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Effects of Genotype x Plant Density Interactions on Cotton Yield and Fiber Quality in Iraq

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ABSTRACT
A field experiment was conducted during the summer season of 2024 in Al-Boaitha district, Anbar province, with the aim of determining the response of several genotypes of cotton to plant densities and its effect on some yield and components traits and fiber quality. The experiment was applied in split plot arrangement, according to the design of the randomized complete block design (RCBD), with three replications. The main plots included three of plant densities (33.333, 44.444, 66.666 Plant h^{-1}) while the sub-plots included fifteen cotton genotypes (Cocker 310, Lashata, ST-468 , BA440 , FLASH , Cocker 310 X Lashata , Cocker 310 X ST-468 , Cocker 310 X BA440 , Cocker 310 X FLASH , Lashata X ST-468 , Lashata X BA440 , Lashata X FLASH , BA440 X ST-468 , FLASH X ST-468 and FLASH X BA440).The results showed that the Cocker 310 X ST-468 genotyp outperformed with the highest average of the studied traits plant height (156.50 cm) and total number and opened bolls per plant (59.40 , 39.32 bolls $plant^{-1}$) which reflected an increase in the individual and total seed cotton yield (3.735 tons ha^{-1}) While the Lashata X ST-468 genotype gave the highest average of Upper half mean, the Cocker 310 X Lashata genotype showed the best Strenght 26.70 mm and 23.03 g/tex) respectively. The increase in plant density led to an increase in the total seed cotton yield 3.972 tons ha^{-1}.

KEYWORDS: Cotton, Genotypes, Plant density, Seed cotton. Fiber.

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تأثير تداخل التركيب الوراثي x الكثافة النباتية في حاصل القطن ونوعية الألياف في العراق

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الملخص
أُجريت تجربة حقلية خلال الموسم الصيفي لعام 2024 في قضاء البوعيثة بمحافظة الأنبار، بهدف تحديد استجابة عدد من التراكيب الوراثية للقطن للكثافات النباتية وتأثير ذلك في بعض صفات الحاصل ومكوناته ونوعية الألياف. نُفذت التجربة وفق ترتيب الألواح المنشقة **(Split Plot)** باستخدام تصميم القطاعات العشوائية الكاملة **(RCBD)** وبثلاث مكررات. اشتملت الألواح الرئيسية على ثلاث كثافات نباتية (33.333، 44.444، 66.666 نبات.هـــ$^{-1}$)، في حين تضمنت الألواح الثانوية خمسة عشر تركيبًا وراثيًا من القطن **(Cocker 310، Lashata، ST-468، BA440، FLASH، Cocker 310 × Lashata، Cocker 310 × ST-468، Cocker 310 × BA440، Cocker 310 × FLASH، Lashata × ST-468، Lashata × BA440، Lashata × FLASH، BA440 × ST-468، FLASH × ST-468، FLASH × BA440).**
أظهرت النتائج تفوق التركيب الوراثي **Cocker 310 × ST-468** بإعطائه أعلى متوسط لصفات الدراسة، إذ بلغ ارتفاع النبات 156.50 ســم، وعدد الجوز الكلي والمفتوح للنبات الواحد (59.40 و39.32 جوزة نبات$^{-1}$)، مما انعكس في زيادة حاصــل القطن الزهري الفردي والكلي ليصل إلى 3.735 طن.هـــ$^{-1}$. في حين أعطى التركيب الوراثي **Lashata × ST-468** أعلى متوسط لطول نصف الألياف الأعلى**(Upper Half Mean)** ، بينما أظهر التركيب الوراثي **Cocker 310 × Lashata** أفضل قيم لمتانة الألياف (26.70 مم و23.03 غم/تكس) على التوالي. كما أدى زيادة الكثافة النباتية إلى زيادة حاصــل القطن الزهري الكلي ليصل إلى 3.972 طن. هـ$^{-1}$.
الكلمات المفتاحية: القطن، التراكيب الوراثية، الكثافة النباتية، القطن الزهري، الألياف.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.), which belongs to the Malvaceae family, is considered one of the most important fiber crops and industrial crops in the world, as it is used as a raw material in many industries such as spinning and textile production. Its fibers constitute 85-90% of the world's fiber production. The fibers represent about 35% of the weight of the cotton boll, while the seeds are a source of important oils that are used in some industries, ranging from 18-26% of the weight of the seeds. In addition, the *Cottonseed* meal (by-product) of cotton production is used in feed fodders, as it contains a high percentage of protein ranging from 32-36% Al-Qaisi, 2010. Cotton production represents an important source of income for the producing country, which goes beyond agriculture to include work in gins, spinning mills, and textile factories. Iraq still suffers from a shortage in cotton production, and its local production represents only a small percentage of the actual demand, due to the high cost of production, the inflation of imports, and the lack of suitable varieties.

