ridge width (P1) and using 75 Kg N/feddan treatments, the cotton planted on March 15th (D1) showed the highest values of the number of days from planting up to the first flower and the number of days from planting up to the first open boll, On the contrast, the cotton planted on April 15th (D2), showed the highest values of plant height (cm) at harvest time and first fruiting node. While, the cotton planted on March 15th (D1), under 35 cm distance between 2 hills and 140 cm raised bed width (P4) and using 75 Kg N/feddan treatments, showed the highest values of the number of fruiting (sympodial) branches/plant. In other hand, the planting on March 15th (D1), under 35 cm distance between 2 hills and 140 cm raised bed width (P4) and using 75 Kg N/feddan treatments, showed the highest values of number of open bolls/plant, boll weight average (g). While planting on April 15th (D2), under 30 cm between hills on ridge (P1) and the application of 45 Kg nitrogen/feddan produced the lowest values of these properties.

Keywords: cotton, new variety, planting pattern, boll weight.

*Corresponding author: Omar Azza O. M.,
E-mail address: azza.87@gmail.com

1. Introduction

Cotton was the backbone of Egyptian agriculture in past years and still plays a sensible role in agricultural production, industry and national economy. Egyptian cotton has superiority over other global cotton because of its length, strength, luster, and silky appearance, which make Egypt the world's chief source of long-staple cotton (El-Sayed, 2020). Egypt is highly vulnerable to climate change, and agriculture is the most vulnerable sector to climate change (Smith *et al*., 2014). In recent times, there are greater warming trends in summer and winter, also an increase in the frequency of warm nights and a decrease in the frequency of cool nights (USAID, 2015). Determining the optimum sowing dates has a vital role to meet the climate changes and enhance the seed cotton yield (Ishaq *et al*., 2022). Economic returns were two to three times greater in early-planted cotton than in late-planted cotton (Aghaee *et al*., 2019). Bilal *et al.* (2015) found that maximum days to first squaring, first flowering and first boll splition were recorded in mid-March planting, compared to late planting. Sowing dates showed an insignificant effect on the node number of the first fruiting branch as well as more first fruiting branch. Salih (2019) in Egypt, indicated that sowing dates (March and April), significantly affected mean boll weight and boll characters. A greater number of plants per unit area may lead to cotton yield reduction due to the increased competition for sunlight and CO_2 (Kumar *et al.*, 2017). As the distance between the plants increased, the number of bolls per plant also increased (Sylla *et al.*, 2013). Currently, raised beds planting method is widely used in many arid and semi-arid areas (Saharawat *et al*., 2010). Raised bed width is double, and plants grow on the two edges compared with the traditional system where the widths of the ridges are half of the size and only one plant row per ridge. The raised bed method helps in enhancing the seedling emergence and eliminates the formation of crust on the soil surface (Ahmad *et al*., 2009). Reduce the irrigation requirements of crops and increase crop production even in soils having low permeability, seasonal waterlogging, salinity, and shortage of water supply (Qureshi *et al*., 2008). Most cultivated soils in Egypt are low organic matter content and so, accordingly, is the concentration of total nitrogen (FAO, 2005), which is considered the most extracted nutrient by cotton and other plants. On the other side, Egyptian land productivity has declined in the last years, because the agricultural rotation was not being followed and the incompatibility of the fertilization regimes with the different crops (ICARDA, 2011). Hence there is a continuous need to find out the optimum nitrogen levels for local cotton cultivars. Galdi *et al.* (2022) found that increasing the N rate is a strategy to boost yields with low soil fertility in low plant density crops and early maturation cultivars. Hence, the main objectives of the present investigation were to study the effect of sowing dates, plant density, plant pattern and nitrogen fertilizer levels on the growth and productivity of Egyptian cotton cultivar Giza 98 under Upper Egypt conditions.

2. Materials and methods

This research was conducted at Al-Matana Agricultural Research Station in Luxor governorate, Egypt during the two growing seasons (2019 and 2020) to verify the response of the new variety of Egyptian cotton Giza 98 to planting dates, different agricultural patterns and nitrogen fertilization. The two field experiments were conducted to measure the potential of the cotton variety Giza 98 as a new variety on two planting dates of March 15 and April 15, the planting pattern *i.e.*, 30 cm between two folds, a width of 70 cm, and 30 cm between the hills. Two hills, a high bed width of 140 cm, 35 cm between two hills, a width of 70 cm hills, 35 cm between two hills, a high width of 140 cm, and three levels of nitrogen fertilizers *i.e.* 45, 60 and 75 kg N/feddan under the conditions of Upper Egypt.

2.1 Climatic characteristics prevailing

Aiming to enhance yield and its component traits, the three bread wheat genotypes were treated with two chemical mutagens (hydrazine hydrate and Di Methyl Sulfoxid and electric shock) to trigger genetic variations and identify superior mutants.

