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The Effects of Soil and Foliar Humic + Fulvic Acid Applications on Yield and Yield Components of Cotton (*Gossypium hirsutum* L.)

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Abstract
The study was carried out to determine the effects of soil and foliar humic+fulvic acid applications on yield and yield components of cotton. The experiment was laid out in randomized block design with three replications. Stoneville-468 cotton cultivar and humic+fulvic acid were used as the materials of the experiment. The main plots consisted of soil applications (0, 1000, 2000 and 3000 g ha^{-1} humic+fulvic acid), and the sub-plots were foliar applications (0, 12.5, 25 and 37.5 kg ha^{-1} humic+fulvic acid). The highest seed cotton yield, seed cotton weight per boll, ginning outturn and lint index were obtained in 2000 g ha^{-1} soil×250 g ha^{-1} foliar treatment. The highest number of sympodial branches was obtained in 1000 g ha^{-1} soil×125 g ha^{-1} of foliar treatment. The highest seed index was recorded in 2000 g ha^{-1} soil×375 g ha^{-1} foliar treatment. The highest number of bolls per plant was obtained in 1000 g ha^{-1} soil application. The results concluded that humic+fulvic acid application had no significant effect on earliness ratio. The number of monopodial branches and plant height in humic + fulvic acid applications were lower compared to the control treatment. The number of bolls per plant increased with humic+fulvic acid applications. The results indicated that recomended only for soil application is 2000 g ha^{-1}, only for foliar application is 125 g ha^{-1}, and both for soil and foliar application is 2000 g ha^{-1} soil×250 g ha^{-1} foliar.

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1. Introduction

Cotton (*Gossypium hirsutum* L.), which is the main source of natural fiber, is a culture plant with a very high economic value with its oil and pulp obtained from the seeds and other by-products. Cottonseed contains hull and kernel. The hull produces fibre and linters. The kernel contains oil, protein, carbohydrate and other constituents such as vitamins, minerals, lecithin, sterols etc. Its seeds also contains 20-25% protein (Agarwal et al., 2003).

The fiber cotton production of the world in 2022/2023 season is estimated to be 24.8 million tons in 31.4 million ha area, the consumption is 25.9 million tons and the world fiber cotton import is around 9.09 million tons. The cotton production of Turkey in 2022/2023 was 925 thousand of MT, while it was 825 thousand of MT in 2021/2022 (USDA, 2023).

Turkey ranks 9th in the world in cotton acreage and 7th in the amount of production. However, Turkey ranks 3rd in fiber yield per unit area after China and Australia (USDA, 2023).

Low organic matter content of soils in Turkey and rapid decrease of organic matter under changing climate conditions increased the mineral fertilizer consumption in agricultural production. However, no matter how much mineral fertilizers are used at the end of a certain period, the producers will not be able to obtain sufficient yield, and the soils will face with the threat of desertification.

The fertility of a soil is determined by the availability of plant nutrients in that soil. The amount and availability of plant nutrients are closely related to the organic matter content of a soil. Many organic resources are used to increase the organic matter content of soils.

The low yield and quality in crop production are highly associated with the low productivity potential of soils, and are the most important reasons low income of producers. Improving the productivity potentials of soils by increasing the organic matter content will improve soil quality and help to solve the low productivity problem. Therefore, plant and animal residues such as farmyard manure, crop residues, green manure, compost and leonardite should be used intensively in agricultural lands (Matisic et al., 2024). Application of sufficient organic fertilizers to all agricultural fields is not possible, however, fertility potential of soils can be increased by application of humic and fulvic acids, which are active fractions of organic matter and humus, in much less amount than the organic fertilizers. Positive effect of organic fertilizers on soil properties is related to organic compounds released by the decomposition and breakdown through microorganisms and humus consisting of humic and fulvic acids. Therefore, the application of humic matter increases the soil fertility and positively affects the availability of plant nutrients (Stevenson, 1994).

HAs are polyelectrolytic macromolecular compounds originating from chemical and biological degradation of plant and animal residues, and microbial cells (Hayes and Wilson, 1997).