One of the important goals for developing and improving productivity in a unit area is selecting a suitable variety that is characterized by high productivity and adaptation to environmental conditions. Yogita *et al* 2019 pointed out significant differences among twenty-seven genetically different genotypes in terms of the total number of bolls per plant, boll weight, and seed cotton yield. Ibrahim,*et al* 2022. also found that varieties differed significantly in the number of opened bolls, boll weight, and seed cotton yield.Al-Obaidi.2022. confirmed the existence of significant differences among varieties in terms of the total number of bolls, the number of opened bolls, seed cotton yield, and boll weight.

Plant density is the number of plants per unit area or the distance between rows and between plants, and it has a significant impact on plant growth. Many studies have shown its importance due to its direct effect on growth characteristics, yield and its components, in addition to qualitative characteristics.

Akhteruzzaman *et al*., (2021) and Al-Bazi 2022 concluded that there is a significant effect of plant density on vegetative growth characteristics (plant height and number of branches).and

Khan *et al* (2020) succeeded in increasing the number of fruiting branches, the total number of bolls, and the yield of seed cotton yield. While, Ishrat Zaman (2021) found that the yield of seed cotton increased at low plant density. While the length and strength properties (qualitative properties of fibers) increased with increasing distance between plants (low density).

This study aimed to determine the effect of plant density on yield and its components traits and fiber quality for several genotypes of cotton.

MATERIALS AND METHODS

A field experiment was conducted during the summer season of 2024 in Al-Boaitha district, Anbar province, with the aim of determining the response of several genotypes of cotton to plant densities and its effect on some yield and components traits and fiber quality. The experiment was applied in split plot arrangement, according to the design of the randomized complete block design (RCBD), with three replications.The main plots included three of plant densities (33.333, 44.444, 66.666 Plant h^{-1}) while the sub-plots included fifteen cotton genotypes (Cocker 310, Lashata, ST-

468 , BA440 , FLASH , Cocker 310 X Lashata , Cocker 310 X ST-468 , Cocker 310 X BA440 , Cocker 310 X FLASH , Lashata X ST-468 , Lashata X BA440 , Lashata X FLASH , BA440 X ST-468 , FLASH X ST-468 and FLASH X BA440. The experimental plot was prepared by plowing, smoothing, and leveling, and was divided into experimental units (Total of 45 rows – rows length 5 m). DAP fertilizer (46% P) was added at a rate of 100 kg ha-1 in one dose during planting, and nitrogen fertilizer was added at a rate of 80 kg N ha^{-1} in the form of urea (46% N) in two doses, the first with a half dose during planting, and the second after a month from the first dose Mohamed (2011).

The planting was done on 12/5/2025 by placing (2-3) seeds in each hole. After planting the seeds, the field was immediately irrigated. Agricultural operations such as watering, weeding, thinning, and pest control were performed as needed. Thinning was done to leave only one plant per hole. The first picking was done on 12/10/2025 and the second picking was done on 14/11/2025 after the bolls had fully matured and opened.

Studied characters

1- Plant height (cm): It was measured from the surface of the soil to the top of the main stem of the plant after the last harvest.
2- The number of fruiting branches in the plant (branch $plant^{-1}$): It was calculated from the average number of fruiting branches bearing the heads on the main stem.
3- Number of bolls per plant ($plant^{-1}$): The total number of healthy and open bolls was calculated for each of the ten randomly selected plants from each experimental unit.
4- Number of open bolls in the plant (boll $plant^{-1}$): The number of open bolls per one
5- Seed cotton yield (t ha^{-1}): Represents the yield of the two pickings per experimental unit converted to t ha^{-1}.