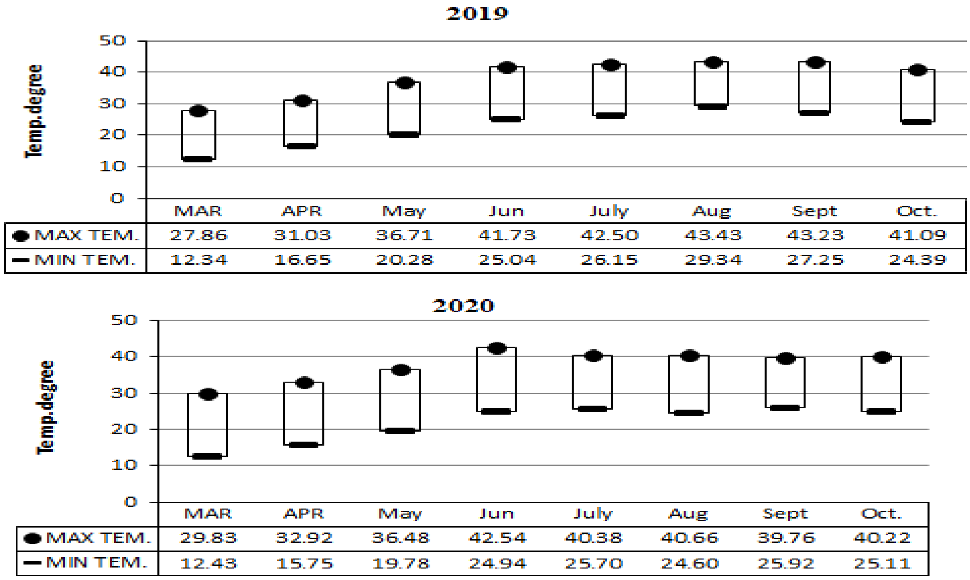

Figure (1): Maximum and minimum temperature degrees for Al-Matana Agricultural Research Station, Luxor governorate, Egypt, during the growing seasons of 2019 and 2020.

2.2 Soil characteristics of the experimental site

Representative soil samples were taken from the experiment site before planting during the two seasons and analyzed.

2.3 Soil characteristics of the experimental site

Representative soil samples were taken from the experimental sites before sowing in the two seasons and were prepared and analyzed, according to FAO (2008). The results of the soil analysis are shown in Table (1).

Table (1): Soil analysis of the experimental site in the two growing seasons.

Seasons	Properties													
	Texture		pH	EC (dS/m)	$CaCO_3$ (%)	Available elements (ppm)								
						N	P	K	Fe	Mn	Zn	Cu	B
2019	Sand (%) = 35 Silt (%) = 29 Clay (%) = 36	Clay loam	7.6	0.26	2.9	60	10	375	12.4	16.4	2.2	4.0	0.45
2020			7.7	0.22	3.1	58	10	326	13.5	8.6	1.7	3.3	0.40

2.4 Experimental details

The experimental design was a split- split-plot with three replications. Main plots included two sowing dates, sub plots included four plant planting patterns and the sub-sub plots included three nitrogen fertilizer levels. Cotton seeds were planted on the 15th of March and 15th of April in the 2019 and 2020 seasons, respectively. Hills were spaced at 30, 35 cm within each planting pattern, and seedlings were thinned at 2 plants/hill after 35 days from planting. The two planting patterns (3 raised beds: (5 m long and 140 cm apart) and 6 ridges: (5 m long and 70 cm apart) occupy an area of 21 m²). Cotton was planted on the two edges of the raised bed to save the same plant density for the two plant distances (30 and 35 cm) (Figure 2). While, three nitrogen fertilizer levels (45, 60 and 75 Kg N_2/feddan) were applied. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) at the tested traits was applied in two equal doses, immediately before the first and the second irrigations (Table 2).

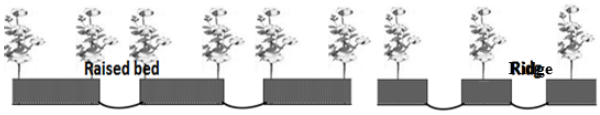

Figure (2): Raised bed and ridge planting methods.

Phosphorus fertilizer as ordinary superphosphate (15.5% P_2O_5) at the rate of 22.5 Kg P_2O_5/feddan. was incorporated during seedbed preparation. Potassium fertilizers in the form of potassium sulfate (48% K_2O) at the rate of 24 Kg K_2O/feddan was side-dressed in a single dose before the second irrigation. Standard agricultural practices were followed throughout the growing seasons.

Table (2): The studied factors and their treatments.