Humic acid improves seed germination, root development, proliferation of soil microorganisms and decomposition of stubble for a short time, and increase water holding capacity of light textured soils. In addition, humic acid facilitates uptakes of plant nutrients such as nitrogen, phosphorus, potassium, iron and zinc, improves the structure of heavy clay soils, prevents salt accumulation in soils and has positive effects on the aeration of soils.

The need for organic additives containing humic acid, which directly and indirectly enhances plant growth and improves soil conditions, is continuously increasing. Organic fertilizers with humic acid content as well as rich organic colloidal minerals are used in many areas such as soil improvement, cleaning the soil polluted by industrial wastes, removing disturbing odors, animal feed additive, air and water filter systems (Saglam et al., 2012).

Humic substances act as a buffer in a wide pH range in soils and improves availability of many micronutrients to plants (Chen et al., 2001).

Cotton is intensively cultivated in Turkey, while the organic matter content in most of the cotton fields is very low. Therefore, humic acid is applied to promote plant growth and increase crop yield. Contradicting results have been reported in humic acid application studies carried out in different parts of the world. Basbag (2008) reported an increase in plant height, earliness ratio, boll number, seed cotton yield under different humic acid applications. In another study carried out by Haroon and Muhammad (2010) showed that 0.5, 1 and 2 kg ha^{-1} humic acid applications increased the cotton yield by 10.5, 15.6 and 13.5%, respectively. Similarly, other studies reported that application of humic acid increased plant height and number of sympodial branches (Seadh et al. 2012), and plant height, number of sympodial branches, number of boll, boll weight, seed index and seed cotton yield (Abou-Zaid et al. 2013). Ahmed et al. (2013) obtained higher number of bolls and seed cotton yield with foliar humic acid applications and Rady et al. (2016) reported positive effects on growth, yield, fiber quality and water use efficiency under salt stress in humic acid applications. The findings of Tarhan and Karademir (2019) who reported an increase in seed cotton yield, number of boll and seed cotton weight per boll with humic acid applications, are in accordance with the others. In contrast to aforementioned positive effects of humic acid application on cotton yield and yield related characteristics, Temiz et al. (2009) reported that humic acid applications had no significant effect on ginning outturn and seed cotton yield. Similarly, Basbag (2008) did not obtain any effect on lint yield, and Tarhan and Karademir (2019) did not report positive effect of humic acid applications on plant height, number of monopodial branches, seed index and earliness ratio. Moosavi (2020) reported that humic acid applications increased seed cotton yield, plant height and number of sympodial branches, and the use of mycorrhiza and humic acid reduced the negative effects of water stress, especially under moderate stress conditions.

This study was carried out to investigate the effects of soil and foliar humic acid applications on yield and yield components of cotton and to assist future studies which will be carried out on humic acid applications on cotton.

2. Materials and Methods

The experiment was conducted in Doğrular village of Hilvan district, Şanlıurfa province, Turkiye in 2014 cotton growing season. The lay out of the experiment was split plots in randomized blocks with 3 replications. Stoneville-468 which is the commonly cultivated cotton variety in the region (MAY, 2021) was used as plant material and humic+fulvic acid (trade name K-Humate), raw material of which is leonardite, was used as organic soil conditioner (HEKTAŞ, 2021).

The application doses to soil constituted the main plot (0, 1000, 2000, 3000 g ha^{-1}), and the foliar application doses constituted the sub plots (0, 125, 250, 375 g ha^{-1}). The amount of water to be used in each plot was determined using a back atomizer and the amount was calibrated, accordingly. Water was applied to the control plots, and the calculated humic acid was applied to soil surface of other plots with a back pump. Immediately after the applications, soil surface in each plot was mixed with a hand harrow. Foliar applications were carried out with a back pump after 19:00 p.m. in the evening when the weather was cooler. Water was sprayed on the leaves of plants in the control plots.

The properties of organic soil conditioner used as a humic + fulvic acid source are given in Table 1.

The experimental site had a clayey texture, soil pH was 7.83 and organic matter content was 0.90% (Table 2) (Anonymous, 2014).

