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Influence of Micro-Environment on Some Growth Character of Cotton (*Gossypium Hirsutum L.*) with Reference to Row Positions

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ABSTRACT

This experiment was conducted at Grdarasha Experimental Field, University of Salaheddin, Erbil (36.11º N, 44.01º E), to study the growth performance of cotton cultivar Coker 310 under four micro environmental conditions. The levels were composed of row directions and sowing dates as main plot (E1-E4) in split plot of Randomized Complete Block Design (RCBD). A total of 13 row positions (RP1-RP13) of different central and outer positions were included in sub plots, those rows had dual roles, as a principle constitute of the sub-plot and as a bilateral use to check the reality of the sampling statistic concept that suggests not to depend on the samples from terminal parts. with three replicates, during two successive growing seasons in 2021 and2022. Results showed that the highest value was recorded from (E1and E2) for both seasons. The highest values were recorded of weight dry matter from (E3 and E4), leaf area from (E3), leaf area index from (E3 and E4), crop growth rate and relative growth rate from (E4 and E1) at 60 DAS for both seasons. at 90 DAS the highest values of weight dry matter, leaf area, crop growth rate was recorded form (E4) and leaf area index from (E3) in the first season, while the second season at 90DAS the highest values of weight dry matter, leaf area, leaf area index, crop growth rate was recorded from (E3) and relative growth rate was recorded from (E4). The row positions (RP8 and RP5) superiority in plant height for both yeas. (RP1 and RP9) recorded superiority in weight dry matter, (RP1 and RP8) recorded superiority in leaf area, (RP2 and RP8) recorded superiority in leaf area index and (RP10 and RP3) in relative growth rate at 60DAS for both years. The highest values at 90DAS of weight dry matter, leaf area and leaf area index were recorded from (RP9 and RP10) for both years. The highest values of crop growth rate were recorded from (RP9 and RP11) at 60 and 90 DAS for both years. The highest value of relative growth rate at 90DAS was recorded from (RP12) in the first year.

Keywords: Cotton, Environments, Row Positions, Growth Traits.

1. Introduction

Cotton is one of the most valued sources of fiber. It is crucial to the nation's industrial and agricultural economies. Often referred to as the "White Gold" or the "king of fibers," it is a major cash crop. Worldwide cotton production is approximately 25 million tons annually [1]. In Iraq amounted to the cultivated area (82282) Dunam an in 2010 average production capacity of (45278 kg. ha^{-1}) [2]. Microclimatic variations can be done by alteration in sowing date, spacing and row direction, by adopting suitable cropping systems [3]. Optimization of sowing dates is considered a strategy for adapting crop production to climate change, and this method has been mentioned in a study [4]. Different sowing times results in varied weather conditions which impacts the growth and yield production, the sowing time is optimized in such a way that the growing stage may coincide with favorable environmental conditions [5-6]. The reduction in plant height with delayed sowing [7]. According to El Hassan [8] compared to later sowing dates, early sowing produced taller plants with higher LAI and more total dry weight in Sudan. The study conducted by Ali et al. [9] included three planting dates: April 21, May 5, and May 20, the sowing date on May 5th yielded a greater leaf area index, but the sowing date April 21st produced higher TDM yield. The TDM accumulation per plant at all of stages in crop growth was affected by varying plant geometries, the increase in dry matter can be due to the higher availability of nutrients, resulting in increased plant height, leaf count, and leaf area. Mohammed [10] Leaf area index one of the primary factors determining the total dry matter produced by a crop.

Damahe et al. [11] presented that plant highest, leaf area, leaf area index and DM per plant were significantly greater with crop sown earlier compared to later sown. Siddiqui et al. [12] noted that early sowing has higher DM than late sowing. This, in turn, enhances the production of photosynthates and their subsequent accumulation in the plant, the relative growth rate (RGR) based

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on the TDM accumulation per plant per day exhibited a slow pace during the initial 0 to 30 days after sowing (DAS), accelerated significantly during 61 to 90 DAS, and subsequently decelerated as observed by [13]. Ali et al. [9] showed that 15th April to 10th May sown cotton gave maximum crop growth rate. Kaur et al. [14] studied on three sowing dates (20th April, 10th May, and 30th May) revealed that the crop growth rate (CGR) was greater for the cotton sown earlier 20th April. The range from 90–120 DAS (days after sowing) produced the maximum RGR. Dawood et al. [15] leaf area, Plant height and leaf area index are significant effected by row orientation. Jha [16] reported superior leaf area index in North-South sowing orientation over East-West. Anda and William [17] reported on the sugar beet under different sowing directions, and the results noted that the LA from east-west higher than north-south. Sandhu and Dhaliwal [18] also mentioned that the DM accumulation was maximum in East-West row direction than North-South row direction. Net photosynthesis determines the TDM production and leaf area index of E-W row orientation crop was greater than N-S row orientation crop. Dhir et al. [19] revealed that among various planting times, and row directions very little variation was recorded among observed and simulated maximum leaf area index. The choice of sample strategies is critical in agricultural statistics as it lays the groundwork for dependable data that are essential for making decisions [20]. Selecting the appropriate locations for the statistical sample is a crucial choice that involves balancing the centrally located plants in a plot against the peripheral plants. A plot's inner plants endure a more stable microclimate, whereas plants on its edges may perform differently due to influences from both the internal microclimate and the nearby macroclimate. This widely held idea casts doubt on the reliability of statistics, especially when it comes to the analysis of agricultural production systems.

The objective of this research was to find the effect of environments (sowing dates and row orientation) and row position on some growth characters of cotton plant.

2. Methods and Materials

2.1 Study location

The experiment was conducted at the Girdarasha Agriculture Research Station, belongs to the Department of Field Crops and Medicinal Plants at the College of Agriculture Engineering Sciences at the University of Salahaddin in Erbil, Kurdistan (Latitude: 36° 4’ N and Longitude: 44° 2’ Elevation 415 Meters above sea level). The study was conducted at two growing seasons of 2020-2021 and 2021-2022.

2.2 Experimental Design

The experiment was organized in a Randomized Complete Block design (RCBD) with a split-plot arrangement and three replications: The main plot (A) consisted of four micro environment levels, including; east-west first sowing date 12April (E1), north-south first sowing date 12April (E2), east-west second sowing date 27 April (E3) and north-south second sowing date 27April (E4) as shown in Table (1). The sub plot (B) included thirteen sowing rows (used also as row positions). The American type cotton cultivar sown in this study was Coker 310, released and recorded in Iraq), The experiment was repeated in two consecutive growing seasons of the years 2020– 2021 and 2021–2022 the micro environments were allotted to main plots, and the sowing rows was allotted to a subplot. The main plot area of 8.40m x 5.25m. Subplot size was 5.25m x 0.70m, contained 21 plants interspaced by 0.7 meters between rows and 0.25m between plants, so that each plant occupied 0.175 m^{-2}.

Table 1: Design of the study environments.

Sowing date / Sowing row direction	12-Aprl	27-Apr
East-West	E1	E3
North- south	E2	E4
E= Environment		

2.3 Soil preparation and water management

Field experiment was prepared for cultivation by ploughing with two perpendicular directions by using mold board plow. The soil was well softened by rotavator and leveled then rows established. Sowing was made manually with the rate of 25 Kg. ha-1. DAP fertilizer (45% P2O5) applied once with rate (240Kg.ha-1) and Urea (46% N) with two doses rated (160Kg.ha-1). The first dose was applied at planting and the second dose was after thinning equally quantum [21]. The plots were drip-irrigated and maintained well-watered throughout the growing season. The first pick was conducted on 1st September 2021, while for the second-year, first pick was conducted on 2nd September 2022. The second pick was conducted on 2nd October (one-month interval) for both years 2021 and 2022.

2.4 Soil Sampling

Soil samples were taken at the depth of 0 to 15 cm randomly from the land before the experiment setup. Then, the sample transported to the laboratory. Afterward, the soil was air dried and sieved through a 2 mm pore size sieve. Table 2 shows the physical and chemical properties of the soil at both locations.

2.5 Meteorological Data Collection

Figure 1 shows the meteorology of both years Grdarasha during the growing seasons summer, 2021 and 2022. The data was obtained from Ainkawa Research Station of.