Fiber technology traits

6- Upper half mean “UHM” (mm).
7- Strength (g/tex).

RESULTS AND DISCUSSION

Plant height (cm)

The results show that there are significant differences between cotton genotypes and plant densities, and the interaction between them in plant height (Table 1). Cocker 310 X ST-468 plants outperformed with the highest mean of 156.50 cm, which did not differ significantly from the plants of the FLASH genotype (156.22 cm) , while plants of BA440 X ST–468 genotype gave the lowest mean of 128.36 cm. Perhaps the reason for this increase is due to the genetic variation of the cultivars in the lengths of the internodes that distinguish each cultivar from the other. This is consistent with what was mentioned by Sahito et al 2015 and Ali *et al* 2019 and Abbas *et al*, 2022 Nadir and Noaman 2024 who indicated that the genotypes differed significantly in plant height.

The high plant density 66.666 Plant h^{-1} gave a highest mean (161.90 cm) whereas the low plant density 33.333 Plant h^{-1} gave a lowest mean (126.49 cm).The reason of increasing may be due to the increased competition between plants for light, in addition to the fact that the planting at a high density help to increase the concentration of auxins due to the lack of light oxidation which leads to an increase the cell division and elongation and then an increase the plant height.These results are in agreement with Khan *et al* (2019) Akhteruzzaman *et al*.,(2021) and Al-Bazi 2022 who indicated that the plant height of cotton was significantly increased when increase the plant density. The interaction between two factors had significant effect on the plant height (Table 1); the FLASH genotype with high plant density (66.666 Plant h^{-1}) gave a highest value (179.58 cm), while the BA440 X ST–468 genotype with low plant density (33.333 Plant h^{-1}) gave a lowest value (112.61cm).

Table 1. Effect of Genotypes and Plant Density and the interaction between them on plant height (cm) of the cotton crop

Genotypes	Plant Density (Plant h^{-1})			Mean
	33.333	**44.444**	**66.666**	
Cocker 310	132.41	145.62	170.23	149.40
Lashata	113.72	121.33	151.35	128.76
ST - 468	121.55	131.25	161.41	138.03
BA440	118.92	128.96	158.97	135.56
FLASH	139.61	149.54	179.58	156.22
Cocker 310 X Lashata	136.27	147.18	153.53	148.80
Cocker 310 X ST-468	146.14	155.73	167.78	156.50
Cocker 310 X BA440	115.32	123.57	153.51	130.77
Cocker 310 X FLASH	127.83	146.94	166.92	147.20
Lashata X ST-468	114.17	121.28	151.27	128.83
Lashata X BA440	120.36	128.73	158.72	135.90
Lashata X FLASH	135.58	140.28	170.25	148.63
BA440 X ST-468	112.61	121.12	151.18	128.36
FLASH X ST- 468	125.28	138.49	158.26	140.53
FLASH X BA440	138.24	146.25	176.22	153.55
L.S.D 5%		12.31		
Mean	126.49	136.37	161.90	7.10
L.S.D 5%		8.31		

The number of fruiting branches per plant (branch plant^{-1})

The results show that there are significant differences between cotton genotypes and plant densities , and the interaction between them in the number of fruiting branches per plant (Table 2). The plants of the Lashata X ST-468 genotypes were characterized by the highest average of vegetative branches to 14.87 branch plant^{-1}, compared to Cocker 310 plants, which gave the lowest average of 11.27 branch plant^{-1}. The reason for the superiority of the Lashata X ST-468 genotypes may be due to the nature of this genotype, its response to environmental conditions, its increased vegetative growth, cell division, and the activity of vital processes. These results are consistent with the findings of Sadabadi *et al* 2018, Dawood and Noaman 2023 and Nadir 2024 Who found that the varieties differed significantly in the number of fruiting branches in the plant.

Increasing the plant density led to an decrease in the number of fruiting branches per plant, as the cotton plants that were planted with low plant density (33.333 Plant h^{-1}) achieved a highest mean (15.87 branch plant^{-1}) compared with high density (66.666 Plant h^{-1}) which achieved a lowest mean (10.38 branch plant^{-1}).The reason of the superiority may be due to the lack of competition between plants on the light and nutrients, which positively reflected on the increase the growth of lateral buds and then increase the number of branches per plant. These results are in agreement with Teshome *et al.,* (2020) and Ibrahim *et al* 2022 who noted that the branches of plants was significantly increased when decrease the plant density.