Factor	Treatment	Legend
Planting date	15^{th} March	D1
	15^{th} April	D2
Planting pattern	30 cm distance between 2 hills and 70 cm ridge width (40000/feddan)	P1
	35 cm distance between 2 hills and 70 cm ridge width (34285/feddan)	P2
	30 cm distance between 2 hills and 140 cm raised bed width (40000/feddan)	P3
	35 cm distance between 2 hills and 140 cm raised bed width (34285/feddan)	P4
Fertilizer levels	45 kg N_2 $feddan^{-1}$ as ammonium nitrate (134 kg/feddan)	N1
	60 kg N_2 $feddan^{-1}$ as ammonium nitrate (179 kg/feddan)	N2
	75 kg N_2 $feddan^{-1}$ as ammonium nitrate (233 kg/feddan)	N3

2.5 Studied characters

2.5.1 Earliness traits

Position of first fruiting node: Estimated as the number of nodes below the first fruiting branch. Number of days to first flower: Expressed as the number of days from planting date to first flower appearance. Number of days to first open boll: Expressed as the number of days from planting date to the first boll opening. Number of fruiting branches /plant. Plant height: from the cotyledonary nodes to the top of the plant at harvest.

2.5.2 Yield traits

Number of open bolls per plant: The average number of open bolls in 10 plants picked at random from each plot. Boll weight average in grams: The average boll weight in grams of 50 bolls picked at random from each plot.

2.6 Statistical analysis

The results of vegetative growth and yield, as well as yield compounds of cotton, were statistically analyzed according to Gomez and Gomez (1984), using the computer MSTAT.C statistical analysis package by Freed *et al.* (1989). The least significant differences (L.S.D) probability level of 5% was manually calculated to compare the differences among means.

3. Results and Discussion

3.1 Earliness traits

Significant differences were found among the means of earliness traits. The planting date, planting pattern and nitrogen levels and their interactions affected significantly the first fruiting node, number of days to first flower, number of days to first open boll, number of fruiting branches/plant and plant height at harvest in both seasons, while this increase was insignificant at the two studied seasons for the effect of panting date on number of days to the first flower. Also, the interaction between the three factors affected significantly plant height at harvest in the two studied seasons.

3.1.1 Position of first fruiting node

The first fruiting node is affected by planting date, Planting pattern and nitrogen fertilizer level in the two studied seasons as shown in Table (3). Regarding planting date treatments, the data showed that April 15th (D2) increased non significantly first fruiting node by 3.72% and 1.82% in the 1st season and the 2nd season compared to March 15th (D1), respectively. The late sowing registered the highest number of heat units and resulted in increasing the vegetative growth. These results are similar to those of Abdel Aal *et al.* (2015) and Bilal *et al.* (2015). Concerning planting patterns, data showed that the ridge planting method with 30 cm distance resulted in a significant increase in the first fruiting node. The ridge planting method with 30 cm distance treatment led to a significant increase in the first of fruiting node by 7.14, 13.21 and 20.00% in the 2019 season, and by 6.09, 12.96 and 23.23% as compared to other planting method treatments ridge planting method with 35 cm distance (P2), raised bed planting method with 30 cm distance (P3), and raised bed planting method with 35 cm distance (P4), in the two studied seasons, respectively. This may be due to the decreasing planting distances which resulted in increasing plant density and more competition for nutrients and light. Wang *et al.* (2011) endorsed that inter-plant competition for nutrients and light produced taller plants at high plant density. Hence, the first fruiting node increases as a result. These results are in accordance with those of Munir *et al.* (2015) and El-Shazly (2020).

Table (3): First fruiting node position under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	6.33	6.67	7.00	6.67	6.67	6.67	7.00	6.78
	P2	5.67	6.00	6.67	6.11	6.00	6.33	6.67	6.33
	P3	5.33	5.67	6.33	5.78	5.67	6.00	6.33	6.00
	P4	5.00	5.33	5.67	5.33	5.00	5.33	5.67	5.33
Mean		5.58	5.92	6.42	5.97	5.83	6.08	6.42	6.11
D2	P1	6.33	6.67	7.00	6.67	6.67	6.67	7.00	6.78
	P2	6.00	6.33	6.67	6.33	6.00	6.67	6.67	6.44
	P3	5.67	6.00	6.33	6.00	5.67	6.00	6.33	6.00
	P4	5.33	5.67	6.33	5.78	5.33	5.67	6.00	5.67
Mean		5.83	6.17	6.58	6.19	5.92	6.25	6.50	6.22
Mean	P1	6.33	6.67	7.00	6.67	6.67	6.67	7.00	6.78
	P2	5.83	6.17	6.67	6.22	6.00	6.50	6.67	6.39
	P3	5.50	5.83	6.33	5.89	5.67	6.00	6.33	6.00
	P4	5.17	5.50	6.00	5.56	5.17	5.50	5.83	5.50
Mean		5.71	6.04	6.50	6.08	5.88	6.17	6.46	6.17
LSD at 0.05 level of significance:									
Planting dates (A)					N.S				N.S
Space (B)					0.84				0.78
Nitrogen (C)					0.27				0.34
A × B					N.S.				N.S.
A × C					N.S.				N.S.
B × C					N.S.				N.S.
A × B × C					N.S.				N.S.