Table 1. Composition of organic soil conditioner used in the experiments*

Content	(% w/w)
Total Organic Matter	30
Total Humic + Fulvic Acid	60
Water soluble K_2O	15
Moisture	20
pH	9-11

*(Hektaş, 2014)

Table 2. Some soil properties of the experimental field*

Depth (cm)	Organic matter (%)	Total salt (%)	pH	Lime (%)	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})
0-20	0.90	0.008	7.83	8.4	5.6	121

*(Anonymous, 2014)

Sanliurfa province is located in the Southeastern Anatolia climate zone, while the influence of Mediterranean climate is partially observed. The climate is hot and dry in summers and mild in winters. Dogrular village is located at 76 km to Sanliurfa province and 21 km to Hilvan district. The effects of Mediterranean and continental climates are observed in the study area. The summers are hot and dry, and winters are generally cold and rainy due to the continental climate.

The average temperature during the cotton growth period in the experiment (March-November 2014) varied between 11.1 and 31.4 °C, and the long-term average is between 9.1 and 30.5 °C. The highest temperatures during the experiment were between 20.7 and 41.5 °C, while the long-term averages are between 15.6 and 38.1 °C. The lowest temperatures during the experiment were between 8.2 and 29.3 °C and the long-term averages were between 3.1 and 20.8 °C. The average precipitations during the experiment were between 0.3 and 89.5 mm, and the long-term averages were between 0.4 and 63.8 mm. Average relative humidity values during the experiment varied between 25.4 and 50.9% and the long-term averages between 32.5 and 61.7%. The soil temperatures at 5 cm during the experiment were 9.7 and 35.6 °C, and the long-term average temperatures were 9.4 and 28.2 °C (TSMS, 2014).

The experimental area was tilled at a depth of 25-30 cm in autumn with a plow. Before planting, the clods were broken pieces with a disc harrow and then the field was made ready for planting with the roller. Seeds were planted on May 6, 2014 with a pneumatic seed drill in 4 rows with a row length of 12 m. Inter-row spacing at planting was 70 cm and intra-row spacing was 15 cm. Three meter of space was left between the blocks to carry out the maintenance easily. During the experiment, 2 times hand hoes and 2 times machine hoes were carried out depending on the growth state and weed density of the plants. Considering the demands of cotton plants fertilizers at a rate of 160 kg N ha^{-1} and 132 kg P ha^{-1} were applied. At planting 54 kg N ha^{-1} and all of phosphorus (300 kg ha^{-1} diammonium phosphate (18 N-46 P_2O_5) were applied. The remaining nitrogen was divided two and 52 kg N ha^{-1} (200 kg ha^{-1} calcium ammonium nitrate, 26% N) applied right before the 1st irrigation (19.06.2014) and the 54 kg N ha^{-1} was applied (117.4 kg ha^{-1} Urea, 46% N) before the 2nd irrigation (26.06.2014). Initial two irrigations were carried out with the sprinkler irrigation system and then the drip irrigation system was established. The drip irrigation was used 6 times based on the need of cotton plants. Total of 800 mm of water was applied during the growing period in 8 irrigations.

Figure 1. Experimental area

The maintenance during the growth period was performed based on the cultural practices in the region. One meter from the beginning and end of the plots was left as side effect, and the middle 2 rows were harvested (10 m×1.4 m = 14.0 m^2). The first harvest was carried out when 50% of bolls opened (12.10.2014), and the second harvest was made 19 days after the first harvest (31.10.2014). The plant properties examined were determined with the methods specified by Worley et al. (1976), and the fiber quality properties were determined using a HVI 1000 instrument (USTER, 2014).

The data obtained were subjected to variance analysis according to the split plots in randomized blocks experimental design using the MINITAB® 18.1 software, and the mean values were grouped using the Tukey-HSD test.

3. Results and Discussion

The effects of soil and foliar humic + fulvic acid applications and soil x foliar humic + fulvic acid interactions on cotton yield, number of boll, number of monopodial branches, number of sympodial branches, plant height, seed cotton weight per boll, lint yield, 100 seed weight and fiber index were statistically significant ($p<0.01$), while the effects on earliness ratio was not statistically significant.