2.6 Data Collection and Sampling Method

Data from the trials of the seasons 2020–2021 and 2021–2022 were collected for each single plant in the population (out of 3276 plants for each year). A complete plant destructive sampling for the total of 21 plants from each of the 13 rows (the total plants in each row) were sampled and booked the data recording. Data were collected from each seven plants at three different growth stages (7 plants x 3 stages), at the flowering stage (60 days after sowing), the boll stage (90 days after sowing), and harvesting stage (138 days after sowing). The data were taken from each plant by cutting the whole plant from the above ground to ensure that the entire population of plants was sampled finally to reduce their sampling errors concerned to population parameter estimates such as sample and population mean variances. The data collected include growth parameters. The parameters studied are listed below.

Table 2: Physicochemical properties of the soil sample for the experiment location in2021 and 2022.

Physicochemical properties		Average value 2021	Average value 2022
Particles size distribution(Kg^{-1})	Sand	25.5	31.0
	Silt	42	37.3
	Clay	32.8	31.7
	texture	Clay loam	Clay loam
pH		7.2	7.83
EC(micro siemrns cm^{-1}) or (ds cm^{-1})		0.48	0.5
O.M (g Kg^{-1})		1.8	1.14
$CaCO_3$(g Kg^{-1})		304	312

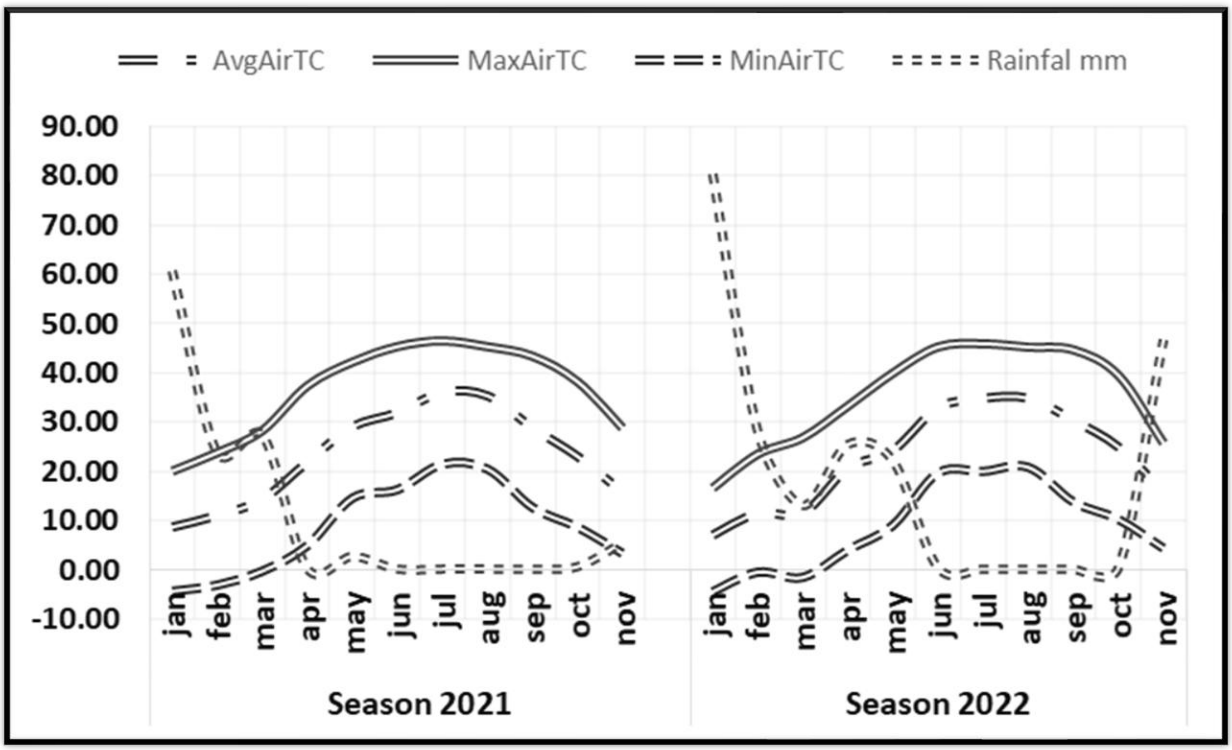

Figure 1: Meteorological data (Erbil Agricultural Research Center).

2.7 Studied parameters

1. Plant height (cm): Measured as vertical distance from the soil surface to the highest point of the main stem of the plant.
2. Dry matter accumulation (g): In each row, dry matter (DM) accumulation was measured 60-, 90-, and 138-days DAS. A consistent dry weight was obtained after 72 hours of drying in an oven at 70°C ± 5°C, using samples taken from seven plants in every stage, then weighed to calculate the fresh weight.
3. Leaf area (cm^2): Measured on seven plants in each row at different growth stages using ImageJ software, as described in previous studies [22, 23]. The measurements were taken at 60 and 90 (DAS).
4. Leaf Area Index (%):
   Leaf area index was measured in seven plants from each plot at two different stages of plant growth (60 and 90 DAS) using the equation described in previously [24]. Leaf area index was calculated as the ratio of total plant leaf area to the average land area occupied by the plant.
5. Crop growth rate:

The crop growth rate clarifies the total plant dry weight (g cm^{-2} day^{-1}) per unit land area per unit time. Crop growth rate was calculated at 60, 90, and 138 days after sowing in each row [25].

$$CGR = \frac{(w2 - w1)}{(t2 - t1)}$$

where W1 and W2 are the total dry weights of the crop at time t1 and t2. t1 and t2 are the times in days after planting.

6. Relative growth rate (RGR):
The Relative Growth Rate (RGR), which is expressed as unit dry weight / unit dry weight / unit time (g g^{-1} day^{-1}) represents the total plant dry weight increase in a time interval in relation to the initial weight or Dry matter increment per unit biomass per unit time or grams of dry weight increase per gram of dry weight [26].

$$RGR = \frac{Log\ w2 - Log\ w1}{t2 - t1}$$

were,
W1 = weight of dry matter (g) at time t1
W2 = weight of dry matter (g) at time t2
t2 - t1 = the interval in days
loge = natural logarithms (logarithms to the base of 2.71828 or ln(x)
x is any positive number

The relative growth rate is expressed in g/plant/day. RGR was calculated at 60, 90, and 138 days after sowing in each row.

2.8 Statistical analysis

The data for each character were analyzed statistically using SAS (version 2003, SAS, institute Inc. cary, Nc, USA) program. Differences between means were tested using Tukey's method test at a probability level of ($P \leq 0.05$) for all the studied characters according to [27]. The analyses of this experiment were unique because the sample size was equal to the size of the population as explained above.

3. Results and Discussions

3.1 Influence of environments and row positions on cotton plant height (cm)

Data presented in Table 3 shows that the mean value in plant height was significantly affected by environment, row positions and interaction between environment and row positions. The results suggest that the environment has a significant impact on plant height. Average environment value for plant height was maximum in (E1) and (E2) (118.51 and 105.62 cm) during first 2021 and second 2022 seasons. Whereas the minimum values of (99.73 and 92.40 cm) were recorded from (E2) and (E4) during both years respectively, could be due to in the north-south orientation, the angle of the sunlight hitting the plants is not direct as compared to the east-west orientation.

It is said that compared to a north-south orientation, an east-west sowing orientation allows lighter to enter and intersect the plant canopy [28]. These findings are consistent with those of [29] the early-planted crop in March allows the accumulation of more growth degree days producing superior plant heights. This result in second year is agreement with those of [30] indicating that the North-South orientation produced the tallest plants. The result given in Table 3 indicates that plant height significantly affected by environment of row positions treatment 13 during both years the highest plant height were obtained (111.61 and 103.76 cm) from (RP8 and RP5) during 1st and 2nd years, While the lowest mean value of 100.69 cm and 90.40 cm was recorded from RP6 and RP12, respectively during both years this could be due to the neurocomputation among both sides in each of RP6 and RP 12 , while RP13 possessed intra competition only with one neighbor (RP12) . In the interaction between environment along with row positions represented significant results regarding plant height on both years. The highest value for plant height was recorded from (E1X RP1) (132.53 cm) during 2021, followed by E2 X RP5 with 120.55 cm, during 2022. While, the lowest values were obtained (88.93 cm and 71.06 cm) from E2 X RP6 and E4 X RP1, respectively at both seasons. This results in first year is agreement with [28], reporting that for height of plant in the East-west (E-W) row orientation was greater than the North-south (N-S) orientation. The result in the second year is similar with what was obtained by [31] Significantly greater plant height values were obtained in the north-south row direction.