The results indicate that there is a significant interaction between cotton genotypes and plant density in number of branches per plant. The Lashata X ST-468 genotype that were planted with a (33.333 Plant h^{-1}) gave the highest value of interaction (17.23 branches plant^{-1}), which did not differ significantly from the plants of the FLASH X ST – 468 genotype that were planted with the same density with 17.15 branches plant^{-1}, compared to BA440 plants, which gave the lowest value of the interaction (8.93 branches plant^{-1}) in the (66.666 Plant h^{-1}), and it is the least branched among the other treatments.

Table 2. Effect of Genotypes and Plant Density and the interaction between them on the number of fruiting branches per plant (branch plant^{-1}) of the cotton crop

Genotypes	**Plant Density (Plant h^{-1})**			**Mean**
	33.333	**44.444**	**66.666**	
Cocker 310	13.72	10.61	9.52	11.27
Lashata	14.97	13.55	9.83	12.73
ST – 468	15.63	14.23	10.58	13.43
BA440	14.86	11.92	8.93	11.87
FLASH	16.32	13.14	10.72	13.37
Cocker 310 X Lashata	16.76	13.76	10.95	13.77

Cocker 310 X ST-468	16.93	15.22	11.32	14.47
Cocker 310 X BA440	15.25	13.72	10.13	13.00
Cocker 310 X FLASH	16.51	12.67	9.63	12.90
Lashata X ST-468	17.23	15.12	12.36	14.87
Lashata X BA440	15,46	13.18	10.12	12.87
Lashata X FLASH	16.42	13.37	10.52	13.40
BA440 X ST– 468	15.83	12.97	9.93	12.87
FLASH X ST– 468	17.15	14.12	11.23	14.13
FLASH X BA440	15.66	13.32	10.45	13.10
L.S.D 5%		1.23		
Mean	15.87	13.35	10.38	0.71
L.S.D 5%		1.00		

Total number of bolls in the plant (bolls Plant^{-1})

The result indicated a significant difference between genotypes and plant densities, and their interaction in the total number of bolls per plant plant (Table 3). Plants of the Cocker 310 X ST-468 genotype outperformed with the highest average of the total number of bolls at 59.40 bolls plant^{-1}, while plants of the FLASH genotypes gave the lowest average of 45.83 bolls plant^{-1}. The reason for this superiority may be due to the genetic nature and the genetic material difference for each genotype and their response to the surrounding environmental conditions, and the genetic factor for each genotype controlled the total number of bolls per plant This is in agreement with what was mentioned by Mudassir, *et al* 2021 , Al-Bazi 2022 and Ibrahim *et al* 2022 who pointed out that genotype differ in the total number of bolls in the plant.

The results in the Table 3 indicate the low plant density (33.333 Plant h^{-1}) achieved a highest mean (59.58 boll plant-1) at an increase of 18.42 and 35.31 % with 44.444 and 66.666 Plant h^{-1} plant density (50.31 and 44.03 bolls plant^{-1}) respectively. The superiority of the low plant density in the number of boll per plant could be due to the superiority in number of fruiting branches per plant (Table 2),These results are in agreement with Xiaoyu *et al* 2016 , Manuel *et al* 2019 and Khan *et al* 2020 and Shah *et al* 2021 who noted that the number of boll per plant was significantly when Differences in plant density. The Cocker 310 X ST-468 genotype with low plant density (33.333 Plant h^{-1}) recorded a highest value (69.21 boll plant-1), whereas the FLASH X BA440 genotype with high plant density (66.666 Plant h^{-1}) recorded a lowest value (38.71 boll plant-1).