Regarding fertilization levels, data indicated that 75 Kg N_2/feddan fertilizer level enhanced first of fruiting node. 75 Kg N_2/feddan fertilizer had a significant increase of first of fruiting node by 13.87 and 7.59% in 2019, and by 9.93 and 4.73% in the second season as compared to 45 and 60 Kg N_2/feddan, respectively. This may be due to the role of nitrogen as an essential element for cotton vegetative and reproductive growth, biomass production, and photosynthesis (Emara and El-Gammal, 2012). These results are in accordance with those of Munir *et al.* (2015).

3.1.2 The Number of days from planting up to the first flower

The number of days from planting up to the first flower as affected by planting date, Planting pattern and nitrogen fertilizer level in the two studied seasons is shown in Table (4).

Table (4): Mean number of days from planting up to the first flower under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	59.00	59.67	60.00	59.56	60.67	61.00	62.33	61.33
	P2	58.67	59.33	59.67	59.22	59.00	59.67	60.00	59.56
	P3	57.67	58.67	59.33	58.56	58.33	59.00	59.67	59.00
	P4	56.67	57.67	58.33	57.56	57.67	58.33	58.67	58.22
Mean		58.00	58.83	59.33	58.72	58.92	59.50	60.17	59.53
D2	P1	58.33	59.00	59.67	59.00	59.67	60.67	61.00	60.44
	P2	57.67	58.67	58.67	58.33	59.33	59.67	60.33	59.78
	P3	57.00	57.67	58.33	57.67	57.67	58.33	59.33	58.44
	P4	56.33	56.67	57.67	56.89	57.00	58.00	59.00	58.00
Mean		57.33	58.00	58.58	57.97	58.42	59.17	59.92	59.17
Overall mean	P1	58.67	59.33	59.83	59.28	60.17	60.83	61.67	60.89
	P2	58.17	59.00	59.17	58.78	59.17	59.67	60.17	59.67
	P3	57.33	58.17	58.83	58.11	58.00	58.67	59.50	58.72
	P4	56.50	57.17	58.00	57.22	57.33	58.17	58.83	58.11
Mean		57.67	58.42	58.96	58.35	58.67	59.33	60.04	59.35
LSD at 0.05 level of significance									
Planting dates (A)					1.62				0.71
Space (B)					0.63				0.78
Nitrogen (C)					0.36				0.37
A × B					N.S.				N.S
A × C					N.S.				N.S
B × C					N.S.				N.S
A × B × C					N.S.				N.S

Regarding planting date treatments, the data showed that March 15th (D1) increased significantly number of days from planting up to the first flower by 1.29 in the 2019 season, and by 0.61% in the 2nd season compared to April 15th (D2), respectively. Late sowing produced the first flower in a shorter period as compared to early sowing. Within early sowing, cotton was exposed to low air temperature and heat units at the beginning of the season but consumed more heat units through the growing season as compared to late sowing (Hamed, 2011). These results are similar to Bilal *et al.* (2015). Concerning planting pattern, data showed that the ridge planting method with 30 cm distance resulted in a significant increase in number of days from planting up to the first flower. The ridge planting method with 30 cm distance treatment led to a significant increase in number of days from planting up to the first flower by 0.85, 2.01 and 3.59% in the 2019 season, and by 2.05, 3.69 and 4.78% as compared to other planting method treatments ridge planting method with 35 cm distance (P2), raised bed planting method with 30 cm distance (P3) and raised bed planting method with 35 cm distance (P4) in the two studied seasons, respectively. This is maybe due to intense competition between plants for soil and water resources which led to earlier flowering. These results are in accordance with those of El-Shazly (2020). Regarding fertilization levels, data indicated that 75 kg N/feddan fertilizer level enhanced number of days from planting up to the first flower. 75 kg N/fed fertilize had a significant increase of Number of days from planting up to the first flower by 2.24 and 0.93% in 2019, and by 2.34 and 1.19% in the second season as compared to 45 and 60 kg N/feddan respectively. This may be because nitrogen is required through all stages of plant development. Excess N encourages vegetative growth and late maturity (Galloway *et al.*, 2003). These results are smeller to those of Munir *et al.* (2015).