3.2 Influence of environments and row positions on plant dry weight (g $plant^{-1}$) for cotton plant

The effect of environment, different row positions treatment and interaction between environment and row positions on dry matter recorded throughout the crop seasons is depicted in Table 4. The results suggest that the environment has a significant impact on dry matter at 60 and 90 DAS (first and second cutting). The greatest average environment values for dry matter at 60 DAS from E3 and E4 (16.49 g and 23.61 g) due to wormer climate condition as compared to early sown crop, and during 90 DAS from E4and E2 (67.50g and 64.79 g) were recorded, respectively, during both years. Whereas the lowest means (5.34g and 8.31g) during 60 DAS from (E2) and (42.47g and 51.28g) were recorded during 90 DAS from E1 and E2, respectively during the both years. This outcome might be referred to the reduced wind damage and affect temperature effect on soil for North-South direction. In the North-South direction temperature of soil were 5-8 degrees warmer in East-West direction [32]. Our results in 2022 at 60DAS and in 2021 at 90DAS are in agreement with [33] it is indicating that sowing orientation had significant effect on weight dry matter, the maximum values for dry matter was obtained when using north-south direction than east-west direction. Talentino [34] observed that 53 days after growing, the daily intercepted solar energy was greater at north-south row direction.

Table 4 shows a significant effect of environment dry matter between all the row positions for the both seasons.

The maximum values were obtained (12.07 g) from RP1 and (20.42 g) from RP8 at 60 DAS, 64 g from RP9 and 72.06g from RP10 at 90 DAS, respectively during 1st and 2nd years.

However minimum mean values during 60 DAS were recorded

Table 3: Effect of environments, row positions and their interaction on the plant high (cm) for the years 2021 and 2022.

Year	**2021**				
Row position	**Environment**				**row average**
	E1	**E2**	**E3**	**E4**	
RP1	106.33 e-m	90.93 l-n	112.93 b-j	100.87 h-n	102.77 bc
RP2	119.60 a-e	103.60 e-n	101.20 g-n	102.27 f-n	106.67 abc
RP3	128.20 a-c	102.58 f-n	101.40 g-n	103.47 e-n	108.91 ab
RP4	109.67 e-j	92.13 k-n	102.33 f-n	110.73 d-j	103.72 bc
RP5	119.07 a-f	96.20 j-n	101.20 g-n	112.13 c-j	107.15 abc
RP6	117.80 a-g	91.62 l-n	88.93 n	104.40 e-n	100.69 c
RP7	127.47 a-d	91.40 l-n	100.20 h-n	111.33 c-j	107.60 abc
RP8	117.13 a-h	106.87 e-m	119.60 a-e	102.85 e-n	111.61 a
RP9	107.33 e-l	99 .53 i-n	112.73 b-j	99.20 i-n	104.70 abc
RP10	129.53 ab	103.53 e-n	98.33 i-n	89.93 mn	105.33 abc
RP11	132.53 a	109.93 e-j	99.07 i-n	103.07 e-n	111.15 a
RP12	112.27 c-j	96.33 j-n	111.47 c-j	100.93 g-n	105.25 abc
RP13	113.73 b-i	111.77 c-j	99.80 i-n	108.80 e-k	108.53 ab
Average environment	118.51 a	99.73 b	103.78 b	103.84 b	
Year	**2022**				
	Environment				
Row position	**E1**	**E2**	**E3**	**E4**	**row average**
RP1	99.51 d-k	101.10 c-k	86.02 j-n	96.88 e-l	95.88 b-e
RP2	87.15 i-n	105.43 a-h	86.55 i-n	109.00 a-f	97.03 a-e
RP3	106.84 a-g	98.32 d-l	85.28 j-n	115.33 a-d	101.45 a-c
RP4	90.89 g-m	100.44 c-k	96.74 e-l	104.29 a-i	98.09 a-d
RP5	95.93 e-l	120.55 a	100.22 c-k	98.34 d-l	103.76 a
RP6	102.62 a-k	117.65 abc	97.99 d-l	92.23 f-l	102.62 ab
RP7	119.64 ab	103.33 a-j	94.11 f-l	92.45 f-l	102.38 ab
RP8	102.08 b-k	108.11 a-g	102.66 a-k	95.35 e-l	102.05 ab
RP9	97.47 d-l	108.89 a-g	102.44 b-k	84.94 k-n	98.43 a-d
RP10	113.18 a-e	95.00 f-l	95.11 e-l	74.04 mn	94.33 cde
RP11	101.42 c-k	118.11 abc	98.77 d-k	71.06 n	97.34 a-e
RP12	92.94 f-l	92.99 f-l	88.67 h-n	87.00 i-n	90.40 e
RP13	106.55 a-h	103.10 a-j	80.44 l-n	80.34 lmn	92.61 de
Average Environment	101.25 a	105.62 a	93.46 b	92.40 b	

(7.49 g) from RP12 and (11.17 g) from RP4, 42.69 g from RP1 and 52.24g from RP2 at 90 DAS, respectively for the both years. According to the results in Table 4 the interaction between environment along with 13 row positions represented significant results regarding dry matter during 1st and 2nd years. For the both cultivation years data recorded the maximum values at 60 days after sowing for DM (23.26 g and 37.23 g) respectively from E3 X RP2 and E3 X RP8. Dry matter at 90 dates after sowing, recorded the maximum values (65.59 g and 108.51g) from E4 X RP2 and E1 X RP1, respectively. The lowest values at 60 DAS (23.63g and 5.21 g) were obtained from E2 X RP12 and E2 X RP12 for the same trait. The lowest values of dry matter at 90 DAS were recorded from E2 X RP1 and E2 X RP2 with the amount of 16.04g and 36.73g, respectively both seasons. The study shows that the second year was with higher dry matter than first year, this result is a line with [18] the accumulation of dry matter is greater in the East-West row orientation than in the North-South row orientation. Lunagarhia and Shekh [35] discovered that row orientation had an impact on light capture percentage determined at various canopy depths. Compared to North-South row direction, ridged land with an East-West row direction allowed more light to enter the canopy. Our finding is in accordance with a study [12] to find that April to May sowing date showed maximum total dry matter production than late sowing date.

Table 4: Effect of environments, row positions and their interaction on the plant dry weight (g plant-1) for the years 2021-2022.

