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Original article

Effect of 1-naphthalene acetic acid concentrations and the number of applications on the yield components, yield and fibre properties of the Egyptian cotton (*Gossypium barbadense* L.)

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Abstract – Field experiments were performed in two successive seasons at the Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt, on the Egyptian cotton cultivar Giza 75 (*Gossypium barbadense* L.). Cotton plants were sprayed with the growth regulator 1-naphthalene acetic acid (NAA) once (90 days after planting (DAP)), or twice (90 and 105 DAP) or three times (90, 105 and 120 DAP), during the square and bolling stage). The concentrations 5, 10, 15, 20 or 25 ppm were used. The volume of solution was the same for all treatments, 960 $L \cdot ha^{-1}$. The control plants were sprayed with water only. The effect of the previous treatments on yield components, cotton yield and fibre properties was studied. The application of NAA increased the number of opened bolls/plant, boll weight, seed index, seed cotton yield/plant and seed cotton and lint yields$\cdot ha^{-1}$. The most significant effects were obtained with the 15 and 20 ppm concentrations, when each was applied twice. Lint percentage, fibre length parameters and micronaire value were not significantly affected by NAA. Flat bundle strength was significantly affected by NAA but with no consistent trend. The application of NAA twice or three times tended to give the best results on yield components and cotton yield compared with a single application. The results of this study suggested that 20 ppm of NAA gave the best figures when applied twice on the Egyptian cotton plants. (© Inra/Elsevier, Paris.)

growth regulator / NAA-concentrations / cotton yield / fibre properties

Résumé – Effet des concentrations de l'acide 1-naphtalène-acétique et du nombre d'applications sur les composantes du rendement et les propriétés des fibres du coton égyptien (*Gossypium barbadense* L.). Des essais sur le terrain ont été effectués durant deux saisons successives à la station de recherches de la faculté d'agronomie de l'univer-

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sité du Caire à Guizeh, en Égypte sur le cultivar de coton égyptien Guizeh 75 (*Gossypium barbadense* L.). Les cotonniers reçurent des pulvérisations d'un régulateur de croissance (acide 1-naphtalène-acétique) soit une seule fois 90 jours juste après le semis soit deux fois (90 et 105 jours après la date de semis) soit trois fois (90–105 et 120 jours après le semis durant l'étape de la formation des capsules). Des concentrations de 5, 10, 15, 20 et 25 ppm furent utilisées. Les plantes témoins furent pulvérisées par de l'eau pure. Une étude fut entreprise concernant l'effet des traitements mentionnés sur les composantes du rendement du coton et les propriétés des fibres. L'application de l'acide 1-naphtalène-acétique, a augmenté le nombre de capsules ouvertes par plant, la masse moyenne des capsules, la masse de graines, le rendement en coton-graine et en fibres, par plante et par hectare. Les effets les plus marqués furent obtenus en utilisant les concentrations 15 et 20 ppm, à condition d'appliquer chaque concentration deux fois. Le pourcentage de fibres, les paramètres de longueur des fibres et la valeur du micronaire n'ont pas été affectés significativement par l'acide 1-naphtalène-acétique. La solidité du faisceau fut affectée par l'acide mais sans qu'aucune tendance stable ne puisse être dégagée. L'usage de deux ou trois traitements a donné les meilleurs résultats concernant les composantes du rendement et le rendement final du coton, en comparaison avec une seule application. Les résultats de cette étude suggèrent que 20 ppm d'acide 1-naphtalène-acétique appliqués deux fois sur les cotonniers égyptiens améliorent la production.

régulateur de croissance / acide 1-naphtalène-acétique / rendement du coton / propriétés des fibres

1. INTRODUCTION

Since most plant growth and development processes are regulated by natural plant hormones, many of these processes may be manipulated either by altering the plant hormone level or by changing the capacity of the plant to respond to its natural hormones. Plant growth regulator (PGR) chemicals are synthetic hormones that have the capacity to do this. Thus, PGR chemicals could become another tool in the cotton producers reserve for ensuring efficient production. Research with PGRs on cotton has increased significantly during the past few years, with the major emphasis being directed primarily to the areas of 1) improved seed germination; 2) early flower production and increased early fruit retention; 3) improved quality and yield; 4) control of excessive vegetative growth; 5) early termination of reproductive and vegetative growth; and 6) improved harvest-aid systems [8, 9, 24]. The response of a plant or plant part to a PGR may vary with the variety. Also, a single variety may respond differently depending on its age, the environmental conditions, its physiological state of development, and its state of nutrition [21].