3.1.3 The number of days from planting up to the first open boll

The number of days from planting up to the first open boll as affected by planting date, planting pattern and nitrogen fertilizer level in the two studied seasons is shown in Table (5). Regarding planting date treatments, the data showed that March 15th (D1) increased significantly the number of days from planting up to the first open boll by 0.79% and by 0.86% in the 1st season and the 2nd compared to April 15th (D2), respectively. This might be due to the same number of days from planting up to the first flower and a relatively low night temperature early planting date at the beginning of the season which prolonged the period of the appearance of flowering and bolling. These results are similar to Bilal *et al.* (2015). Concerning planting pattern, data showed that the ridge planting method with 30 cm distance resulted in a significant increase in the number of days from planting up to the first open boll. The raised bed planting method with 35 cm distance (P4) treatment led to a significant increase in the number of days from planting up to the first open boll by 0.66, 0.87 and 1.70% in 2019 season, and by 0.77, 0.93 and 2.30% as compared to other planting method treatments ridge planting method with 30 cm distance, ridge planting method with 35 cm distance (P2) and raised bed planting method with 30 cm distance (P3) in the two studied seasons, respectively. This is maybe due to intense competition between plants for soil and water resources which led to earlier flowering and boll formation. These results are in harmony with those of El-Shazly (2020). Regarding fertilization levels, data indicated that 75 Kg N/feddan fertilizer level enhanced the number of days from planting up to the first open boll. 75 Kg N/feddan fertilizer had a significant increase in the number of days from planting up to the first open boll by 1.23 and 0.57% in 2019, and by 1.60 and 0.89% in the second season as compared to 45 and 60 kg N/feddan respectively. It may be due to N role in more leaf production, resulting in an increase in photosynthesis and formation of sugars for boll set and maturation (Emara *et al.*, 2012).

Table (5): Mean number of days from planting up to the first open boll under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	109.00	110.67	110.67	110.11	109.00	109.33	109.33	109.22
	P2	109.33	109.33	110.00	109.56	108.00	108.33	108.67	108.33
	P3	108.67	109.00	110.33	109.33	106.33	107.00	110.33	107.89
	P4	107.00	108.33	109.00	108.11	105.67	106.67	108.67	107.00
Mean		108.50	109.33	110.00	109.28	107.25	107.83	109.25	108.11
D2	P1	108.67	109.33	110.00	109.33	107.00	108.33	109.33	108.22
	P2	108.00	109.00	108.33	108.44	107.33	107.67	107.33	107.44
	P3	107.33	108.33	109.00	108.22	106.67	107.67	108.33	107.56
	P4	107.33	107.00	108.67	107.67	104.67	105.67	106.33	105.56
Mean		107.83	108.42	109.00	108.42	106.42	107.33	107.83	107.19
Overall mean	P1	108.83	110.00	110.33	109.72	108.00	108.83	109.33	108.72
	P2	108.67	109.17	109.17	109.00	107.67	108.00	108.00	107.89
	P3	108.00	108.67	109.67	108.78	106.50	107.33	109.33	107.72
	P4	107.17	107.67	108.83	107.89	105.17	106.17	107.50	106.28
Mean		108.17	108.88	109.50	108.85	106.83	107.58	108.54	107.65
LSD at 0.05 level of significance									
Planting dates (A)					2.15				2.12
Space (B)					1.04				0.84
Nitrogen (C)					0.49				0.66
A × B					N.S				N.S.
A × C					N.S				N.S.
B × C					N.S				N.S.
A × B × C					N.S				N.S.

3.1.4 The number of fruiting (sympodial) branches/plant

The number of fruiting (sympodial) branches/plant as affected by planting date, planting pattern and nitrogen fertilizer level in the two studied seasons is shown in Table (6). Regarding planting date treatments, the data showed that March 15th (D1) increased significantly the number of fruiting branches /plant by 9.31% in the 1st season and an insignificant increase by 1.99 % in the 2nd season compared to April 15th (D2), respectively. The number of sympodial per plant increased in favor of early sowing due to lower night temperature which lowered the position of the first sympodium and induced early balance between vegetative and fruiting development (Makram *et al.*, 2001). These results are in accordance with El-Shahawy and Hamoda (2011).

Table (6): Mean number of fruiting (sympodial) branches/plant under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	13.67	14.33	15.33	14.44	13.00	13.33	13.67	13.33
	P2	14.00	14.33	15.33	14.56	13.33	14.00	15.00	14.11
	P3	15.00	15.33	15.67	15.33	13.67	14.33	15.67	14.56
	P4	14.33	15.67	17.00	15.67	14.33	14.67	16.00	15.00
Mean		14.25	14.92	15.83	15.00	13.58	14.08	15.08	14.25
D2	P1	11.33	12.00	13.67	12.33	12.33	13.33	14.33	13.33
	P2	13.00	13.33	15.00	13.78	13.00	13.67	14.67	13.78
	P3	13.33	13.67	15.67	14.22	13.00	14.67	15.00	14.22
	P4	14.00	14.33	15.33	14.56	14.00	14.67	15.00	14.56
Mean		12.92	13.33	14.92	13.72	13.08	14.08	14.75	13.97
Overall mean	P1	12.50	13.17	14.50	13.39	12.67	13.33	14.00	13.33
	P2	13.50	13.83	15.17	14.17	13.17	13.83	14.83	13.94
	P3	14.17	14.50	15.67	14.78	13.33	14.50	15.33	14.39
	P4	14.17	15.00	16.17	15.11	14.17	14.67	15.50	14.78
Mean		13.58	14.13	15.38	14.36	13.33	14.08	14.92	14.11
LSD at 0.05 level of significance									
Planting dates (A)					2.47				N.S.
Space (B)					0.79				0.91
Nitrogen (C)					0.42				0.46
A × B					N.S.				N.S.
A × C					N.S.				N.S.
B × C					N.S.				N.S.
A × B × C					N.S.				N.S.