Year	2021									
Row position	60 DAS sampling				Average row	90 DAS sampling				row average
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	6.06 p-x	7.43 o-v	21.28 ab	13.52 f-i	12.07 a	37.54 l-q	16.04 r	54.97 f-k	93.20 e-l	42.69 g
RP2	6.06 p-x	5.54 q-x	23.26 a	9.58 j-o	11.11 ab	44.98 j-o	27.97 p-r	56.50 f-k	65.59 a	55.66 bc
RP3	7.07 o-x	7.05 o-x	17.92 bd	13.04 f-j	11.27 ab	49.18 h-m	30.72 o-r	56.37 f-k	79.51 e-g	50.47 c-f
RP4	4.64 t-x	4.28 u-x	12.44 g-k	14.15 e-i	8.88 def	35.30 n-q	28.00 p-r	76.58 b-e	86.46 a-d	54.85 bc
RP5	4.84 s-x	6.28 o-x	16.31 d-f	15.14 d-h	10.64 b	31.93 n-q	26.20 qr	67.43 c-f	37.77 ab	53.01 b-d
RP6	8.23 m-x	4.03 v-x	13.20 f-i	8.49 l-r	8.49 ef	46.51 j-n	47.05 i-n	57.90 f-k	57.31 l-q	47.31 d-g
RP7	5.88 p-x	4.20 v-x	13.16 f-i	8.23 m-s	7.87 ef	46.06 j-n	24.82 qr	56.44 f-k	57.63 f-k	46.16 e-g
RP8	7.14 o-w	5.24 r-x	16.21 d-f	11.21 i-n	9.95 bcd	47.14 i-n	59.38 f-j	51.73 g-l	80.39 f-k	53.97 bc
RP9	8.15 m-s	5.95 p-x	15.69 d-g	11.85 h-l	10.41 bc	43.10 k-p	55.77 f-k	76.71 b-e	64.28 a-c	64.00 a
RP10	7.43 o-v	4.28 u-x	15.66 d-g	9.22 k-p	9.15 cde	58.63 f-j	49.28 h-m	59.48 f-j	64.68 e-h	57.92 ab
RP11	8.75 l-q	3.71 wx	20.46 abc	7.35 o-v	10.07 bcd	44.26 j-o	33.72n-q	66.64 c-g	69.20 e-g	52.33 b-e
RP12	7.75 n-u	3.63 x	11.61 i-m	6.98 o-x	7.49 f	35.45 m-q	28.93 p-r	67.19 c-f	59.26 c-f	50.19 c-f
RP13	9.63 j-o	7.77 n-t	17.11 c-e	8.81 l-q	10.83 ab	32.08 n-q	33.63 n-q	56.19 f-k	93.20 f-j	45.29 fg
Average Environment	7.05 c	5.34 d	16.49 a	10.58 b		42.47 c	35.50 d	61.86 b	67.50 a	
Year	2022									
Row position	Environment 60 DAS				Average row	Environment 90 DAS				row average
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	12.11 m-u	6.34 tuv	26.45 cde	33.44 ab	19.58 a	73.19 d-g	67.14 e-j	49.25 o-w	67.55 e-i	64.28 b
RP2	5.80 uv	7.28 r-v	16.73 h-n	23.25 d-h	13.26 def	63.49 e-n	36.73 w	51.00 m-u	57.74 i-s	52.24 d
RP3	5.02 v	7.16 s-v	13.82 j-r	20.27 e-j	11.57 f	56.44 i-s	36.79 w	75.56 de	60.67 g-p	57.36 cd
RP4	7.77 q-v	7.25 s-v	10.97 n-v	18.69 g-l	11.17 f	46.47 r-w	50.26 n-v	64.08 e-m	58.16 h-r	54.74 d
RP5	10.51 n-v	8.58 q-v	20.64 d-j	26.99 bcd	16.68 bc	47.28 q-w	66.68 e-j	53.89 j-t	60.57 g-q	57.10 cd
RP6	8.77 p-v	9.58 p-v	16.53 i-o	16.32 i-o	12.80 ef	62.01 f-o	62.32 e-o	51.83 k-u	48.45 p-w	56.15 cd
RP7	11.33 n-v	9.10 p-v	15.21 i-p	24.66 c-g	15.07 cde	60.49 g-q	71.21 e-h	56.26 i-s	73.81 d-g	65.44 b
RP8	10.48 n-v	10.83 n-v	37.23 a	23.14 d-h	20.42 a	74.23 def	50.24 n-v	67.20 e-j	64.51 e-l	64.04 b
RP9	14.29 i-q	10.03 o-v	26.32 cde	24.26 c-g	18.72 ab	64.69 e-k	37.43 vw	90.92 bc	49.61 o-w	60.66 bc
RP10	12.61 l-t	9.43 p-v	26.41 cde	25.78 c-f	18.56 ab	73.35 d-g	56.09 i-s	100.30 ab	58.48 h-r	72.06 a
RP11	8.55 q-v	8.01 q-v	30.50 bc	19.25 f-k	16.58 bc	108.51 a	44.52 s-w	84.78 cd	48.27 p-w	71.52 a
RP12	9.51 p-v	9.20 p-v	18.48 g-m	25.63 c-f	15.70 cd	51.28 l-u	40.88 t-w	61.46 f-p	63.05 e-n	54.17 d
RP13	13.64 k-s	5.21 v	20.47 d-j	25.27 c-f	16.15 bc	60.81 g-p	46.43 r-w	65.45 e-j	40.11 uvw	53.20 d
Average environment	10.03 c	8.31 d	21.52 b	23.61 a		64.79 a	51.28 c	67.07 a	57.77 b	

3.3 Influence of environments and row position on the leaf area per plant (cm^2 $plant^{-1}$) for cotton plant

The effect of microclimatic conditions on plant leaf area at 60 and 90 DAS (first and second cutting) is shown in Table 5. A significant and higher average environments of plant leaf area at 60 DAS were recorded (715.79 cm^2 and 919.22 cm^2) from E3 and the maximum leaf area at 90 DAS were 2356.16 $cm^2$and 2255.32 cm^2 in E4 and E3, respectively for both seasons due to increase dry matter accumulation. This result might be referred to the reason that under east-west sowing direction more light interception by the crop and more soil moisture would be received than the planting of north-south sowing direction. While the lower average values in 60 DAS were recorded (113.50cm^2 and 306.96 cm^2) along-with E1 and E2, and the lower average environment 90 DAS were recorded (714.52 cm^2 and 1132.44cm^2) in E2 and E4, respectively, for the both years.

The results in Table 5 indicated that the plant leaf area at 60 and 90 DAS were significantly affected by environment on the different row positions at both years. The highest mean values at 60 DAS were recorded from RP2 (672.27cm^2) and RP8 (880.87cm^2), while at 90 DAS, the rate of 1653.46 cm2 and 1968.42cm^2 were recorded from RP9 and RP10, respectively for the both years. The lowest values at 60 DAS were recorded from RP12 (218.42 cm^2) and RP4 (408.03 cm^2), for both growing seasons, respectively. The lowest values at 90 DAS were obtained (1294.26 cm^2 and 1241.64cm^2) from RP7 and RP2, respectively during the 1st and 2nd years. The interaction between environment and row positions caused significant differences within plant leaf area for the years 2021 and 2022. It can be observed that the maximum values plant leaf area at 60 DAS (2160.25 cm^2) and (1941.69cm^2) were noticed from RP2 X E3 and for RP8 X E3 during both years. The maximum value of 90 DAS (3076.30cm^2) was obtained from RP5 X E4 and (3833.50cm^2) was observed from RP10 X E3, respectively, during the both years. While the minimum value plant leaf area at 60 DAS (82.00 cm^2) was obtained from RP11 X E1 and from RP13 X E2 (179.46 cm2) respectively, during 2021 and 2022. The minimum values (291.66cm2) were recorded 90 DAS from RP1 X E2 and (612.71) from RP1 X E4, respectively during 2021 and 2022. The results in leaf area 60 DAS and 90 DAS are in agreement with those of [28] to report that for plant leaf area due to the plant canopy in the east-west row orientation has more light interception than the north-south orientation in the morning and afternoon.

3.4 Influence of environments and row positions on leaf area index of cotton plant ($Plant^{-1}$)

Leaf area index was significantly influenced by environment, row positions and their interaction between environment and rows significantly influenced at 60 and 90 DAS as showed in Table 6 the maximum values of leaf area index at 60 DAS (0.41 and 0.53) were obtained from E3 and at 90 DAS the maximum values (1.35 and 1.29) were recorded from E4 and E3, due to increases in leaf area respectively during the both years. Higher values at 60 DAS in E3 might be due to more light interception, while the lowest values 60 DAS (0.06 and 0.18) were recorded in E1 and E2, and at 90 DAS lowest values (0.41 and 0.65) were recorded from E2 and E4 respectively during the both years. Moreover, sowing dates of March to April presented significant effects on growth LAI [36]. According to Abd EL-Maksoud [28], the east-west (E-W) row orientation has a higher LAI than the north-south (N-S) row orientation.

Table 6 shows that 13 rows significantly influenced by environments on the leaf area index at 60 and 90 DAS the highest values (0.38 and 0.50) were recorded from RP2 and RP8, while 90 DAS the highest values (0.94 and 1.12) were recorded from RP9 and RP10, were as the lowest values at 60 DAS (0.12 and 0.23) were recorded from RP12 and RP4 and 90 DAS lowest values were recorded in RP7 and RP2 (0.74 and 0.71) respectively in 2021 and 2022. The interaction of factors showed that the highest values of leaf area index at 60 DAS (1.23 and 1.11) for E3 X RP2 and E3 X RP8, respectively which were during 1st and 2nd years, and the highest values at 90DAS (1.83 and 2.19) were noted from E4 X RP2 and E3 X RP10, Whereas the lowest values of leaf area index at 60 DAS (0.05 and 0.10) were reported from E1 X RP11,RP12 and E2 X RP13, and 90DAS the lowest values were recorded in E2 X RP1 (0.15) and E4 X RP11 (0.35) respectively which were during both years, Direction of sowing can influence light interception as well as crop canopy. The results in agreement with [19] showed that the LAI was found significantly superior with the sowing date on 30th April under East- West row orientation.

3.5 Influence of environments and row positions on crop growth rate (g cm^{-2} d^{-1}) stage

It is evident from Table 7 that the crop growth rate of cotton was influenced statistically by each of environments, row positions and interaction between them in the flowering to boll formation stage in 2021 and 2022. The highest values (1.90 and 1.83 g cm^{-2} d^{-1}) were obtained from E4 and E1, due to increase leaf area index. While the lowest values (1.01 and 1.14 g cm^{-2} d^{-1}) were obtained from E2 and E4 for the both years respectively. Delaying planting increases the danger of stressors like heat and moisture in the soil, limits the growth season, and shortens the time available for plants to finish their life cycle.