3.1. Seed cotton yield (kg ha^{-1})

The highest cotton yield was obtained in 2000 g ha^{-1} (4886.16 kg ha^{-1}) soil humic+fulvic acid application, 125 g ha^{-1} (4431.40 kg ha^{-1}) foliar application and 2000 g ha^{-1} soil×250 g ha^{-1} foliar humic+fulvic acid interaction (5334.33 kg ha^{-1}) (Table 3). The results indicated that both soil and foliar humic+fulvic acid applications increased the seed cotton yield compared to the control. Humic acid not only supports root growth, but also increases the nutrient and water uptake of plants by stimulating the H^+-ATPase enzyme activity of the stem cells (Olaetxea et al., 2019). The results revealed that the amount and quality of cotton were increased in parallel with the use of humic acid. The higher yields in humic acid applications compared to control plots supports the aforementioned situation. The results indicated that soil application at 2000 g ha^{-1} or foliar application at 125 g ha^{-1}, or combination of 2000 g ha^{-1} soil + 250 g ha^{-1} foliar humic + fulvic acid application (interaction) can be recommended to obtain high cotton yield. Positive effect of humic+fulvic acid application on seed cotton yield has been reported by Dileep (1999), Atak et al. (2004), Oren (2007), Basbag (2008), Haroon and Muhammad (2010), Kaptan and Aydın (2012), Abou-Zaid et al. (2013), Ahmed et al. (2013), Almaca and Nacar (2013), Rady et al. (2016) and Moosavi (2020). On the contrary, Temiz et al. (2009) stated that humic + fulvic acid applications had no effect on seed cotton yield.

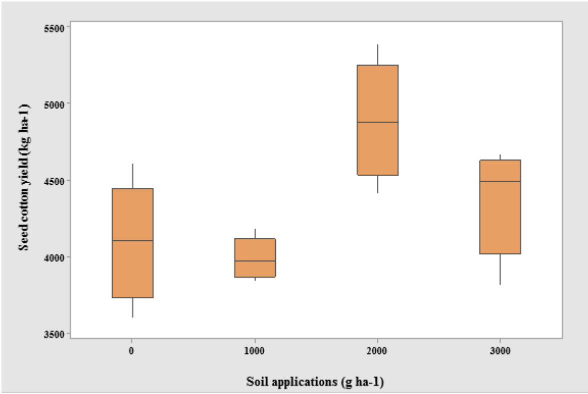

Figure 2a. Soil humic acid applications (kg ha^{-1})

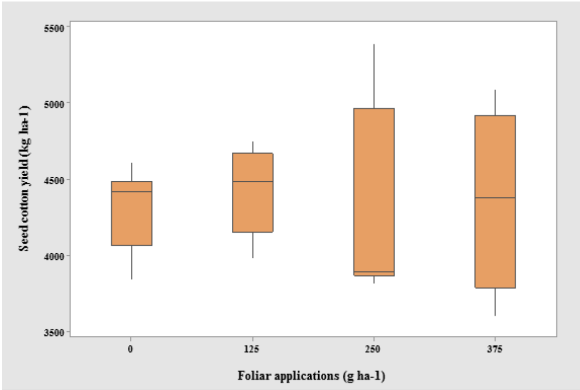

Figure 2b. Foliar humic acid applications (kg ha^{-1})

3.2. Earliness ratio (%)

Soil and foliar humic+fulvic acid applications and soil×foliar humic+fulvic acid interactions had no statistically significant effect on earliness ratio (Table 3). The result reveals that humic+fulvic acid applications have no effect on earliness ratio of cotton. Early maturity or early ripening in cotton is defined as the short vegetation period of a cultivated variety or maturation of the variety earlier than the regular harvest period of the region. Early maturation can vary depending on genetic characteristics, cultural practices and environmental stress factors. Early maturity is the end result of several growth and fruiting processes, or components, which are interrelated, and which presumably can be manipulated separately in the breeding process. The early cotton is harvested earlier, thus, the risk of early rainfalls in autumn will be low, which allows a cleaner cotton collection. The result which indicated no significant effect on cotton earliness of humic+fulvic acid applications is in accordance with the findings of Oren (2007), Basbag (2008) and Abou-Zaid et al. (2013).