Table 3. Effect of Genotypes and Plant Density and the interaction between them on the total number of bolls in the plant (bolls Plant^{-1}) of the cotton crop

Genotypes	Plant Density (Plant h^{-1})			Mean
	33.333	**44.444**	**66.666**	
Cocker 310	54.33	49.66	44.66	49.55
Lashata	52.44	46.66	43.11	47.40
ST – 468	58.33	48.24	43.13	49.90
BA440	51.33	46.51	44.23	47.35
FLASH	51.41	45.66	40.41	45.83
Cocker 310 X Lashata	67.33	56.66	49.66	57.88
Cocker 310 X ST-468	69.21	58.66	50.33	59.40
Cocker 310 X BA440	61.33	53.33	49.31	54.66
Cocker 310 X FLASH	64.52	52.03	47.13	54.56
Lashata X ST-468	61.13	47.65	41.66	50.15
Lashata X BA440	55.67	45.66	41.81	47.71
Lashata X FLASH	61.45	48.34	42.33	50.71
BA440 X ST– 468	65.76	55.21	42.33	54.43
FLASH X ST– 468	67.21	53.63	41.66	54.17
FLASH X BA440	52.31	46.72	38.71	45.91
L.S.D 5%		4.45		
Mean	59.58	50.31	44.03	2.57
L.S.D 5%		2.59		

Number of open bolls in the plant (boll plant^{-1})

The results indicate a significant effect of genotypes and plant densities and the interaction between them on the number of open bolls per plant (Table 4). The plants of the Cocker 310 X ST-468 genotype outperformed with the highest average of 39.32 bolls plant^{-1}, compared to the Cocker 310 genotype plants that gave the lowest average of opened bolls of 28.76 bolls plant^{-1}. The reason for this increase may be due to the genetic composition of the genotype plants in response to environmental conditions (temperature and light), which helps in opening a larger number of bolls in the plant. This is consistent with Copure *et al* 2019 , Tuttolomondo *et al* 2020 , Abbas *et al* 2022 and Abdulsamad 2024 who indicated that genotypes differ in the number of opened bolls in plants.

The results indicate that cotton plants were planted with low density (33.333 Plant h^{-1}) achieved a highest mean (41.54 boll plant^{-1}) at an increase of 25.30 and 67.63 % with 44.444 and 66.666 Plant h^{-1} plant densities (33.15 and 24.78 boll plant^{-1}) respectively. The reason of increase may be due to the lack of competition between plants per unit area and increase the consumption of water and nutrients by the plant, and the plant received the maximum amount of light and heat, which helped which helped to increase the number of open bolls per plant. These results are in agreement with Tariq *et al* 2017 , Shah *et al* 2021 and Al-Bazi 2022 who noted that the number of open boll per plant of cotton plants was significantly increased when decrease the plant density.

The interaction between two factors had significant effect on the number of open bolls per plant (Table 1); the Cocker 310 X ST-468 genotype with low plant density (33.333 plant h^{-1}) gave a highest value (48.63 boll $plant^{-1}$), while the Cocker 310 genotype with high plant density (66.666 plant h^{-1}) gave a lowest value (20.61 boll $plant^{-1}$).

Table 4. Effect of Genotypes and Plant Density and the interaction between them on the number of open bolls per plant (boll $plant^{-1}$)of the cotton crop

Genotypes	Plant Density (Plant h^{-1})			Mean
	33.333	44.444	66.666	
Cocker 310	35.22	30.46	20.61	28.76
Lashata	38.73	29.87	21.32	29.97
ST - 468	41.56	35.23	27.86	34.88
BA440	36.98	28.14	22.51	29.21
FLASH	42.83	33.79	25.22	33.95
Cocker 310 X Lashata	46.47	36.55	27.73	36.92
Cocker 310 X ST-468	48.63	39.92	29.42	39.32
Cocker 310 X BA440	40.15	31.63	23.17	31.65
Cocker 310 X FLASH	37.54	29.36	20.95	29.28
Lashata X ST-468	45.36	36.13	28.52	36.67
Lashata X BA440	41.27	33.86	25.79	33.64
Lashata X FLASH	42.62	33.67	25.15	33.81
BA440 X ST- 468	39.87	30.27	22.36	30.83
FLASH X ST- 468	44.14	35.58	26.94	35.55
FLASH X BA440	41.73	32.74	24.15	32.87
L.S.D 5%		2.56		
Mean	41.54	33.15	24.78	1.72
L.S.D 5%		1.55		

Seed cotton yield (ton ha^{-1})

The results indicate significant differences between genotypes and plant densities, and their interaction on the total seed cotton yield (Table 5). The genotype Cocker 310 X ST-468 was characterized by the highest average of 3.735 ton ha^{-1}, compared to the BA440 genotype, which gave the lowest average of 2.618 ton ha^{-1}. This increase in the total seed cotton yield for Cocker 310 X ST-468 is due to its superiority in the total number of open boll per plant (Table 4). These results are consistent with those of Shah *et al* 2017 , Engizek *et al* 2021 and Nader 2024 who pointed out the significant differences between varieties in the total seed cotton yield.