It is well established that PGRs play an important role in flower formation and development, fruit-set and fruit growth [16], modifying processes such as photosynthesis rate and photosynthate export from leaves [7] in such a way that more photosynthetic products are mobilised and brought to the developing fruits.

Several synthetic PGRs have been developed such as 1-naphthalene acetic acid (NAA) which is classified as a reproductive development oriented PGR. It is one of the synthetic auxin compounds. It may be possible to use these chemicals to modify plant performance in desirable ways. The application of these substances at the correct concentration and at a specific time during plant development may improve the fruit set.

In this respect, Murty et al. [19] claimed a 50 % decrease in boll shedding and a 20–35 % increase in yield after spraying cotton plants with 10 and 30 ppm NAA. They concluded that spraying with 30 ppm at the beginning of flowering and again at the time of peak flowering would decrease boll shedding and increase yields. Varma [26] reported that application of NAA to flower buds, or boll explants completely counteracted the abscission-promoting effect of abscisic acid (ABA). Sawan [23], Goyal et al. [13] and Pothiraj et al. [22] reported that applying NAA to cotton plants increased the boll weight and seed cotton yield. Jadhav and Kalbhor [15] found that applying NAA at 30 ppm increased the number of bolls/cotton plant. Also, spraying NAA twice, at square formation stage and 30 days later, increased the number of bolls/plant and reduced boll shedding compared with one application at that stage. Goyal et al. [13] found that application of NAA at 175 mL at the beginning of squaring, flowering and boll formation stages increased fibre length, but decreased fibre fineness. Mehetre et al. [17] found that fibre bundle strength was highest when NAA was applied at 20 ppm; however, mean fibre length, uniformity ratio, fineness and maturity coefficient were unaffected by treatments.

The objective of this study was to determine the effect of NAA applied at different concentrations and number of applications during square and bolling stage on yield and fibre properties of the Egyptian cotton.

2. MATERIALS AND METHODS

Two field experiments were conducted during two successive seasons, I and II, at the Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The Egyptian cotton cultivar Giza 75 (*Gossypium barbadense* L.) was the subject of this study. Soil in both seasons was a clay loam. Each experiment included 16 treatments, which were five concentrations from the growth regulator 1-naphthalene acetic acid (NAA), i.e., 5, 10, 15, 20 or 25 ppm and three application treatments, i.e., cotton plants were sprayed with every concentration, once (90 days after planting (DAP)), or twice (90 and 105 DAP), or thrice (90, 105 and 120 DAP), during the square and bolling stage. The application was carried out between 9 and 11 a.m. The phenostage of the plants and temperature at the time of application are found in *table I*. The volume of solution was the same for all treatments, 960 $L \cdot ha^{-1}$. The control treatment was foliar-sprayed with water.

The experimental design was randomised complete blocks with four replications. The plots were 3 m wide × 4 m long with five rows/plot. The plots were planted on 27 March in both seasons. Hills were spaced 20 cm apart in rows. Plants were thinned to two plants/hill after 6 weeks to attain a plant density of 166 000 plants ha^{-1}. The first irrigation was given 3 weeks after planting and the second was given 3 weeks later; then the plots were irrigated every 2 weeks until the end of the season (a total of nine irrigations). Phosphorus fertiliser was applied at the rate of 54 kg $P_2O_5 \cdot ha^{-1}$ as calcium superphosphate (15 % P_2O_5), during preparing of the field for cultivation. Potassium fertiliser was applied at the rate of 57 kg $K_2O \cdot ha^{-1}$ as potassium sulfate (48 % K_2O) before the first irrigation (3 weeks after planting). Nitrogen fertiliser was applied at the rate of 144 kg $N \cdot ha^{-1}$ as ammonium nitrate with lime (33.5 % N) in two equal amounts, the first one after thinning and before the second irrigation (6 weeks after planting) and the second one before the third irrigation (8 weeks after planting). Pest management was carried out according to local practice performed at the Experimental Station of Cairo University.

Ten plants were randomly chosen from the centre row of each plot and were used to determine the number of opened bolls/plant, boll weight (g of seed cotton/boll), lint percentage (lint mass/seed-cotton mass × 100),

Table I. Phenostage of plant and temperature at the time of application.