3.3. Monopodial branches (no plant^{-1})

The highest number of monopodial branches at humic+fulvic acid application doses obtained in control plots (2.04 to 2.13 no. plant^{-1}). The number of monopodial branches is related to characteristics of a variety, however, excessive irrigation and fertilizer applications, wide interrow spacing and sparse planting increase the development of monopodial branches (Table 3). Damaging the crown bud further increases the development of branches. An average of 1 to 4 monopodial branches occurs in a cotton plant, and rarely, the number of monopodial branches can reach between 6 and 8. The number of monopodial branches in late developing varieties is higher than in early developing varieties. In early developing varieties, the number of monopodial branches is usually 1 or 2. However, higher number of monopodial branches is not desired in cotton cultivation due to low number of bolls and delay in maturation. In addition, the fiber yield and fiber properties of the bolls formed in the monopodial branches remain low when a cotton plant produces higher number of monopodial branches. The number of monopodial branches decreased in foliar humic+fulvic acid applications, especially at 375 g ha^{-1} treatment. In addition, the number of monopodial branches in the control plots was higher compared to the interactions, which shows that the humic+fulvic acid applications reduce the number of monopodial branches (Table 3).

Table 3. Means and groups of main (Soil Applications), sub variables (Foliar Applications) and interactions (SAxFA) for seed cotton yield (kg ha^{-1}), earliness ratio (%), monopodial branches (no plant^{-1}), sympodial branches (no plant^{-1}) and number of bolls (no plant^{-1})

Treatments		Seed cotton yield (kg ha^{-1})	Earliness ratio (%)	Monopodial branches (no plant^{-1})	Sympodial branches (no plant^{-1})	Number of bolls (no plant^{-1})
Soil applications						
0		4108.86 c*	86.00^{ns}	2.13 a*	11.09 c*	13.66 b*
1000 g		3990.92 d	86.00	2.08 ab	11.97 a	15.82 a
2000 g		4886.16 a	86.67	1.93 c	11.82 a	15.73 a
3000 g		4376.68 b	86.33	2.04 b	11.60 b	15.93 a
Foliar applications						
0		4325.38 b	86.17	2.04 ab	11.71ab	15.73 a
125 g		4431.40 a	86.17	2.07 a	11.82 a	15.58 ab
250 g		4245.53 c	86.08	2.09 a	11.58 b	15.35 b
375 g		4360.30 b	86.58	1.98 b	11.37 c	14.47 c
Interactions						
0	0	4552.57 de	85.67	2.27 a	11.03 h	15.60 def
	125 g	4313.47 g	85.67	2.27 a	11.23 gh	13.07 j
	250 g	3922.60 i	86.00	2.13 abc	11.00 h	13.73 ij
	375 g	3646.80 j	86.67	1.87 ef	11.10 h	12.23 k
1000 g	0	3894.83 i	85.67	1.97 cde	12.27 ab	17.40 a
	125 g	4061.93 h	86.33	2.23 ab	12.63 a	16.73 ab
	250 g	3861.10 i	85.33	2.07bcd	11.67 def	14.97 fg
	375 g	4145.80 h	86.67	2.03 cde	11.30 fgh	14.17 hi
2000 g	0	4457.33 ef	86.67	1.97 cde	11.70 cdef	14.57 gh
	125 g	4711.30 c	86.00	1.73 f	11.73 cde	16.23 bcd
	250 g	5334.33 a	87.00	1.93 de	12.10 bc	16.33 bcd
	375 g	5041.67 b	87.00	2.07 bcd	11.73 cde	15.77 cde
3000 g	0	4396.80 fg	86.67	1.97 cde	11.83cd	15.37 ef
	125 g	4638.90 cd	86.67	2.03 cde	11.67 def	16.27 bcd
	250 g	3864.10 i	86.00	2.23 ab	11.57 d-g	16.37 bc
	375 g	4606.93 cd	86.00	1.93 de	11.33 e-h	15.70 cdef
CV %		10.55	1.11	7.68	4.00	9.10
F Values						
SA		1113.40**	1.52^{ns}	25.11**	91.82**	246.89**
FA		42.91**	0.76^{ns}	8.21**	23.46**	67.03**
SA x FA		258.66**	0.94^{ns}	20.64**	15.56**	68.50**

