Effect of 1-Naphthaleneacetic Acid on the Seed, Protein, Oil, and Fatty Acids of Egyptian Cotton

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The effects of 1-naphthaleneacetic acid (NAA) applied at various levels and times on yield, seed index, protein and oil content and fatty acid compositions of cotton plants seeds were studied. NAA increased the seed yield/plant and the seed, protein, and oil yields/ha compared to the control. A level of 20 ppm proved best for yield. Most NAA treatments significantly increased the seed index, but only slight increases in seed protein content were recorded. Increases in the amount of seed oil was moderate, with fluctuation that was due to treatment. NAA generally caused decreases in saturated fatty acids that were associated with increases in unsaturated fatty acids. One treatment proved to be more effective than multiple treatments. Palmitic acid and linoleic acid were the most abundant saturated and unsaturated fatty acids, respectively.

It was well established that plant growth regulators (PGR) modify processes such as increased photosynthesis rate, altered photosynthate export from leaves, and altered respiration rates (1). They also play an important role in flower initiation and development, fruit-set, and fruit growth (2).

The effects of PGR 1-naphthaleneacetic acid (NAA) on seed cotton yield and fiber quality have been widely studied, but few studies documented their effects on the quantity and quality of seed yield. Using NAA on cotton plants produced increases in cottonseed yield, seed index, and seed oil content, while seed protein was unchanged (3-5). Brar and Mukand (6) have reported that two sprays of NAA increased seed index more than only one spray.

Due to the economic importance of cottonseed as the main source of edible oil and meal for livestock in Egypt, this investigation was carried out to evaluate the effect of NAA in the form of foliar sprays on cotton plants with different levels and times of application during square initiation and boll development. The seed oil and protein contents, seed protein and oil yields, seed index, and fatty acid compositions were also studied.

MATERIALS AND METHODS

Two field experiments were performed during the seasons of 1984 and 1985 at the Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt, using the Egyptian cotton cultivar Giza 75 (*Gossypium barbadense* L.). Each experiment consisted of 16 treatments, which included five concentrations of NAA (5, 10, 15, 20, and 25 ppm) in three multiple applications. Cotton plants were sprayed once (at 90 days), twice (90 and 105 days), or three times (90, 105, and 120 days from sowing), in addition to the control group (sprayed with water only).

Each experiment was performed in a randomized complete block design with four replicates. Each plot was 3 × 4 m, including five ridges. Seeds were sown on March 25 in both seasons. Normal cultivation practices were followed.

At harvest, ten plants were chosen at random from each plot and laboratory-ginned to determine seed yield in g/plant and seed index (weight of 100 seed in g). The seed cotton yield of each plot was picked and ginned to determine the cottonseed yield in kg/ha.

For the laboratory tests, a random sample of 200 g of seed represented each plot, then a composite seed sample representing the four replicates of each treatment was taken for the chemical analysis. The following were measured: (a) The seed crude protein content according to AOAC (7); (b) the seed oil content in which oil was extracted from the seed with ether according to AOAC (7) and (c) the fatty acid compositions in which fatty acids were prepared according to the technique described by Ahmed *et al.* (8). The fatty acids and standards were analyzed with a Gcv Pye Unicam gas chromatography equipped with dual flame ionization detector and dual channel recorder. The chromatographic conditions were identical to those described by Farag *et al.* (9).

RESULTS AND DISCUSSION

Cottonseed yield. The cottonseed yield/plant and hectares were significantly increased with most of the NAA levels compared to the control. The exceptions were 5 ppm (applied once and twice), 15 ppm (applied once), and 10 ppm (applied once), although it affected the yield/plant only (Table 1). The highest yield was obtained with 20 ppm, followed by 15, 25, 10, and 5 ppm, respectively. The three sprayings proved to be the most effective, followed by twice and then once. These results may be due to the effects of NAA (auxin) on increasing and stimulating the transportation of photosynthetic products to the cotton bolls (10), which increases their weight. Also, the application of auxins inhibits the production of enzymes involved in abscission (11) and reduces the effect of abscisic acid and abscission (12) therefore decreasing the rate of bud and boll abscission. The present results agree with those obtained by El-Halawany (5), Jadhav and Kalbhor (13), Jagannathan and Iruthayaraj (14), and Sawan (15).