Close examination of Table 7 shows that the crop growth rate was significantly affected by different row positions, the highest values (1.79 and 1.83 g cm^{-2} d^{-1}) were recorded from RP9 and RP1 while the while the lowest values (1.02 and 1.24 g cm^{-2} d^{-1}) were recorded from RP1 and RP13 for the both seasons respectively. The two-factor combination (environments and row positions) were also found to be significant on the studied trait, the biggest values (2.79 and 3.33 g cm^{-2} d^{-1}) were observed from E4 X RP2 and E1 X RP1 treatment combination. Whilst the smallest values (0.29 and 0.49 g cm^{-2} d^{-1}) were recorded from E2 X RP1 and E4 X RP13 treatment combination for the both growing seasons, respectively.

The statistical analysis of the data in Table 7 explained that the environments, row positions and interaction between them had a significant effect on crop growth rate in the second stages boll formation to harvest stage of cotton in 2021 and 2022. The highest values (0.90 and 0.97 g cm^{-2} d^{-1}) were attained from E4 and E3 might be refereed that increase leaf area index. While the lowest values (0.50 and 0.73 g cm^{-2} d^{-1}) were reported from E2 for the both growing seasons, respectively. Close examination of Table 7 shows that the crop growth rate was significantly affected by

Table 5: Effect of environments, row position and their interaction on the leaf area (cm2 plant-1) for the years 2021 and 2022.

Row position	2021									
	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	152.50 i-k	120.50 i-k	658.50 bc	379.00 c-k	327.63 b	1367.52 f-k	291.66 p	1415.69 e-j	2190.61 bd	1316.37 cd
RP2	101.00 jk	139.50 i-k	2160.25 a	288.33 d-k	672.27 a	735.64 k-p	463.80 n-p	1299.42 f-l	3198.13 a	1424.25 a-d
RP3	141.50 i-k	181.50 f-k	660.33 bc	400.00 c-k	345.83 b	1600.84 c-j	449.05 op	1124.81 h-o	2209.72 bc	1346.10 b-d
RP4	91.00 jk	89.50 jk	772.50 b	430.00 b-k	345.75 b	1521.42 d-j	613.00 m-p	1536.20 c-j	2655.85 ab	1581.62 a-c
RP5	119.50 i-k	126.67 i-k	635.67 b-d	384.50 c-k	316.58 b	1126.35 h-o	592.58 m-p	1615.03 c-j	3076.30 a	1602.56 ab
RP6	101.00 jk	150.50 i-k	770.00 b	353.50 c-k	343.75 b	1582.37 c-j	953.24 j-p	1562.44 c-j	1435.61 e-j	1383.42 a-d
RP7	83.50 k	178.50 g-k	464.00 b-i	309.00 c-k	258.75 b	1671.70 c-i	570.26 m-p	1040.42 h-o	1894.67 c-f	1294.26 d
RP8	126.00 i-k	128.67 i-k	517.00 b-h	284.50 d-k	264.04 b	1101.98 h-o	993.12 j-o	1329.41 f-k	1869.92 c-g	1323.61 cd
RP9	119.00 i-k	172.50 g-k	599.00 b-e	273.00 e-k	290.88 b	1002.86 i-o	991.09 j-o	1461.46 e-j	3158.43 a	1653.46 a
RP10	166.50 g-k	186.00 f-k	535.00 b-f	251.50 e-k	284.75 b	1339.14 f-k	1049.49 h-o	1107.04 h-o	2086.00 b-e	1395.42 a-d
RP11	82.00 k	135.50 i-k	575.33 b-e	196.50 f-k	247.33 b	1212.15 g-m	949.21 j-p	1421.70 e-j	1898.87 c-f	1370.48 b-d
RP12	84.00 k	170.50 g-k	438.67 b-j	180.50 g-k	218.42 b	1569.79 c-j	648.14 l-p	1703.26 c-h	1907.14 c-f	1457.09 a-d
RP13	108.00 jk	164.00 h-k	519.00 b-g	517.33 b-h	327.08 b	1136.89 h-m	724.08 k-p	1308.42 f-k	3048.87 a	1554.57 a-d
Average Environment	113.50 c	149.53 c	715.79 a	326.74 b		1305.28 b	714.52 c	1378.87 b	2356.16 a	
Year	2022									
Row	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	548.52 i-t	248.85 s-u	1172.30 bc	1072.86 b-e	760.63 ab	1528.32 f-k	1733.28 e-h	1387.27 f-l	1369.41 g-l	1504.57 bc
RP2	273.80 r-u	255.15 r-u	665.95 f-n	796.68 d-j	497.90 fg	1272.16 g-m	984.48 h-m	1588.84 f-k	1121.07 g-m	1241.64 c
RP3	226.00 tu	264.19 r-u	618.12 g-o	540.27 i-t	412.15 g	1583.65 f-k	1032.64 h-m	2514.78 b-d	1319.21 g-m	1612.57 b
RP4	312.69 o-u	278.09 q-u	457.47 k-u	583.89 h-r	408.03 g	1127.25 g-m	1349.14 g-m	2591.22 b-d	853.15 k-m	1480.19 bc
RP5	453.48 k-u	342.47 n-u	942.17 b-g	890.82 c-h	657.23 b-e	1323.57 g-m	1587.74 f-k	1437.65 f-l	1417.52 f-l	1441.62 bc
RP6	389.08 m-u	365.63 n-u	732.66 f-l	559.93 i-s	511.82 fg	1500.28 f-k	1422.23 f-l	1403.46 f-l	977.86 i-m	1325.96 bc
RP7	427.11 l-u	354.57 n-u	605.55 h-q	723.69 f-l	527.73 efg	906.01 j-m	1706.05 e-i	1671.91 e-i	1600.50 f-k	1471.12 bc
RP8	477.82 j-u	391.74 m-u	1941.69 a	712.22 f-m	880.87 a	1412.72 f-l	1266.60 g-m	2137.85 c-f	1563.59 f-k	1595.19 b
RP9	614.92 g-p	358.06 n-u	988.83 b-f	788.04 d-j	687.46 bcd	1369.68 g-l	1212.17 g-m	3022.03 b	875.43 j-m	1619.83 b
RP10	567.43 h-s	343.84 n-u	1106.38 bcd	855.99 c-i	718.41 bc	1619.81 f-g	1406.69 f-l	3833.50 a	1013.68 h-m	1968.42 a
RP11	367.83 n-u	287.31 p-u	1236.85 b	608.24 h-p	625.06 c-f	1848.98 d-g	1300.77 g-m	2757.15 bc	612.71 m	1629.90 b
RP12	415.55 l-u	321.09 o-u	767.97 e-k	832.00 d-i	584.15 c-f	1382.47 g-l	1347.48 g-m	2421.06 b-e	1303.48 g-m	1613.62 b
RP13	611.07 h-p	179.46 u	713.96 f-m	772.68 e-k	569.29 def	1353.88 g-m	1160.98 g-m	2552.52 b-d	694.14 lm	1440.38 bc
Average environment	437.33 c	306.96 c	919.22 a	749.02 b		1402.21 b	1346.94 b	2255.32 a	1132.44 b	

Table 6: Effect of environments, row positions and their interaction on the leaf area index for the years 2021 and 2022.