*($p \leq 0.05$), ** ($p \leq 0.01$), ns: non-significant

3.4. Sympodial branches (no plant^{-1})

The highest number of sympodial branches at humic+fulvic acid application doses was obtained in 1000 and 2000 g ha^{-1} soil (11.97 and 11.82 no plant^{-1}) and 125 g ha^{-1} foliar (11.82 no plant^{-1}) treatments. In addition, the highest number of sympodial branches in soil×foliar interaction was obtained in 1000 g ha^{-1} soil×125 g ha^{-1} foliar interaction (Table 3). Monopodial branches are formed from the development of the central bud, and sympodial branches are formed from the development of the other side buds of the cotton plants. The number of sympodial branches varies between 12 and 20 depending on the genetic structure of the variety, genotype and environmental conditions. The first sympodial branch in cotton plants usually occurs on the main stem at 6th or 7th nodes. However, the place of the first branch may change depending on temperature, plant density, plant nutrition practices, stress, and genetics of the variety. In this study, the number of sympodial branches increased in humic+fulvic acid application compared to the control. Similar findings have been noted by Seadh et al. (2012), Abou-Zaid et al. (2013), Ahmed et al. (2013) and Moosavi (2020).

3.5. Number of bolls (no plant^{-1})

The lowest number of bolls in soil humic+fulvic acid applications was obtained in the control plot (13.66 no plant^{-1}), while all other treatments with high value were placed in the a statistical group (15.73, 15.82 and 15.93 no plant^{-1}). The highest number of bolls in foliar application doses was obtained in control plots (15.73 no plant^{-1}). In addition, the highest number of bolls in soil×foliar interaction was obtained in 1000 g ha^{-1} soil×control foliar (17.40 no plant^{-1}) treatment and followed 1000 g ha^{-1} soil×125 g ha^{-1} (Table 3). The results showed that soil humic + fulvic acid applications increased the number of bolls compared to the control, while foliar applications decreased the number of bolls. High number of bolls and high weight of bolls are necessary to obtain high yield (Çeçen ve Karademir, 2021). Boll of production in cotton varies depending on the environment, variety and management practices. Cotton yield is a function of the number of bolls, boll size, and lint percentage (Worley et al., 1976; Ritchie et al., 2009). Similar findings indicating that humic + fulvic acid applications increased the number of bolls compared to control were stated by Basbag (2008).

3.6. Seed cotton weight per boll (g)

The highest seed cotton weight per boll in humic+fulvic acid applications was recorded in 2000 g ha^{-1} soil (5.04 g) and 125 g ha^{-1} foliar (4.99) treatments. In addition, the highest seed cotton weight per boll in soil×foliar humic+fulvic acid application interactions was obtained in 2000 g ha^{-1} soil×125 g ha^{-1} foliar (5.22 g) and 2000 g ha^{-1} soil×250 g ha^{-1} foliar (5.13 g) interactions (Table 4). Cotton yield is calculated by multiplying the number of plants per unit area and the number of bolls per plant by the average seed cotton weight per boll. In commercial varieties, the boll weight varies between 3.0 g and 10.0 g, and the seed cotton weight per boll can be between 2.0 g and 8.0 g and an average of 4.5 to 7.0 g, depending on years, genotypes and the growth period of the bolls (Leffler and Tubertini, 1976). Similar findings indicating that humic+fulvic acid applications increased the seed cotton weight per boll compared to control were reported by Oren (2007) and Abou-Zaid et al. (2013).