Seed index. NAA applications caused increases in the seed index (Table 1), which was statistically significant with the applied levels of 5 and 10 ppm twice and thrice, 15, 20, and 25 ppm once, twice, and thrice. NAA at 20 and 15 ppm produced the best results. Similar results were obtained by Sawan (15). NAA produced high results when applied more than once, which confirmed the results gotten by Brar and Mukand (6). The increase in seed index could be referred to the role of NAA in stimulating the biosynthetic activities, especially the photophosphorylation of chloroplasts and the transportation of photosynthetic products (10,16).

Seed protein (%) and yield. NAA treatments tended to show a slight seed protein percentage increase (Table 1) which was similar to the results obtained by Sawan *et al.*

(3,4). The seed protein yield (kg/ha) was markedly increased because of NAA applications as compared to the control. The highest protein yield was detected at 20 ppm, followed by the 15 ppm level. Two and three NAA treatments increased protein yield/ha more than just one treatment did.

TABLE 1

Effect of NAA Concentrations and Number of Applications on the Cottonseed Yield, Seed Index, Seed Protein and Oil Content and Yield

Treatments								
NAA concent. (ppm)	Number of applications	Cottonseed yield (g/plant)[a]	Cottonseed yield (kg/ha)[a]	Seed index (g)[a]	Seed protein (%)[b]	Protein yield (kg/ha)[b]	Seed oil (%)[b]	Oil yield (kg/ha)[b]
0	Control	13.43	1636.6	9.42	22.32	365.3	20.50	335.5
5	Once	13.90	1676.5	9.50	22.70	380.6	21.16	354.7
	Twice	14.05	1708.5	9.66[c]	22.68	387.5	21.19	362.0
	Thrice	15.23[c]	1845.8[c]	9.61[d]	22.47	414.8	21.43	395.6
10	Once	14.59[d]	1755.0	9.54	22.71	398.6	22.14	388.6
	Twice	15.17[c]	1846.0[c]	9.76[c]	22.62	417.6	22.20	409.8
	Thrice	16.02[c]	1940.5[c]	9.99[c]	22.40	434.7	21.87	424.4
15	Once	14.38	1750.3	9.89[c]	22.62	395.9	21.78	381.2
	Twice	16.41[c]	1990.9[c]	9.73[c]	22.50	448.0	21.82	434.4
	Thrice	16.40[c]	1971.6[c]	9.87[c]	22.60	445.6	22.28	439.3
20	Once	15.88[c]	1927.0[c]	9.82[c]	22.68	437.0	21.92	422.4
	Twice	16.60[c]	2007.9[c]	9.92[c]	22.60	453.8	22.10	443.7
	Thrice	16.89[c]	2021.8[c]	9.77[c]	22.65	457.9	21.96	444.0
25	Once	15.02[c]	1829.5[c]	9.73[c]	22.54	412.4	21.09	385.8
	Twice	15.54[c]	1911.8[c]	9.80[c]	22.40	428.2	21.11	403.6
	Thrice	15.74[c]	1919.9[c]	9.77[c]	22.37	429.5	21.90	420.5
L.S.D.	0.05	1.05	145.1	0.17	—	—	—	—
	0.01	1.40	192.6	0.23	—	—	—	—

[a]Combined data for 1984 and 1985 seasons.
[b]Mean data for 1984 and 1985 seasons.
[c]Significant at 1% level.
[d]Significant at 5% level.
—, not significant.