Concerning planting patterns, data showed that raised bed planting method with 35 cm distance (P4) resulted in a significant increase in the number of fruiting branches/plant. The raised bed planting method with 35 cm distance (P4) treatment led to a significant increase in the number of fruiting branches/plant by 12.86, 6.67 and 2.26% in the 2019 season, and by 10.83, 5.98 and 2.70% as compared to other planting method treatments (P1) ridge planting method with 30 cm distance, ridge planting method with 35 cm distance (P2) and raised bed planting method with 30 cm distance (P3) in the two studied seasons, respectively. Space availability would have enabled the plants to uptake more water and nutrients to produce a greater number of sympodial branches. These results are in accordance with Liaqat *et al.* (2018) and El-Shazly (2020). Regarding fertilization levels, data indicated that 75 Kg N/feddan fertilizer level enhanced the number of fruiting branches/plant. 75 kg N/feddan treatment had a significant increase in the number of fruiting branches/plant by 13.19 and 8.85% in 2019, and by 13.33 and 5.92% in the second season as compared to 45 and 60 Kg N/feddan respectively. Nitrogen deficiency decreased the nutritive substance content and caused senescence in the source system of upper fruiting branches. In other hand, sufficient N fertilizer and better facilitation of cotton plants to utilize light, water, nutrients, etc., more efficiently in a raised bed caused more cotton growth (Saleem *et al.*, 2009). These results are in accordance with those of Munir *et al.* (2015).

3.1.5 Plant height (cm) at harvest time

The plant height (cm) at harvest time as affected by planting date, planting pattern and nitrogen fertilizer level in the two studied seasons is shown in Table (7). Regarding planting date treatments, the data showed that April 15th (D2) increased significantly plant height (cm) at harvest time by 0.2% and 5.05% in the 1st season and the 2nd season compared to March 15th (D1), respectively. This could be attributed to the increase of internode length and late planting resulted in rapid vegetative growth compared with early planting which was exposed relative to low air temperature. Also, it is known that overheat units lead to increasing vegetative cotton growth, however, under the experiment condition and at the two studied seasons, it can be estimated that the increasing temperature rate didn't lead to an uncommonly increase in vegetative growth and therefore the higher cotton plants were recorded at the early planting time. These results are in harmony with those of El-Shahawy and Hamoda (2011) and Elayan *et al*. (2013). Concerning the planting pattern, data showed that the ridge planting method with 30 cm distance (P1) resulted in a significant increase in plant height (cm) at harvest time. The (P1) ridge planting method with 30 cm distance treatment led to a significant increase in plant height (cm) at harvest time by 1.97, 3.63 and 6.08 % in the 2019 season, and by 1.39, 3.18 and 4.79% in the 2nd season as compared to other planting method treatments ridge planting method with 35 cm distance (P2) raised bed planting method with 30 cm distance (P3) and raised bed planting method with 35 cm distance (P4) in the two studied seasons, respectively. This increase is mainly due to the competition for the light and solar energy among the plants, which push the plants to grow up for obtaining enough light. These results are similar to those of Awan *et al.* (2011) and Liaqat *et al.* (2018) and El-Shazly (2020). Regarding fertilization levels, data indicated that 75 Kg N/feddan fertilizer level enhanced plant height (cm) at harvest time. 75 Kg N/feddan fertilizer treatment had a significant increase in plant height (cm) at harvest time by 5.67 and 2.35% in 2019, and by 7.55 and 3.83% in the second season as compared to 45 and 60 Kg N/feddan respectively. Providing the right N amount during the plant growth will provide healthy leaves with the photosynthetic capacity needed to support the growth of the reproductive components and result in an increase in plant height (Emara *et al.*, 2012). These results are similar to those of Munir (2014). The interactions of experimental factors had a different significant effect on plant height (cm) at harvest time (planting date × planting pattern), (planting pattern × nitrogen fertilizer) and (planting date × planting pattern × nitrogen fertilizer) showed a significant effect on plant height at the two studied seasons, while (planting date × nitrogen fertilizer) showed a significant effect on plant height only at 2nd season.