Year	2021									
Row	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	0.09 i-k	0.07 i-k	0.38 bc	0.22 c-k	0.19 b	0.78 f-l	0.15 q	0.81 e-k	1.25 bd	0.75 cd
RP2	0.06 jk	0.08 i-k	1.23 a	0.16 d-k	0.38 a	0.42 k-q	0.27 o-q	0.74 f-m	1.83 a	0.81 ad
RP3	0.08 i-k	0.10 f-k	0.38 bc	0.23 c-k	0.20 b	0.91 c-j	0.26 pq	0.64 h-p	1.26 bc	0.77b-d
RP4	0.05 j-k	0.05 jk	0.44 b	0.25 b-k	0.20 b	0.87 d-j	0.35 n-q	0.88 c-j	1.52 ab	0.90 a-c
RP5	0.07 i-k	0.07 i-k	0.36 b-d	0.22 c-k	0.18 b	0.64 h-p	0.34 n-q	0.92 c-j	1.76 a	0.92 ab
RP6	0.06 jk	0.09 i-k	0.44 b	0.20 c-k	0.20 b	0.90 c-j	0.54 j-p	0.89 c-j	0.82 e-j	0.79 a-d
RP7	0.05 k	0.10 g-k	0.27 b-i	0.18 c-k	0.15 b	0.96 c-i	0.33 n-q	0.59 h-p	1.08 c-f	0.74 d
RP8	0.07 i-k	0.07 i-k	0.30 b-h	0.16 d-k	0.15 b	0.63 h-p	0.57 i-p	0.76 f-l	1.07 c-g	0.76 cd
RP9	0.07 i-k	0.10 g-k	0.34 b-e	0.16 e-k	0.17 b	0.57 i-p	0.57 j-p	0.84 e-j	1.80 a	0.94 a
RP10	0.10 g-k	0.11 f-k	0.31 b-f	0.14 e-k	0.16 b	0.77 f-l	0.60 h-p	0.63 h-p	1.19 b-e	0.80 a-d
RP11	0.05 k	0.08 i-k	0.33 b-e	0.11 f-k	0.14 b	0.69 g-n	0.54 j-p	0.81 e-j	1.09 c-f	0.78 b-d
RP12	0.05 k	0.10 g-k	0.25 b-j	0.10 f-k	0.12 b	0.90 c-j	0.37 m-q	0.97 c-h	1.09 c-f	0.83 a-d
RP13	0.06 jk	0.09 h-k	0.30 b-g	0.30 b-h	0.19 b	0.65 h-o	0.41 l-q	0.75 f-m	1.74 a	0.89 a-d
Average Environment	0.06 c	0.09 c	0.41 a	0.19 b		0.75 b	0.41 c	0.79 b	1.35 a	
Year	2022									
Row position	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	0.31 i-t	0.14 stu	0.67 bc	0.61 bcd	0.43 ab	0.87 f-k	0.99 e-h	0.79 f-l	0.78 g-l	0.86 bc
RP2	0.16 r-u	0.15 r-u	0.38 f-n	0.46 e-j	0.28 f-g	0.73 g-m	0.56 h-m	0.91 f-k	0.64 g-m	0.71 c
RP3	0.13 tu	0.15 r-u	0.35 g-o	0.31 i-t	0.24 g	0.90 f-k	0.59 h-m	1.44 bcd	0.75 g-m	0.92 b
RP4	0.18 o-u	0.16 q-u	0.26 k-u	0.33 h-r	0.23 g	0.64 g-m	0.77 g-m	1.48 bcd	0.49 k-m	0.85 bc
RP5	0.26 k-u	0.20 n-u	0.54 b-g	0.51 c-h	0.38 b-e	0.76 g-m	0.91 f-k	0.82 f-l	0.81 f-l	0.82 bc
RP6	0.22 m-u	0.21 n-u	0.42 f-l	0.32 i-s	0.29 f-g	0.86 f-k	0.81 f-l	0.80 f-l	0.56 i-m	0.76 bc
RP7	0.24 l-u	0.20 n-u	0.35 h-q	0.41 f-l	0.30 e-g	0.52 j-m	0.97 e-i	0.96 e-i	0.91 f-k	0.84 bc
RP8	0.27 j-u	0.22 m-u	1.11 a	0.41 f-m	0.50 a	0.81 f-l	0.72 g-m	1.22 c-f	0.89 f-k	0.91 b
RP9	0.35 g-p	0.20 n-u	0.57 b-f	0.45 d-j	0.39 b-d	0.78 g-l	0.69 g-m	1.73 b	0.50 j-m	0.93 b
RP10	0.32 h-s	0.20 n-u	0.63 bcd	0.49 c-i	0.41 bc	0.93 f-j	0.80 f-l	2.19 a	0.58 h-m	1.12 a
RP11	0.21 n-u	0.16 p-u	0.71 b	0.35 h-p	0.36 c-f	1.06 d-g	0.74 g-m	1.58 bc	0.35 m	0.93 b
RP12	0.24 l-u	0.18 o-u	0.44 e-k	0.48 d-i	0.33 c-f	0.79 g-l	0.77 g-m	1.38 b-e	0.74 g-m	0.92 b
RP13	0.35 h-p	0.10 u	0.41 f-m	0.44 e-k	0.33 def	0.77 g-m	0.66 g-m	1.46 bcd	0.40 l-m	0.82 bc
Average environment	0.25 c	0.18 c	0.53 a	0.43 b		0.80 b	0.77 b	1.29 a	0.65 b	

Table 7: Effect of environments, row positions and their interaction on the crop growth rate for the years 2021-2022.

Year	2021									
Row position	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	1.05 o-w	0.29 x	1.12 n-w	1.62 f-n	1.02 f	0.85 c-k	0.22 q	0.76 d-o	0.86 c-j	0.67 bc
RP2	1.30 j-u	0.75 vwx	1.11 o-w	2.79 a	1.49 bcd	0.66 f-p	0.39 o-q	0.70 e-p	1.29 ab	0.76 ab
RP3	1.40 h-s	0.79 u-x	1.28 k-u	1.75 d-k	1.31 de	0.68 f-p	0.43 m-q	0.71 e-p	0.91 c-h	0.68 bc
RP4	1.02 p-w	0.79 u-x	2.14 b-e	2.18 dcd	1.53 bc	0.49 j-q	0.47 l-q	0.65 f-p	0.53 h-q	0.53 c
RP5	0.90 s-w	0.66 wx	1.70 d-k	2.38 ab	1.41 cd	0.44 m-q	0.36 pq	1.31 a	0.98 a-f	0.77 ab
RP6	1.28 k-u	1.43 h-r	1.49 h-p	0.98 q-w	1.29 de	0.65 f-p	0.65 f-p	0.80 d-m	0.53 i-q	0.66 bc
RP7	1.34 i-t	0.69 vwx	1.44 h-q	1.64 e-m	1.28 de	0.60 f-p	0.34 pq	0.78 d-m	0.80 d-m	0.63 bc
RP8	1.33 i-t	1.80 d-j	1.18 l-v	1.55 g-o	1.47 bcd	0.65 f-p	0.82 c-l	0.72 e-p	0.80 d-m	0.75 ab
RP9	1.17 m-w	1.66 e-m	2.03 b-g	2.28 abc	1.79 a	0.66 f-p	0.77 d-n	1.07 a-e	1.12 a-d	0.90 a
RP10	1.71 d-k	1.50 h-p	1.46 h-q	1.84 c-i	1.63 ab	0.61 f-p	0.68 f-p	0.95 a-g	0.89 c-i	0.78 ab
RP11	1.18 l-v	1.00 p-w	1.54 g-o	1.91 c-h	1.41 cd	0.59 g-q	0.47 l-q	0.93 b-g	0.90 c-i	0.72 b
RP12	0.92 r-w	0.84 t-w	1.85 c-h	2.07 b-f	1.42 bcd	0.87 c-i	0.40 n-q	1.33 a	0.96 a-g	0.89 a
RP13	0.75 vwx	0.86 t-w	1.30 j-t	1.68 d-l	1.15 ef	0.48 k-q	0.47 l-q	0.77 d-n	1.18 abc	0.73 b
Average Environment	1.18 c	1.01 d	1.50 b	1.90 a		0.63 b	0.50 c	0.88 a	0.90 a	
Year	2022									
Row position	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	2.04 bcd	2.03 b-e	0.76 rs	1.14 m-r	1.49 bcd	1.02 c-h	1.07 b-h	0.79 c-l	0.94 c-j	0.95 b
RP2	1.92 c-g	0.98 o-s	1.14 m-r	1.15 l-r	1.30 de	0.88 c-j	0.43 kl	1.11 a-g	0.80 c-l	0.80 bcd
RP3	1.71 c-k	0.99 o-s	2.06 bcd	1.35 h-q	1.53 bc	0.85 c-k	0.51 jkl	1.05 c-h	1.02 c-h	0.86 bcd
RP4	1.29 h-r	1.43 f-p	1.77 c-i	1.32 h-q	1.45 cde	0.65 h-l	0.70 e-l	0.89 c-j	0.81 c-l	0.76 cd
RP5	1.23 j-r	1.94 b-f	1.11 m-r	1.12 m-r	1.35 cde	0.66 h-l	0.93 c-j	1.11 a-f	0.84 c-l	0.88 bcd
RP6	1.77 c-i	1.76 c-j	1.18 l-r	1.07 n-r	1.45 cde	0.86 c-k	0.87 c-k	0.72 e-l	0.67 f-l	0.78 bcd
RP7	1.64 c-m	2.07 bcd	1.37 h-q	1.64 c-m	1.68 ab	0.84 c-l	0.99 c-i	0.78 c-l	1.03 c-h	0.91 bc
RP8	2.12 bc	1.31 h-q	1.00 o-s	1.38 h-p	1.45 cd	1.03c-h	0.70 e-l	0.86 c-k	0.90 c-j	0.87 bcd
RP9	1.68 c-l	0.91 p-s	2.15 bc	0.85 qrs	1.40 cde	0.90 c-j	0.52 jkl	1.52 a	0.69 e-l	0.91 bc
RP10	2.02 b-e	1.56 d-n	2.46 b	1.09 n-r	1.78 a	0.88 c-j	0.41 l	0.77 d-l	0.81 c-l	0.72 d
RP11	3.33 a	1.22 k-r	1.81 c-h	0.97 o-s	1.83 a	1.51 ab	1.21abc	1.18 a-d	0.67 g-l	1.14 a
RP12	1.39 g-p	1.06 n-r	1.43 f-p	1.25 i-r	1.28 de	0.71 e-l	0.57 i-l	0.85 c-k	0.88 c-j	0.75 cd
RP13	1.57 d-n	1.37 h-q	1.50 e-o	0.49 s	1.24 e	0.85 c-l	0.64 h-l	1.00 c-i	1.12 a-e	0.90 bc
Average environment	1.83 a	1.43 b	1.52 b	1.14 c		0.89 ab	0.73 c	0.97 a	0.86 b	