Time of application	Phenostage					Temperature	
	Plant height (cm)	Leaves (no./plant)	Fruiting branches (no./plant)	Squares (no./plant)	Bolls no./plant)	Minimum (°C)	Maximum (°C)
90 DAP*							
Season I	85–90	24–28	8–9	13–16	1–2	21.8	35.5
Season II	80–90	23–26	7–8	12–14	0–1	22.0	34.8
105 DAP							
Season I	95–107	30–35	10–12	15–17	6–8	19.8	32.6
Season II	92–100	28–34	9–11	13–16	5–6	21.5	34.6
120 DAP							
Season I	110–115	37–38	12–13	16–17	8–10	22.6	36.1
Season II	105–112	34–35	11–13	14–16	8–9	24.8	34.0

* DAP: days after planting.

seed index (g/100 seeds), lint index (mass of lint/100 seeds), and seed cotton yield (g/plant). After hand picking, seed cotton yield ($kg \cdot ha^{-1}$) was determined from the total plot yield (including the ten plants described above). The total yield was ginned and lint yield ($kg \cdot ha^{-1}$) was determined.

A composite sample of 100 g was taken from the ginned cotton of each plot. A 10 g lab sample was taken from each composite sample, by spreading the sample into a thin layer and taking pieces of cotton from each part and siole of this layer and mixing them by hand to provide a uniform lab sample. The lab samples were used for carrying out all the fibre tests. Fibre tests were made at the laboratories of the Cotton Technology Research Division, Cotton Research Institute, Agricultural Research Centre, Giza, Egypt.

Fibre tests were made at a relative humidity of 65 ± 2 % and temperature of 20 ± 1 °C to determine: 1) fibre length in terms of 2.5 and 12.5 % span length (inch) and uniformity ratio as measured by a digital fibrograph; 2) micronaire value (a combined measure of fibre fineness and maturity) measured by a Micronaire instrument; and 3) flat bundle strength (expressed in terms of strength weight ratio (s.w.r.)) as measured by the Pressley index (according to Annual Book of ASTM Standards, D 1447-77, D 1448-79, and D 1445-75, respectively, 1979). Results were analysed as a factorial experiment [12].

3. RESULTS AND DISCUSSION

3.1. Yield components

3.1.1. Number of opened bolls/plant

Results in *table II* indicate that the number of opened bolls/plant was increased by the application

Table II. Effect of NAA concentrations and the number of its application on yield components.

NAA concentrations (ppm)		Number of opened bolls/plant		Boll weight		Lint percentage		Seed index		Lint index	
		Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
		(no.)		(g)		(%)		(g)		(g)	
0	Control	9.65	9.62	2.21	2.05	34.77	34.51	9.70	9.14	5.17	4.81
	Once	9.77	9.89	2.28	2.06	35.38	34.47	9.86	9.13	5.40*	4.80
5	Twice	9.89	9.79	2.26	2.10	34.69	34.47	9.88	9.44*	5.24	4.97
	Three times	10.02	10.94**	2.30	2.17*	35.34	34.60	9.94	9.28	5.44*	4.92
	Once	10.55*	10.10	2.26	2.08	34.66	34.82	9.94	9.15	5.27	4.90
10	Twice	11.02**	9.98	2.31*	2.10	34.61	34.65	10.05*	9.46**	5.32	5.02
	Three times	10.73**	10.38	2.38*	2.27**	34.95	34.48	10.11*	9.86**	5.44*	5.19*
	Once	10.15	10.26	2.27	2.07	35.38	34.55	9.89	9.89**	5.41*	5.23*
15	Twice	11.32**	11.61**	2.28	2.11	35.08	34.44	9.97*	9.48**	5.39*	4.98
	Three times	11.55**	10.29	2.35*	2.25**	34.77	34.82	10.14*	9.60**	5.42*	5.13*
	Once	10.67*	10.57*	2.37*	2.20**	34.73	34.35	10.18*	9.47**	5.42*	4.96
20	Twice	10.86**	11.74**	2.40*	2.14	34.84	35.24	10.30*	9.55**	5.51*	5.20*
	Three times	11.19**	11.21**	2.41*	2.22**	35.06	34.59	10.17*	9.38*	5.49*	4.96
	Once	11.04**	10.04	2.30	2.07	35.44	34.49	10.16*	9.30	5.57*	4.90
25	Twice	10.85**	10.48	2.32*	2.17*	35.60	34.66	10.07*	9.53**	5.57*	5.06*
	Three times	11.04**	10.45	2.34*	2.14	34.76	34.61	9.97*	9.56**	5.32	5.06*
L.S.D.	0.05	0.80	0.88	0.10	0.11	*n.s.*	*n.s.*	0.27	0.23	0.21	0.26
	0.01	1.08	1.19	*n.s.*	0.15	*n.s.*	*n.s.*	*n.s.*	0.31	*n.s.*	*n.s.*