It is evident that high density of cotton plants (66.666 plant h^{-1}) was significantly superior and gave a highest mean of seed cotton yield (3.972 ton ha^{-1}) compared with low density (33.333 plant h^{-1}) which gave a lowest mean (2.458 ton ha^{-1}).The reason of increase may be attributed to an increase the number of plants per unit area, which was positively reflected on the seed cotton yield. These results are in agreement with Manuel *et al* 2019 , Ishrate Zaman *et al*,2021, and Kassambara *et al* 2024) who indicated that the seed cotton yield of cotton was significantly increased when increase the plant density.The interaction between the study factors had a significant effect on the total cotton yield. Cocker 310 X ST-468 plants with high density 66.666 plant h^{-1} gave the highest average of the total seed cotton yield 4681 ton ha^{-1}, with non-significant difference with Cocker 310 X Lashata genotype with the same density (4.517 ton ha^{-1}), while the BA440 genotype with low density (33.333 plant h^{-1}) gave a lowest value (1.889 ton ha^{-1}).

Table 5. Effect of Genotypes and Plant Density and the interaction between them on Seed cotton yield (ton ha^{-1}) of the cotton crop

Genotypes	Plant Density (Plant h^{-1})			Mean
	33.333	**44.444**	**66.666**	
Cocker 310	2.257	2.772	3.917	2.982
Lashata	2.175	2.713	3.313	2.733
ST - 468	2.666	3.013	4.002	3.227
BA440	1.889	2.486	3.480	2.618
FLASH	2.209	2.669	3.899	2.925
Cocker 310 X Lashata	2.769	3.491	4.517	3.592
Cocker 310 X ST-468	2.906	3.618	4.681	3.735
Cocker 310 X BA440	2.537	3.113	3.464	3.038
Cocker 310 X FLASH	2.136	2.652	3.282	2.690
Lashata X ST-468	2.867	3.211	4.439	3.505
Lashata X BA440	2.706	3.108	4.183	3.332
Lashata X FLASH	2.527	3.033	4.073	3.211
BA440 X ST- 468	2.146	2.730	3.586	2.820
FLASH X ST- 468	2.798	3.551	4.219	3.522
FLASH X BA440	2.287	2.703	3.856	2.948

L.S.D 5%		2.11		
Mean	2.458	2.990	3.927	1.265
L.S.D 5%		1.064		

Upper half mean "UHM" (mm).

The results indicate a significant effect of genotypes and plant densities and the interaction between them on the Upper half mean (Table 6).The plants of the Lashata X ST-468 genotypes showed the highest mean for the trait, reaching (26.70 mm) while the plants of the Lashata X BA440 genotype gave the lowest mean for the trait, reaching (23.89 mm). This superiority may be due to the genetic nature of the variety and its response to environmental conditions. These results are consistent with what was reached by Rahman *et al* 2020 , Ahmed *et al* 2021 and Nadir 2024 .

The results in the Table 6 indicate the low plant density (33.333 Plant h^{-1}) achieved a highest mean (26.36 mm) at an increase of 7.59 % compared with high density (66.666 plant h^{-1}) which gave a lowest mean (24.50 mm). The reason of increase my be due to the environmental impact of varying planting distances, These results are in agreement with Nangial Khan *et al* 2020 , Ishrat Zaman *et al* 2021 and Rojda and Emine 2021 who noted that the Upper half mean was significantly increased when decrease the plant density. The Lashata X ST-468 genotype with low plant density (33.333 Plant h-1) recorded a highest value (28.18 mm), whereas the Lashata X BA440 genotype with high plant density (66.666 Plant h-1) recorded a lowest value (22.94 mm).