different row positions, the maximum values (0.90and 1.14 g cm^{-2} d^{-1}) were recorded from RP9 and RP1 while the while the minimum values (0.53 and 0.72 g cm^{-2} d^{-1}) were recorded from RP4 and RP10) for the both seasons respectively. Similarly, it was noted that the crop growth rate was affected by the interaction between environments and row positions. The biggest values (1.33 and 1.52 g cm^{-2} d^{-1}) were recorded under the interaction E3 X RP12 and E3 X RP9, while the lowest values (0.22 and 0.41 g cm^{-2} d^{-1}) were recorded under the interactions E2 X RP1 and E2 X RP10 respectively, for the both years. This result in the first year might be due to increase in GDD lead to increase size photosynthetic system and increase dry matter accumulation compared to second year.

3.6 Influence of environments and row positions on relative growth rate (g/plant/day) of cotton plant

The data in table 8 illustrated that there was significant variation among means of different environments, sampling and interaction between them 90 DAS in 2021 and 2022. The highest values (0.062 and 0.063 g plant^{-1} day^{-1}) were recorded from E2, E3 and E1, while the lowest values (0.045 and 0.030 g plant^{-1} day^{-1}) were observed from E3 and E4 during both growing seasons respectively. Increase or decrease of relative growth rate related to dry matter accumulation and crop growth rate. The statistical analysis of the data explained that the row positions had a significant effect on relative growth rate in cotton. the highest values (0.065 g plant^{-1} day^{-1}) and (0.057 g^{-1} plant^{-1} day^{-1}) were recorded from RP10 and RP3 while the while the lowest values (0.042 g plant^{-1} day^{-1}) and (0.040 g plant^{-1} day^{-1}) were recorded from RP1 and RP9 in 2021 and 2022 respectively.

As with combination between environments and rows had a significant effect on the relative growth rate the biggest mean values (0.082 and 0.085 g plant^{-1} day^{-1}) were reported from E2 X RP6 and E1X RP1 treatment combination. while the smallest mean values (0.026 and 0.015 g plant^{-1} day^{-1}) were obtained from E2 X RP1 and E4 X RP13 treatment combination during 2021 and 2022, respectively. Our result in agreement with Huang[37] indicates that the late sown crop reduce relative growth rate than early sown crop.

According to the data in Table 8 in second stage (boll formation to harvest) that there was non-significant variation among means of different environments in 2021, while the means of different environments had significant effect on this trait in 2022, the maximum and minimum values (0.018 and 0.017 g plant-1 day-1) were recorded from E4 and E1, it denotes that plants sown later have a higher mass increase during the vegetative stage, because they need to grow quickly as they are rapidly causes to flowering due to crop response to photoperiod, respectively. Moving on a row position the biggest and smallest values (0.020 and 0.015 g plant^{-1} day^{-1}) were found from RP12 and RP3, respectively in 2021, while among means of row positions in 2022 non-significant effect on this trait. As with interaction between environments and sowing positions had significant effect in 2021 the highest and lowest values (0.024 and 0.017 g plant^{-1} day^{-1}) were obtained from E1 X RP12 and E4 X RP3, respectively in 2021, while non-significant effect on this trait in 2022.

3.7 Row positions as sampling site

This article is a part of a wide base doctorate research including the study of about 36 traits of Cocker 310 cotton cultivar , where the traits each single plant out of 6552 plants under investigation were studied during three growth stages at 60 , 90 and 138 DAS ,whereas seven plants were sampled at each stage (7 plants * 3 stages * 13 rows *4 microenvironments * 2 years * 3 replicates) so that 4368 plants were completely cut from the above ground at each stage to the sum of 6552 total number of plants for the both years , The researcher had seen an opportunity to take advantage of this huge amount of data to examine the prevailing idea of taking samples from central plants in agricultural research and to avoid taking samples from peripheral plants for fear of being affected by the external environment, as central plants are surrounded by plants from their population, while peripheral plants are adjacent to plants from their population from only one side and the just a position of a different environment on the other side. Most researchers believe sampling from central parts and avoid sampling from borders Bennis et al. [38], This research is traying to verify the credibility of this prevailing idea and take the whole population as a sample instate of smaller number of plants to represent the community as usually is done , that to minimize the bias of sampling process via minimizing the experimental errors at least and tried to do the best during sampling and data collection and analysis to minimize the effect of extraneous factors to as minimum as possible Ghaffar et al. [20], and since the data are different in the their nature , types and scales , cluster analysis was adopted to judge the results after standardizing of all the data , row position 7 was regarded as a central row position where its neighbor rows 6 and 8 regarded as central rows and the terminal row one and 13 regarded as border rows that are taken in account as guard rows , so every row position resembles a sampling position or sampling site .

Data from the previous tables 3,4,5,6,7,8 collected in table (9) analyzed based on;

1. Correlation coefficient
2. Clustering dendrogram Bishnu and Bhattacherjee [39] as shown below;

First; the correlation coefficients between X (normalized trait mean) and Y (sampling position) showed that:

1. The correlation between X and Y7 (0.55097) is the strongest positive correlation.
2. The correlation between X and Y13 (0.40893) is the second-strongest positive correlation.
3. The correlation between X and Y6 (-0.14843) is a weak negative correlation.
4. The correlation between X and Y8 (-0.07744) is a very weak negative correlation.
5. The correlation between X and Y1 (-0.44538) is the weakest correlation among the variables, being a moderate negative correlation.

So, from strongest to weakest correlation with X: Y7 > Y13 > Y6 > Y8 > Y1

X=Standardized mean of trait

Y= Sampling position in row

Second; The Clustering procedure;

based on Bishnu and Bhattacherjee [39] represents that, Rows 6 and 8 to the right and left of Row 7 were regarded as intermediate

Table 8: Effect of environments, sampling positions and their interaction on the relative growth rate for the years 2021-2022.