Table (7): Mean plant height (cm) at harvest time under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	138.30	141.45	146.03	141.93	132.00	142.33	147.33	140.56
	P2	135.15	136.87	140.88	137.63	136.67	137.00	144.00	139.22
	P3	134.93	135.52	137.28	135.91	128.00	142.33	146.67	139.00
	P4	122.61	135.52	136.11	131.41	135.33	136.33	141.00	137.56
Mean		132.75	137.34	140.07	136.72	133.00	139.50	144.75	139.08
D2	P1	137.15	140.30	141.49	139.65	146.33	151.67	155.67	151.22
	P2	134.64	138.95	141.94	138.51	146.33	147.00	152.33	148.56
	P3	131.71	135.81	139.92	135.81	137.33	141.00	153.00	143.78
	P4	128.77	133.39	139.92	134.03	138.00	141.67	143.00	140.89
Mean		133.07	137.11	140.82	137.00	142.00	145.33	151.00	146.11
Overall mean	P1	137.73	140.88	143.76	140.79	139.17	147.00	151.50	145.89
	P2	134.89	137.91	141.41	138.07	141.50	142.00	148.17	143.89
	P3	133.32	135.67	138.60	135.86	132.67	141.67	149.83	141.39
	P4	125.69	134.45	138.01	132.72	136.67	139.00	142.00	139.22
Mean		132.91	137.23	140.45	136.86	137.50	142.42	147.88	142.60
LSD at 0.05 level of significance:									
Planting dates (A)					0.21				3.02
Space (B)					1.05				0.75
Nitrogen (C)					0.84				0.56
A × B					1.48				1.06
A × C					N.S.				0.79
B × C					1.68				1.12
A × B × C					2.38				1.58

3.2 Yield traits

Significant differences were found among the means of yield and yield component. The planting date, planting pattern and nitrogen levels and their interactions affected significantly the number of open bolls/plant and boll weight(g) in both seasons. on the same side, all the possible interactions have a significant effect on the number of open bolls/plant.

3.2.1 Number of open bolls/plant

The number of open bolls/plant as affected by planting date, planting pattern and nitrogen fertilizer level in the two studied seasons is shown in Table (8). Regarding planting date treatments, the data showed that March 15th (D1) increased significantly Number of open bolls/plant by 22.27 and 6.65% in the 1st season and the 2nd season compared to April 15th (D2), respectively. This may be due to the lower photosynthesis available for elongation and vice versa in short cotton plants which carried a larger number of open bolls/plant (Boquet *et al*., 2003).

Table (8): Mean number of open bolls/plant under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	36.70	33.41	26.31	32.14	17.78	18.46	33.55	23.26
	P2	47.01	30.13	24.39	33.84	24.80	27.77	33.11	28.56
	P3	35.96	33.74	32.75	34.15	28.40	32.76	45.11	35.42
	P4	42.70	39.07	37.47	39.75	28.77	50.03	51.02	43.27
Mean		40.59	34.09	30.23	34.97	40.70	24.94	24.94	40.70
D2	P1	24.16	21.33	19.20	21.56	24.04	29.55	34.73	29.44
	P2	40.87	27.78	21.97	30.21	22.19	32.66	36.08	30.31
	P3	32.21	31.43	27.01	30.22	25.49	27.94	38.28	30.57
	P4	36.74	31.61	28.87	32.41	24.64	35.32	36.21	32.05
Mean		33.49	28.04	24.27	28.60	36.33	24.09	24.09	36.33
Overall mean	P1	30.43	27.37	22.76	26.85	20.91	24.00	34.14	26.35
	P2	43.94	28.95	23.18	32.02	23.50	30.21	34.60	29.44
	P3	34.08	32.58	29.88	32.18	26.95	30.35	41.69	33.00
	P4	39.72	35.34	33.17	36.08	26.70	42.67	43.61	37.66
Mean		37.04	31.06	27.25	31.78	24.51	31.81	38.51	31.61
LSD at 0.05 level of significance:									
Planting dates (A)					7.88				2.54
Space (B)					1.51				0.76
Nitrogen (C)					3.01				0.53
A × B					2.14				1.07
A × C					N.S.				0.75
B × C					N.S.				1.06
A × B × C					N.S.				1.50

These results are in harmony with those of Saleem *et al*. (2014). Concerning the planting pattern, data showed that raised bed planting method with 35 cm distance (P4) resulted in a significant increase in Number of open bolls/plant. The raised bed planting method with 35 cm distance (P4) treatment led to a significant increase in number of open bolls/plant by 34.36, 12.66 and 12.10% in the 2019 season, and by 42.92, 27.95 and 14.14% as compared to other planting method distance, ridge planting method with 35 cm distance (P2) and raised bed planting method with 30 cm distance (P3) in the two studied seasons, respectively. The increase in the number of bolls per plant with increasing the plant-to-plant distance may be due to more availability of space, less competition and more the number of sympodial branches per plant, the planting method has prime importance because it not only helps in establishing the treatments (P1) ridge planting method appropriate crop stand but also facilitates the conversion of light energy by balancing plant to plant competition in order to produce maximum crop yield (Ali *et al.*, 2012). Raised bed planting method can be considered a sustainable environment for root growth. Bed planting enhances seedling emergence and eliminates the formation of crust on the soil surface (Ahmad *et al.*, 2009). These results are similar to Liaqat *et al.* (2018). Regarding fertilization levels, data indicated that 75 Kg N/feddan fertilizer level enhanced Number of open bolls/plant. 45 Kg N/feddan treatment had a significant increase of Number of open bolls/plant by 19.26 and 35.95% in 2019, and by 21.07 and 57.10% in the second season as compared to 45 and 60 Kg N/feddan, respectively. N excess may induce rank-growth, extend the plant cycle and result in poor boll set number of bolls (Staut and Kurihara, 2001). These results are in accordance with those of Adlah *et al.* (2011). All the interactions of experimental factors had a significant effect on number of open bolls/plant except for (planting date × nitrogen fertilizer) and (planting date × planting pattern × nitrogen fertilizer) in the 1st season. This may be due to the higher air temperature and hence the larger heat units in 2020 than in the other season in 2019.