Table 6. Effect of Genotypes and Plant Density and the interaction between them on Upper half mean "UHM" (mm) of the cotton crop

Genotypes	**Plant Density (Plant h^{-1})**			**Mean**
	33.333	**44.444**	**66.666**	
Cocker 310	26.49	25.56	24.91	25.65
Lashata	25.82	24.92	24.74	25.16
ST – 468	25.37	25.24	24.77	25.13
BA440	26.25	25.18	24.69	25.37
FLASH	25.91	24.65	23.94	24.83
Cocker 310 X Lashata	27.63	26.31	25.36	26.43
Cocker 310 X ST-468	27.05	25.97	24.96	25.99
Cocker 310 X BA440	26.18	25.38	24.62	25.39
Cocker 310 X FLASH	26.62	25.35	24.51	25.49
Lashata X ST-468	28.18	26.68	25.24	26.70
Lashata X BA440	24.98	23.75	22.94	23.89
Lashata X FLASH	27.14	26.47	25.56	26.39

BA440 X ST– 468	25.44	24.24	23.52	24.40
FLASH X ST– 468	26.73	24.65	23.95	25.11
FLASH X BA440	25.66	24.32	23.84	24.61
L.S.D 5%		0.59		
Mean	26.36	25.24	24.50	0.34
L.S.D 5%		0.33		

Strength (g/tex)

The results indicate a significant effect of genotypes and plant densities and the interaction between them on the fiber strength (Table 7). The plants of the Cocker 310 X Lashata genotype revealed with the highest average reaching (23.03 g/tex,) with an increase of (17.86 %) compared to the BA440 X ST – 468 genotype plants that gave the lowest average (19.54 g/tex) , This trait varies from one genotype to another and is linked to the genetic makeup and its interaction with environmental conditions (temperature and length of the photoperiod). These results are consistent with what was reached by Engizek *et al* 2021 , Kazakova 2023 and Abdulsamad 2024 .

The cotton plants were planted with low density (33.333 Plant h^{-1}) achieved a highest mean (22.22 g/tex) at an increase of 9.13 % with 66.666 Plant h^{-1} plant densities 20.36 g/tex . The reason of increase may be due to the lack of competition between plants per unit area and increase the consumption of water and nutrients by the plant, which helped to fiber maturation. These results are in agreement with Nangial Khan *et al* 2020 , Ishrat Zaman *et al* 2021, who pointed out the significant differences between plant density in the fiber Strength .

The interaction between two factors had significant effect on the Strength fiber , the Cocker 310 X Lashata genotype with low plant density (33.333 plant h^{-1}) gave a highest value (23.82 g/tex), with non-significant difference with Cocker 310 genotype with the same density (23.80 g/tex), while the BA440 X ST – 468 genotype with high plant density (66.666 plant h^{-1}) gave a lowest value (18.52 g/tex).

Table 7. Effect of Genotypes and Plant Density and the interaction between them on Fiber strength (Cn/tex) of the cotton crop

Genotypes	Plant Density (Plant h^{-1})			Mean
	33.333	44.444	66.666	
Cocker 310	23.83	22.62	20.82	22.42
Lashata	21.46	20.27	19.86	20.53
ST – 468	21.45	20.38	19.9	20.58
BA440	21.57	20.94	20.62	21.04
FLASH	22.95	21.19	20.09	21.41

Cocker 310 X Lashata	23.82	22.85	22.42	23.03
Cocker 310 X ST-468	23.32	22.76	21.58	22.55
Cocker 310 X BA440	21.95	21.73	20.84	21.51
Cocker 310 X FLASH	21.83	20.25	19.83	20.64
Lashata X ST-468	21.66	21.46	20.83	21.32
Lashata X BA440	21.27	20.73	19.12	20.37
Lashata x FLASH	22.53	21.75	20.95	21.74
BA440 X ST – 468	20.85	19.26	18.52	19.54
FLASH X ST – 468	22.93	22.62	20.24	21.93
FLASH X BA440	21.85	20.27	19.82	20.65
L.S.D 5%		0.54		
Mean	22.22	21.27	20.36	0.32
L.S.D 5%		0.27		

CONCLUSION

It could be concluded that was plant density ((66.666 plant h^{-1}) to cotton genotype Cocker 310 X ST-468 to give maximum seed cotton yield and its components while the genotype Lashata X ST-468 and Cocker 310 X Lashata gave the best results for qualitative characteristics. in Anbar governorate, Iraq .

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