3.7. Plant height (cm)

The highest plant height was obtained in 2000 g ha^{-1} soil (81.78 cm) and 125 g ha^{-1} foliar (79.69 cm) humic+fulvic acid applications. In addition, the highest plant height in the interactions of soil×leaf humic+fulvic acid application interactions were obtained in control plots (Table 4). The number and the length of the internodes, which determine the plant height, are affected by agricultural, genetic and environmental factors such as soil type, moisture, nutrients, pests and diseases, as well as the variety. The main body of a cotton plant is upright, and carries true leaves and branches. The application of 2000 g ha^{-1} humic+fulvic acid from soil and 125 g ha^{-1} from foliar increased the plant height, while the plant height was shortened with the application of both. The findings indicating an increase in plant height with the application of humic+fulvic acid have been also reported by Atak et al. (2004), Basbag (2008), Seadh et al. (2012), Abou-Zaid et al. (2013) and Moosavi (2020).

3.8. Ginning outturn (%)

Soil humic+fulvic acid applications decreased the ginning outturn and the highest ginning outturn was obtained from the control plots (44.63%). In foliar application, the highest ginning outturn was obtained from 125 g (44.44%) and 250 g (44.54%) treatments. The highest ginning outturn in the soil×foliar humic+fulvic acid application treatments was recorded in 2000 g ha^{-1} soil×250 g ha^{-1} foliar (45.60%) treatment (Table 4). Ginning outturn refers to the ratio of fiber obtained from seed cotton per unit weight. Although this feature is hereditary, it may vary depending on growing and environmental conditions.

Table 4. Means and groups of main (Soil Applications), sub variables (Foliar Applications) and interactions (SAxFA) for seed cotton weight per boll (g), plant height (cm), ginning outturn (%), seed index (g) and lint index (g)

Treatments Soil applications		Seed cotton weight per boll (g)	Plant height (cm)	Ginning outturn (%)	Seed index (g)	Lint index (g)
0		4.71 c*	75.53 c*	44.63 a*	8.50 c*	6.85 b*
1000 g		4.82 b	77.49 b	43.80 d	8.58 b	6.69 c
2000 g		5.04 a	81.78 a	44.48 b	8.68 a	6.95 a
3000 g		4.77 b	77.78 b	44.25 c	8.61 b	6.84 b
Foliar applications						
0		4.80 b	77.73 b	44.14 b	8.63 a	6.82 b
125 g		4.99 a	79.69 a	44.44 a	8.61 ab	6.88 a
250 g		4.82 b	78.03 b	44.54 a	8.58 bc	6.90 a
375 g		4.72 c	77.13 c	44.04 b	8.55 c	6.73 c
Interactions						
0	0	4.91 c	85.63 a	43.75 fg	8.59 cde	6.68 g
	125 g	4.67 ef	83.13 b	45.00 b	8.38g	6.86 def
	250 g	4.75 def	81.20 c	44.94 b	8.58 cde	7.00 bcd
	375 g	4.49 g	80.87 c	44.84 b	8.45 fg	6.87 def
1000 g	0	4.74 def	80.03 cd	44.02 def	8.56 def	6.73 fg
	125 g	4.94 c	78.97 de	44.03 def	8.65 cd	6.80 efg
	250 g	4.80 cde	78.93 de	43.94 efg	8.62 cd	6.76 fg
	375 g	4.80 cde	77.73 ef	43.22 h	8.48 efg	6.45 i
2000 g	0	4.84cd	77.43 ef	44.04 def	8.56 def	6.74fg
	125 g	5.22 a	77.13 fg	44.28 cd	8.62 cd	6.85 ef
	250 g	5.13 a	77.03 fg	45.60 a	8.70 bc	7.29 a
	375 g	4.96 bc	76.33 fgh	44.01 def	8.83 a	6.94 cde
3000 g	0	4.72 def	75.50 gh	44.76 b	8.79 ab	7.12 b
	125 g	5.12 ab	74.80 hi	44.44 c	8.79 ab	7.03 bc
	250 g	4.67 fg	73.57 ij	43.69 g	8.42 g	6.53 hi
	375 g	4.67 fg	72.03 j	44.09 de	8.44 fg	6.66gh
CV %		4.22	4.44	1.34	1.61	3.12
F Values						
SA		94.20**	290.98**	169.60**	39.94**	63.06**
FA		56.66**	50.95**	73.45**	8.88**	31.02**
SA x FA		27.83**	104.59**	114.56**	40.92**	68.36**

*(p≤0.05), ** (p≤0.01), ns: non-significant

Findings indicating that humic+fulvic acid applications did not significantly affect the ginning outturn compared to the control have been reported by Basbag (2008), Temiz et al. (2009) and Abou-Zaid et al. (2013). In contrast to our findings, Ahmed et al. (2013) reported a significant decrease in ginning outturn with the humic+fulvic acid applications.