* Significant at 5 % level, ** significant at 1 % level, and *n.s.* = not significant.

of NAA as compared with the untreated control in both seasons. This increase was significant when NAA was applied at 10, 20 or 25 ppm once, twice or three times and at 15 ppm twice or three times in the first season and when NAA was applied at 5 ppm three times, at 15 ppm twice and at 20 ppm once, twice or three times in the second season. The application of NAA at 15 or 20 ppm tended to give the best results. The increase may have been due to the fact that abscission promoting effects of abscisic acid were counteracted when NAA was applied to either flower buds or young bolls [27]. In addition to the previously mentioned impact, NAA could bring about an increase in fruiting site production and/or better survival of young bolls [14]. These effects would contribute either individually or altogether to an increase in number of opened bolls/plant. Negi and Singh [20] applied NAA at 5, 10 and 20 ppm and reported an increase in the number of bolls/plant by 8–9 % with 10 ppm NAA. However, a slight decrease with 20 ppm NAA occurred. Abdel-Al et al. [1] found that the reduction of young boll shedding in case of NAA application was connected with an increase in the total phenols and polyphenols content in young bolls. This may be due to the indirect effect of polyphenols in inhibiting the action of indole acetic acid (IAA) oxidase, yet tended to reduce boll shedding percentage [2].

The increase in number of opened bolls/plant due to the use of NAA has been reported by Sawan [23] who applied NAA at 10 ppm 70, 85 and 100 days after sowing and Goyal et al. [13] who applied NAA at 175 mL at the pre-square, flowering and boll formation stages.

The application of NAA twice or three times tended to be more effective in increasing the number of bolls/plant than a single application. In this connection, Jadhav and Kalbhor [15] found that application of NAA twice at square formation and 30 days later increased the number of bolls/plant and reduced the boll shedding compared with a single application at square formation stage. Swamy [24] studied the effect of 10, 20 or 30 ppm NAA applied at 60, 60 + 90 or 60 + 90 + 120 DAP, and found that boll shedding was reduced.

3.1.2. Boll weight

The application of NAA increased boll weight over the control in both seasons (*table II*). Applying NAA at a rate of 10 or 25 ppm twice or three times, at a rate of 15 ppm three times and at a rate of 20 ppm twice or three times led to a significant increase in the first season; however, applying NAA at a rate of 5, 10 or 15 ppm three times, at a rate of 20 ppm once or three times and at a rate of 25 ppm twice gave significant increase in the second season. NAA concentrations of 10, 15 or 20 ppm tended to give the best results followed by 25 and 5 ppm concentrations. The increase in boll weight can be attributed to that the application of exogenous auxin increases the photophosphorylation of chloroplasts [25], CO_2 fixation [5] and stimulates the transport of photosynthetic products to flowering buds [29]. Varma [28] stated that NAA as an auxin maintains ongoing physiological and biochemical function and mobilises nutrients by attracting assimilates to stronger sinks. These in turn increase the formation of fully matured bolls and their weight. The results agreed with those obtained by Sawan [23], Goyal et al. [13] and Swamy [24].

The application of NAA three times was most effective, followed by application twice and then once.

3.1.3. Lint percentage

The application of NAA did not show any significant effect on lint percentage in the two seasons (*table II*). This result showed great similarity to those obtained by Avtar and Dargan [4] and Sawan [23].

3.1.4. Seed index

Data in *table II* evidently show that application of NAA resulted in seed index increments in both seasons, which reached a significant level when NAA was applied at 10 and 15 ppm twice or three times and at 20 or 25 ppm once, twice or three times in the first season, while in the second season

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significance was reached when NAA was applied at 5 ppm twice, at 10 or 25 ppm twice or three times and at 15 or 20 ppm once, twice or three times. The most effective concentration of NAA in increasing seed index was 20 ppm followed by 15, 25, 10 and 5 ppm concentrations. This indicates that treated cotton bolls had larger photosynthetically supplied sinks of carbohydrates and other metabolites than untreated bolls [5, 25]. The increase in seed index observed herein confirmed the results obtained by El-Halawany et al. [11] who found that application of 20 ppm NAA at the beginning of flowering or 2 or 4 weeks later increased seed index.