Year	2021									
Row position	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	0.061 g-o	0.026 v	0.032 tuv	0.051 m-r	0.042 f	0.022 ab	0.017 ab	0.017 ab	0.017 ab	0.018 ab
RP2	0.067 d-k	0.054 k-q	0.030 uv	0.076 a-e	0.060 cd	0.017 ab	0.017 ab	0.014 ab	0.017 ab	0.016 ab
RP3	0.066 d-l	0.049 o-s	0.038 s-v	0.054 l-q	0.052 de	0.017 ab	0.017 ab	0.014 b	0.013 b	0.015 b
RP4	0.068 d-j	0.062 f-n	0.060 h-o	0.058 i-p	0.062 abc	0.017 ab	0.020 ab	0.017 ab	0.014 b	0.017 ab
RP5	0.063 f-n	0.048 o-s	0.047 p-s	0.058 i-p	0.054 d	0.017 ab	0.017 ab	0.020 ab	0.015 ab	0.017 ab
RP6	0.058 i-p	0.082 a	0.049 o-s	0.049 o-s	0.060 bc	0.017 ab	0.017 ab	0.017 ab	0.017 ab	0.017 ab
RP7	0.069 c-i	0.059 i-p	0.045 o-s	0.065 d-l	0.060 abc	0.017 ab	0.017 ab	0.017 ab	0.017 ab	0.017 ab
RP8	0.063 f-n	0.081 abc	0.039 r-u	0.055 j-q	0.059 bc	0.017 ab	0.017 ab	0.017 ab	0.017 ab	0.017 ab
RP9	0.055 j-q	0.075 a-f	0.053 l-q	0.064 d-m	0.062 abc	0.016 ab	0.017 ab	0.019 ab	0.017 ab	0.017 ab
RP10	0.069 b-i	0.079 ab	0.044 q-t	0.065 d-l	0.065 a	0.016 ab	0.017 ab	0.017 ab	0.017 ab	0.017 ab
RP11	0.054 k-q	0.073 a-g	0.039 r-u	0.073 a-h	0.060 abc	0.020 ab	0.017 ab	0.019 ab	0.017 ab	0.018 ab
RP12	0.051 n-s	0.069 a-i	0.058 i-p	0.076 a-d	0.064 ab	0.024 a	0.017 ab	0.020 ab	0.018 ab	0.020 a
RP13	0.037 r-u	0.049 o-s	0.040 r-u	0.064 e-n	0.048 e	0.017 ab	0.017 ab	0.018 ab	0.021 ab	0.018 ab
Average Environment	0.059a	0.062 a	0.045 b	0.062 a		0.018 a	0.017 a	0.017 a	0.017 a	
Year	2022									
Row position	Environment 60 DAS				Average row	Environment 90 DAS				Average row
	E1	E2	E3	E4		E1	E2	E3	E4	
RP1	0.060 e-j	0.079 a-d	0.021 st	0.024 rst	0.046 c-g	0.017 a	0.016 a	0.023 a	0.017 a	0.018 a
RP2	0.080 abc	0.054 f-n	0.037 o-r	0.030 p-s	0.050 cde	0.017 a	0.017 a	0.020 a	0.017 a	0.018 a
RP3	0.076 ab	0.055 f-n	0.057 f-m	0.037 o-r	0.057 a	0.018 a	0.017 a	0.017 a	0.020 a	0.018 a
RP4	0.060e-j	0.065 d-i	0.059 e-k	0.035 o-r	0.053 ab	0.017 a	0.017 a	0.017 a	0.017 a	0.017 a
RP5	0.050 h-o	0.069 b-f	0.032 p-s	0.027 q-t	0.044 d-g	0.017 a	0.017 a	0.023 a	0.017 a	0.019 a
RP6	0.065 c-h	0.062 e-i	0.038 o-r	0.036 o-r	0.051 bcd	0.017 a	0.017 a	0.017 a	0.017 a	0.017 a
RP7	0.056 f-m	0.069 b-f	0.037 l-p	0.037 o-r	0.051 abc	0.017 a	0.017 a	0.017 a	0.017 a	0.017 a
RP8	0.065 c-g	0.051 g-o	0.020 st	0.034 p-s	0.043 fg	0.017 a	0.017 a	0.018 a	0.017 a	0.017 a
RP9	0.050 g-o	0.044 k-p	0.041 m-q	0.024 rst	0.040 g	0.016 a	0.014 a	0.015 a	0.017 a	0.015 a
RP10	0.059 e-l	0.059 e-k	0.045 j-p	0.027 q-t	0.048 c-f	0.016 a	0.019 a	0.014 a	0.017 a	0.016 a
RP11	0.085 a	0.057 f-l	0.034 p-s	0.031 p-t	0.052 abc	0.017 a	0.023 a	0.017 a	0.017 a	0.019 a
RP12	0.056 f-m	0.050 i-o	0.040 n-q	0.030 p-t	0.044 fg	0.017 a	0.017 a	0.017 a	0.022 a	0.018 a
RP13	0.058 i-o	0.073 a-e	0.039 o-r	0.015 t	0.044 efg	0.018 a	0.017 a	0.018 a	0.023 a	0.019 a
Average environment	0.063 a	0.061 a	0.039 b	0.030 c		0.017 b	0.017 ab	0.018 ab	0.018 a	

rows, and Rows 1 and 13 as peripheral rows. Clustering was used to assess the experiment and show how connected the rows were genetically. "Clustering analysis, which was first used in genetics, has become an essential tool for comprehending population structure, evolutionary history, genetic linkages, functional genomics, and disease genetics. Its application has grown over time to encompass a wide range of study fields outside of genetics. To mimic its genetic use, clustering analysis is applied in this study by evaluating the degree of similarity between sampling points that are reflected in the dataset's rows. This methodology facilitates thorough analysis and interpretation of the data by helping to find patterns and groupings among the sample sites."

It divided into two main groups. The one on the (RP 13 as sampling position 13) left formed a distinct primary group on its own, while the second main group included two secondary groups. One of them (RP 1) stood alone as a separate group, and the other three (lines 5,7 and 8) formed a secondary group.

Table 9: The MEANS Procedure for comparing five sampling positions on five different sowing rows.

Rowiable	N	Mean	Std Dev	Minimum	Maximum
Row1	4	0.6705000	0.4902751	0.1370000	1.2820000
Row6	4	0.6577500	0.5208598	0.1680000	1.3710000
Row7	4	0.9175000	0.5475719	0.5990000	1.7360000
Row8	4	0.8715000	0.2255076	0.6280000	1.1190000
Row13	4	0.8787500	0.6970970	0.1070000	1.5310000

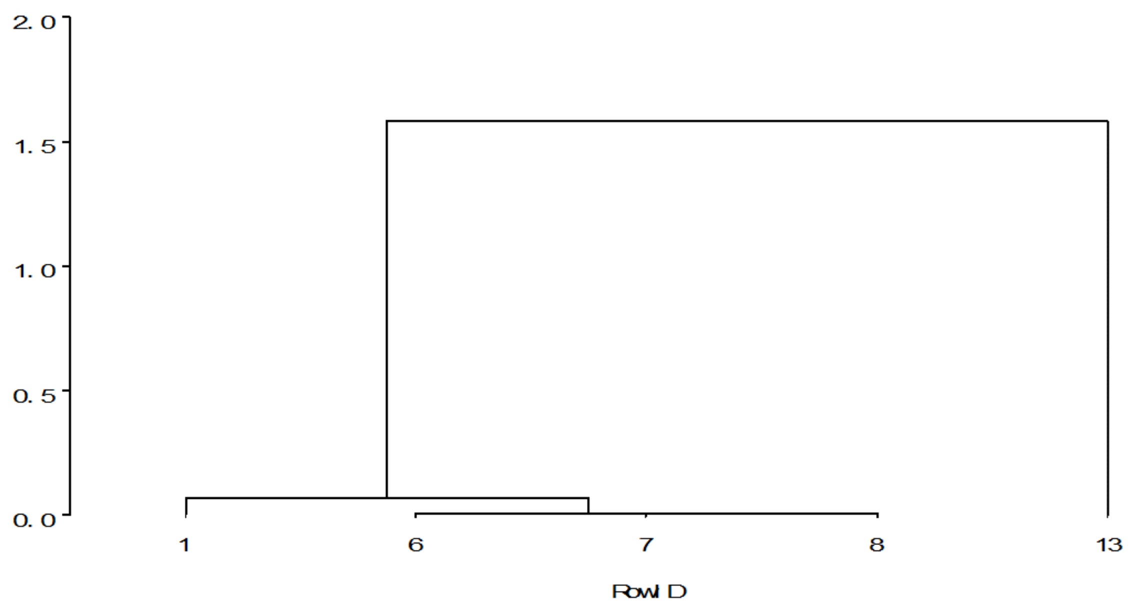

Figure 1: Clustering of sampling positions (RP)on sowing rows 1,6,7,8 and 13.

Table 10: The Cluster History.

NCL	Clusters Joined		FREQ	Dist
4	7	8	2	0.0056
3	6	CL4	3	0.0117
2	1	CL3	4	0.0704
1	CL2	13	5	1.5796

Note: NCL; Number of the Cluster (CL,) FREQ; Frequency, Dist; Euclidean distance.

Conclusion

Study showed that cotton cultivar (coker310) significantly affected by the change in sowing dates and row directions (Environments) and row positions, East-West second sowing date 27th April (E3) cotton resulted in significant increases in plant high, leaf area and leaf area index than North-South sowing dates, whereas dry matter increased in North-South second sowing date (E4) than East-west sowing dates. The crop growth rate in the first-year superior in north-south second sowing date (E4), and in the second-year superior in east-west second sowing date(E3) for all stages. The relative growth rate for the both years superior in north-south first sowing date (E2) than other environments in the first stage. According to the row positions non-significant difference between central rows (RP6,7,8) with lateral rows (RP1,2,3 and RP1, 12, 13) for taking sampling.

Conflict of interests

None

Author's contribution

This paper is a part of PhD dissertation of the first author. The first author conducted the experiment and data collection with analysis, while the second author supervised the experiment in all field works, data analysis and reviewing the research paper.

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