3.2.2 Boll weight average (g)

The boll weight average (g) as affected by planting date, planting pattern and nitrogen fertilizer level in the two studied seasons is shown in Table (9). Regarding planting date treatments, the data showed that March 15th (D1) increased significantly by boll weight average by 2.10 in the 1st season, and by 2.47% in the 2nd season compared to April 15th (D2), respectively. This may be due to lower night temperature and inducing early balance between vegetative and fruiting development. These results are similar to those of El-Shahawy and Hamoda (2011) and Emara (2012). Concerning the planting pattern, data showed that raised bed planting method with 35 cm distance (P4) resulted in a significant increase in boll weight average. The raised bed planting method with 35 cm distance (P4) treatment led to a significant increase in boll weight average by 10.80, 9.49 and 8.89% in 2019 season, and by 20.07, 16.35 and 7.32% as compared to other planting method treatments (P1) ridge planting method with 30 cm distance, ridge planting method with 35 cm distance (P2) and raised bed planting method with 30 cm distance (P3) in the two studied seasons, respectively. This might be due to the higher interception of solar radiation, better utilization of available nutrients and lesser competition for moisture, which resulted in higher photosynthetic activity (Sharma and Dungarwal, 2003). These results are similar to those of Darawsheh *et al.* (2019) and El-Shazly (2020).

Table (9): Mean boll weight average (g) under different planting dates, planting patterns and nitrogen fertilizer levels in 2019 and 2020 seasons.

Treatments		2019				2020			
		Nitrogen fertilizer levels (Kg/feddan)							
		45	60	75	Mean	45	60	75	Mean
D1	P1	2.40	2.42	2.42	2.41	2.38	2.38	2.71	2.49
	P2	2.41	2.44	2.48	2.44	2.50	2.49	2.57	2.52
	P3	2.48	2.49	2.54	2.50	2.69	3.01	3.05	2.92
	P4	2.57	2.64	3.00	2.74	2.77	3.25	3.51	3.18
Mean		2.46	2.50	2.61	2.52	2.59	2.78	2.96	2.78
D2	P1	2.44	2.34	2.46	2.41	2.52	2.57	2.58	2.56
	P2	2.34	2.44	2.55	2.44	2.62	2.68	2.75	2.68
	P3	2.28	2.47	2.50	2.42	2.87	2.56	2.74	2.72
	P4	2.49	2.53	2.82	2.61	2.78	2.80	3.05	2.88
Mean		2.39	2.44	2.58	2.47	2.70	2.65	2.78	2.71
Overall mean	P1	2.42	2.38	2.44	2.41	2.45	2.47	2.65	2.52
	P2	2.37	2.44	2.51	2.44	2.56	2.59	2.66	2.60
	P3	2.38	2.48	2.52	2.46	2.78	2.79	2.90	2.82
	P4	2.53	2.58	2.91	2.67	2.77	3.03	3.28	3.03
Mean		2.43	2.47	2.60	2.50	2.64	2.72	2.87	2.74
LSD at 0.05 level of significance:									
Planting dates (A)					0.07				0.08
Space (B)					0.15				0.34
Nitrogen (C)					0.10				0.18
A × B					N.S.				N.S.
A × C					N.S.				N.S.
B × C					N.S.				N.S.
A × B × C					N.S.				N.S.

Regarding fertilization levels, data indicated that 75 Kg N/feddan fertilizer level enhanced boll weight average. 75 Kg N/feddan fertilizer treatment had an insignificant increase of boll weight average by 7.03 and 5.11% in 2019, and by 8.74 and 5.62% in the second season as compared to 45 and 60 Kg N/feddan respectively. This could be attributed to the subtending leaf being the basic source of photosynthates for boll development and is the major contributor to cotton yield, especially boll weight (Liu *et al.*, 2013). Higher photosynthetic efficiency and more photosynthates translocation, encourage the development of better reproductive organs and hence boll size (Iqbal *et al.*, 2022). These results are similar to those of Adlah *et al.* (2011), Seilsepour and Rashidi (2011) and Rashidi and Gholami (2011).

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