3.9. Seed index (g)

The highest mean seed index was obtained in soil 2000 g (8.68 g), while in foliar application in control treatment (8.63 g). In addition, the highest seed index in the soil×foliar interaction (8.83 g) was recorded in the interaction of 2000 g ha^{-1} soil and 375 g ha^{-1} foliar treatment (Table 4). Seed weight can vary with management practices applied and the maturation degree of a seed or environmental conditions. The seed index indicates that the seeds are mature and of good quality. The emergence rates of large seeds with low weight or low specific gravity may also be low. The seed index in cotton may vary with genotypes, species and delinting processes. The seed index in cotton varieties of the *Gossypium hirsutum* L. mostly varies between 8 and 13 g. Heavy seeds or seeds with high density both emerge from soil earlier than the light ones, total number of seedling emergence will be higher, and the seedlings will be more viable. Similar findings indicating that humic + fulvic acid application increased seed index compared to control have been noted by Oren (2007) and Abou-Zaid et al. (2013).

3.10. Lint index (g)

The highest lint index in soil humic+fulvic acid applications was obtained from 2000 g ha^{-1} (6.95 g) dose, and the highest lint index in foliar applications was recorded in 125 and 250 g ha^{-1} (6.88 and 6.90 g) doses. Lint index is a measure of the number or weight of fibers on a seed (Table 4). The number of fibers on a seed is a hereditary character, however, it varies with the environmental conditions. The number of fibers on a seed varies between 3000 and 20000 depending on the species. The highest seed index in soil x foliar interactions was recorded in 2000 g ha^{-1} soil×250 g ha^{-1} foliar interaction. The results revealed that humic+fulvic acid applications increase the lint index compared to the control.

4. Conclusion

Farmers use excessive amounts of chemical fertilizers to increase product quality and quantity. Excess fertilizer application degrades soil structure and causes an increase in production costs. The ability of humic+fulvic acid to chelate will prevent nutrient losses and cause a decrease in the amount of fertilizers applied. Thus, the use of humic + fulvic acid can make a great contribution to the agricultural economy. Studies conducted recently have focused on eliminating the negative effects of stress factors such as drought, salinity and toxic contents of elements, as well as the growth and development of crops using various forms of humic+fulvic acid. The studies have revealed that appropriate doses of humic+fulvic acid can be an important supporter in combating stress factors such as drought and salinity reducing crop productivity, especially when used in horticulture and field crops, and reducing the toxic effects of contaminated soils on some plants (Akinci, 2011). The results revealed that the seed cotton yield varied between 3647 and 5334 kg ha^{-1}, and except for earliness ratio, soil, foliar and soil×foliar applications had a statistically significant effect on all the properties examined. The highest seed cotton yield, seed cotton weight per boll, ginning outturn and lint index were obtained from the interaction of 2000 g ha^{-1} soil×250 g ha^{-1} foliar humic+fulvic acid application. The highest number of sympodial branches was recorded in 1000 g ha^{-1} soil×125 g ha^{-1} foliar humic+fulvic acid interaction, while the highest seed index was obtained from the interaction of 2000 g ha^{-1} soil x 375 g ha^{-1} foliar application. The results concluded that humic + fulvic acid application had no significant effect on earliness ratio. The number of monopodial branches and plant height in humic + fulvic acid applications were lower compared to the control treatment. However, the number of bolls per plant increased with humic + fulvic acid applications. The results indicated that recommended humic + fulvic acid only for soil application is 2000 g ha^{-1}, only for foliar application is 125 g ha^{-1}, and both for soil and foliar application is 2000 g ha^{-1} soil×250 g ha^{-1}.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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