The application of NAA twice or three times gave the best results compared with one application. In this respect, Brar and Mukand [6] found that two sprays of NAA increased seed index compared with one spray.

3.1.5. Lint index

Applying NAA at different concentrations increased lint index in both seasons with no particular difference in response to those concentrations (*table II*). The increase was significant by the application of NAA at 5 ppm once or three times, at 10 ppm three times, at 15 or 20 ppm once, twice or three times and at 25 ppm once or twice in the first season. However, in the second season application of NAA at 10 ppm three times, at 15 ppm once or three times, at 20 ppm twice and at 25 ppm twice or three times gave a significant increase. This finding could be attributed to the fact that NAA would promote the initiation and development of a greater number of fibres per seed. This was in harmony with the results obtained by Sawan [23]. Brar and Mukand [6] reported that two sprays of NAA increased lint index compared with one spray.

3.2. Yield

Results in *table III* show that seed cotton yield/plant as well as seed cotton and lint yields ha^{-1} increased by the application of NAA compared with the untreated control in the two seasons. The increases in seed cotton yield/plant and ha^{-1} were significant with an application of NAA at 10, 20 or 25 ppm once, twice or three times and at 15 ppm twice or three times, while for lint yield ha^{-1} it was significant with an application of NAA at 10 ppm twice or three times and at 15, 20 or 25 ppm once, twice or three times in the first season. In the second season the increases in seed cotton yield/plant and seed cotton and lint yields ha^{-1} were significant with an application of NAA at 5 or 10 ppm three times, at 15 or 25 ppm twice or three times and at 20 ppm once, twice or three times. The highest yield was achieved with the application of NAA at 20 ppm, followed by 15, 25, 10 and 5 ppm concentrations. Actually, such results may be attributed to the promoting effect of this substance on numerous physiological processes [5, 25, 29], leading to an improvement in all yield components. These results confirmed those obtained by Goyal et al. [13] and Mehetre et al. [17] who applied NAA at 20 ppm, Deshpande and Lakhdive [9] by application of NAA at 20 ppm, and Pothiraj et al. [22] when cotton plants were treated with NAA at 40 ppm.

The application of NAA three times gave the best results in the first season followed by the double and single applications, while in the second season, application of NAA twice gave the best results, followed by the triple and single applications. Similar results were obtained by Jadhav and Kalbhor [15] and Swamy [24] when he studied the effects of 10, 20 or 30 ppm NAA applied at 60, 60 + 90 or 60 + 90 + 120 DAP, and found that boll shedding was reduced and boll weight and seed cotton yield was increased with application of NAA.

3.3. Fibre properties

Data in *table IV* evidently show that fibre length parameters and micronaire value were not significantly influenced by NAA in the two seasons. Flat bundle strength was affected significantly due to NAA application in both seasons. Application of

Table III. Effect of NAA concentrations and the number of its application on cotton yield.

NAA concentrations (ppm)		Seed cotton (yield/plant)		Seed cotton (yield·ha^{-1})		Lint (yield·ha^{-1})	
		Season I	Season II	Season I	Season II	Season I	Season II
		(g)		(kg)		(kg)	
0	Control	21.31	19.78	2 602.4	2 407.5	905.5	831.2
	1 ×	22.29	20.43	2 691.9	2 462.5	952.5	848.9
5	2 ×	22.35	20.60	2 714.6	2 508.6	941.6	864.7
	3 ×	23.04	23.78**	2 788.2	2 883.5**	984.2	995.8**
	1 ×	23.77*	20.95	2 883.0*	2 494.9	999.1	868.8
10	2 ×	25.43**	20.98	3 090.4**	2 554.8	1 069.2**	884.0
	3 ×	25.57**	23.49**	3 099.0**	2 846.3*	1 082.4**	982.0**
	1 ×	23.01	21.22	2 836.1	2 550.7	1 005.5*	880.7
15	2 ×	25.86**	24.43**	3 141.9**	2 961.4**	1 101.6**	1 019.9**
	3 ×	27.16**	23.13**	3 223.7**	2 821.7*	1 120.8**	981.4**
	1 ×	25.29**	23.22**	3 062.4**	2 825.1*	1 063.5**	970.1*
20	2 ×	26.01**	25.12**	3 151.9**	3 032.0**	1 098.6**	1 069.5**
	3 ×	26.91**	24.93**	3 186.1**	3 081.4**	1 117.8**	1 043.2**
	1 ×	25.39**	20.83	3 081.7**	2 547.5	1 091.5**	878.6
25	2 ×	25.17**	22.75**	3 122.6**	2 775.6*	1 111.9**	962.8*
	3 ×	25.81**	22.40*	3 140.1**	2 741.5*	1 092.3**	949.6*
L.S.D. at	0.05	2.05	2.04	274.4	328.4	96.3	107.8
	0.01	2.76	2.75	369.6	442.3	129.7	145.2