TABLE 2

Effect of NAA Concentrations and Number of Applications on the Seed Oil Fatty Acids Compositions

Treatments		Saturated fatty acids				Unsaturated fatty acids			
NAA concent. (ppm)	Number of applications	Myristic	Stearic	Palmitic	Total	Oleic	Linoleic	Total	TU/TS[a] ratio
0	Control	1.1	0.9	21.1	23.1	27.0	49.9	76.9	3.33
5	Once	0.9	1.0	19.2	21.1	29.0	49.9	78.9	3.74
	Twice	1.2	1.0	20.0	22.2	28.8	49.0	77.8	3.50
	Thrice	1.3	1.3	20.2	22.8	28.5	48.7	77.2	3.39
10	Once	0.9	1.1	19.0	21.0	29.3	49.7	79.0	3.76
	Twice	1.1	1.1	20.0	22.2	29.0	48.8	77.8	3.50
	Thrice	1.5	1.3	20.4	23.2	28.5	48.3	76.8	3.31
15	Once	1.0	1.2	19.0	21.2	29.1	49.7	78.8	3.72
	Twice	1.1	1.0	20.8	22.9	28.7	48.4	77.1	3.37
	Thrice	1.7	1.6	20.5	23.8	28.0	48.2	76.2	3.20
20	Once	1.1	1.0	19.2	21.3	29.0	49.7	78.7	3.69
	Twice	1.1	1.0	20.0	22.1	28.5	49.4	77.9	3.52
	Thrice	1.8	1.7	21.5	25.0	27.4	47.6	75.0	3.00
25	Once	1.0	1.1	19.6	21.7	29.0	49.3	78.3	3.61
	Twice	1.2	1.1	19.9	22.2	28.3	49.5	77.8	3.50
	Thrice	2.1	1.8	22.7	26.6	27.0	46.4	73.4	2.76

Mean data for 1984 and 1985 seasons.
[a]TU/TS ratio = (total unsaturated fatty acids)/(total saturated fatty acids).

Seed oil (%) and yield. NAA at various levels increased seed oil percentage against the control (Table 1). The most remarkable effect was obtained with 10 ppm, and this was achieved when NAA was applied twice and/or more, which indicates that NAA might help the accumulation of oil in cottonseed. The oil yield (kg/ha) was markedly increased due to the application of NAA as compared to the control. Twenty ppm produced the best results, followed by the 15 ppm concentration. The number of applications three times, twice, and once was positively effective in the same order. This was in harmony with the results obtained by Sawan *et al.* (3,4).

The effects of NAA application on the chemical components and yield of cottonseed could be attributed to the stimulating effect of the auxin on the photosynthesis capability of chloroplasts (16). It could also be attributed to its necessity for DNA replication, controlling RNA synthesis, stimulating the transcription of mRNAs—which lead to the synthesis of proteins, stimulation of the plasmalemma, and a H^+ pump which moves H^+ ions out across the plasmalemma while spliting ATP (an H^+ ATPase), while the ATP acts as the energy source (17-19). This leads to distinct changes in plant yield and its components.

Oil fatty acid compositions. Table 2 shows that the application of NAA decreases the saturated fatty acids (myristic, stearic, and palmitic) associated with an increase in the unsaturated fatty acids (oleic and linoleic), except in the highest NAA concentration (25 ppm), where the opposite was found. More increases in the saturated fatty acids and decreases in unsaturated fatty acids were observed when NAA was applied twice or three times, rather than just once. These results were confirmed by the ratio of TU/TS (total of unsaturated fatty acids to the total of saturated fatty acids). Ahmed and Osman (20) reported that spraying sunflower plants with indolic compounds altered (to some extent) the percentage of unsaturated fatty acids. It could be mentioned here that the low content of saturated fatty acids is desirable from the standpoint of edible uses (21). The GLC results revealed that the principle unsaturated fatty acids of cottonseed oil were linoleic, followed by oleic, and linolenic acid was not detected, whereas palmitic acid was the most abundant saturated fatty acid. These results were in agreement with those obtained by Cherry and Gray (22). Data also showed a slight increase in myristic and stearic acids due to the application of NAA (especially with 25 ppm), accompanied by a slight decrease in palmitic acid. The increase in unsaturated fatty acids may be due to the conversion of saturated fatty acids to unsaturated fatty acids, which is caused by 5-20 ppms of NAA treatments. However, the opposite conversion was noticed with the use of a high level (25 ppm) of NAA treatments.

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