NAA at 10 ppm once or twice and at 20 or 25 ppm once in the first season and at 10, 15 or 20 ppm once in the second season increased flat bundle strength over the control significantly. The application of NAA once gave the best results. Studies on natural growth substances suggested that there may be specific fibre elongation hormones for cotton [18], so failure to improve fibre properties consistently may simply be due to failure to use the right compound. Sawan [23] reported that low concentrations of NAA increased fibre fineness but had the reverse effect at higher concentrations. Goyal et al. [13] found that application of NAA at 175 mL at the pre-square initiation, flowering and boll formation stages increased fibre length, but decreased fibre fineness. Mehetre et al. [17] found that fibre bundle strength was highest when NAA was applied at 20 ppm. Mean fibre length, uniformity ratio, fineness and maturity coefficient were unaffected by treatments. Deshpande and Lakhdive [10] found that fibre quality was not consistently affected when NAA was applied to cotton plants at 10 ppm.

4. CONCLUSION

According to the results obtained from this study, it could be concluded that, from the economical point of view, it is recommended to apply NAA at a concentration of 20 ppm twice, i.e., 90 and 105 DAP, during square and bolling stages to realise the most efficient effects on improving yield and yield components of Egyptian cotton. However, it seems worthwhile to mention that, generally, application of NAA did not appear to significantly affect the quality characteristics of cotton fibre.

Table IV. Effect of NAA concentrations and the number of its application on fibre properties.

NAA concentrations (ppm)		2.5 % span length (inch)		12.5 % span length (inch)		Uniformity ratio (%)		Micronaire value (mic.v.)		Flat bundle strength (s.w.r.)	
		Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
0	Control	1.223	1.213	0.920	0.913	75.21	75.29	4.57	4.50	10.37	10.17
5	1 ×	1.240	1.233	0.940	0.930	75.81	75.41	4.53	4.57	10.37	10.23
	2 ×	1.250	1.213	0.940	0.920	75.20	75.82	4.77	4.47	10.57	10.47
	3 ×	1.233	1.223	0.923	0.910	74.86	74.41	4.50	4.47	10.43	10.17
10	1 ×	1.223	1.240	0.917	0.937	74.93	75.54	4.67	4.57	10.73*	10.87*
	2 ×	1.257	1.210	0.940	0.910	74.79	75.21	4.63	4.57	10.67*	10.10
	3 ×	1.250	1.250	0.937	0.940	74.93	75.19	4.67	4.50	10.27	10.13
15	1 ×	1.227	1.260	0.937	0.943	76.36	74.87	4.63	4.47	10.63	10.73*
	2 ×	1.233	1.220	0.920	0.913	74.60	74.86	4.60	4.57	10.53	10.33
	3 ×	1.233	1.237	0.943	0.913	76.48	73.86	4.53	4.50	10.53	10.33
20	1 ×	1.230	1.223	0.927	0.930	75.35	76.02	4.57	4.50	10.67*	10.83*
	2 ×	1.247	1.233	0.947	0.933	75.93	75.70	4.70	4.57	10.33	10.33
	3 ×	1.220	1.237	0.927	0.923	75.96	74.68	4.70	4.60	10.47	10.13
25	1 ×	1.233	1.223	0.930	0.930	75.41	76.03	4.63	4.50	10.70*	10.53
	2 ×	1.250	1.240	0.950	0.913	76.00	73.67	4.77	4.60	10.33	10.23
	3 ×	1.220	1.227	0.920	0.910	75.42	74.18	4.67	4.60	10.53	10.20
L.S.D.	0.05	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.29	0.45
	0.01	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

However, it seems that further research work should be conducted to provide further information which would cover other aspects related to physiological mechanisms affecting cotton productivity.

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