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Research Article

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Investigation of the Effects of Different Plant Activators on the Plant Growth of Cotton (*Gossypium hirsutum* L.)

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Abstract The use of plant activators for sustainable agriculture is increasing day by day. Plant activators activate the all-defense mechanism of plants approximately one week after application. This study was conducted to determine the effects of five plant activators with different contents (auxiGRO, Green Miracle, Maxicrop, ProAct Plus and Sojall Vitanal) on physiological properties such as plant height (cm), plant wet weight (g), root length (cm) and root wet weight (g) of late maturing Carmen and early maturing Acala SJ2 cotton cultivars. *In vivo* experiment was carried out with five replicates depending on a completely randomized plots design. Plant activator applications were started 35-40 days after seed sowing and foliar applications were made 3 times at 7 days intervals. Plastic pots sprayed only with sterile destile water were used as a control. In Carmen cultivar (cv), auxiGRO gave the best results in plant height (22.06 cm), ProAct Plus in plant wet weight (7.02 g) and root length (24.40 cm), ProAct Plus and Sojall Vitanal in root wet weight (1.45 g and 1.41 g). The plant activators were statistically in the same group for plant height, plant wet weight and root wet weight in cv Acala SJ2 and ProAct Plus (23.56 cm) showed the highest effect on root length. In the meantime, it would be useful to conduct field trials with the plant activators ProAct Plus (harpin protein), Sojall Vitanal (*Lactobacillus acidophilus*) and auxiGRO (GABA+29.2% L-Glutamic acid), which showed the highest efficacy, in terms of application frequency, application time and phytotoxic effects.

Keywords Plant activator, plant growth, sustainable agriculture, cotton

1. Introduction

Cotton is a plant of the genus *Gossypium* in the family Malvaceae, order Malvales. Cotton is an industrial plant that provides raw materials for about 50 industries [1]. In terms of cotton processing, it is the raw material of the ginning industry, the textile industry with its fiber, the oil and feed industry with its kernel, and the paper industry with its linter [2, 3]. Cotton oil is also increasingly used as a raw material for biodiesel production [4]. Upland cotton (*Gossypium hirsutum* L.) ranks first in world production and accounts for 90% of world cotton production [5]. Therefore, 99.5% of Turkey's cotton is *G. hirsutum* L. species cotton [6].

The world's top cotton producing countries are China, India, USA, Brazil, Pakistan, Uzbekistan, Turkey, Argentina, Burkina Faso and Benin. While 90% of the world fiber cotton import value is realized by China, Vietnam, Bangladesh, Turkey, Pakistan, Indonesia, India, Thailand, Malaysia and Korea, 89% of the world fiber cotton export value is realized by USA, Brazil, India, Greece, Benin, Australia, Burkina Faso, Egypt, Turkey and Uzbekistan [7]. Turkey ranks sixth in the world in terms of cotton production and eleventh in terms of cotton cultivation area. It is the second country in terms of fiber yield obtained from unit area and the sixth

country in cotton imports [8]. In Turkey, cotton is cultivated on a total area of 477 thousand ha in four main regions (Southeastern Anatolia, Aegean, Çukurova, and Antalya) and yielding 2.2 million tons of seed cotton yield [9].

Abiotic (salinity, drought, high temperature, radiation, or frost, etc.) and biotic (pathogen, competition with other organisms, etc.) stress factors cause changes in the physiological functions of cotton plants. These stresses reduce the biosynthetic capacity of plants, alter their normal functions and cause plant death [10]. By using plant activators, it is aimed to strengthen the defense mechanism of plants and to grow plants in a healthy way from planting to harvest. Plant activators are defined as "substances that activate the natural defense systems of plants, enable them to make better use of nutrients, help to protect them from stress conditions and similar external factors and factors, and have natural and/or chemical strengthening, resistance-enhancing, soil structure-regulating properties that positively affect yield and product quality and have one or more of these properties together" [11].

Gamma amino butyric acid (GABA) regulates mineral uptake in plants, accelerates photosynthesis and increases plant disease resistance [12]. *Ascophyllum nodosum* seaweed is successfully used in many parts of the world to increase yield and quality in agriculture and to improve soil structure. When seaweed stays in the soil for a long time, it is easily broken down by natural conditions and abundant nitrogen and calcium are released. It also contains trace elements magnesium, manganese, boron, iron, zinc and copper [13]. Harpin protein stimulates plant growth, reproduction and defense systems. Harpin application increases root development, leaf biomass, flowering and fruit formation. The photosynthetic activity and nutrient storage level of the plant increases [14]. *Lactobacillus acidophilus* activates enzymes in respiration, photosynthesis, nitrogen utilization and protein synthesis [15].

In this study, it was aimed to determine the effects of five commercially licensed plant activators (auxiGRO, Green Miracle, Maxicrop, ProAct Plus and Sojall Vitanal) on physiological properties such as plant height (cm), plant wet weight (g), root length (cm) and root wet weight (g) in Carmen and Acala SJ2 cotton cultivars.

2. Materials and Methods

Plant materials and plant activators

In the study, late maturing Carmen [16] and early maturing Acala SJ2 [17] upland cotton cultivars (*G. hirsutum* L.) were used as plant material. The contents and doses of commercially licensed plant activators used in the experiment conducted under *in vivo* conditions are given in Table 1.

Table 1: Basic data of plant activators used in the experiment

Brand name	Company	Active ingredients	Formulation	Dose (100 l water)
auxiGRO	Boyut Foreign Trade Inc.	29.2% gamma aminobutryric acid (GABA)+ 29.2% l-Glutamic acid	WP	30 g
Green Miracle	Agrobest	80% vegetable fatty acid	EC	200 ml
Maxicrop	Valagro	*Ascophyllum nodosum* seaweed	WP	30 g
ProAct Plus	AMC-TR	Harpin protein 0.6%+am	WG	10 g
Sojall Vitanal	Adana Nature Organic Farming	*Lactobacillus acidophilus*	EC	60 ml

Determination of the effects of plant activators on plant growth in a pot experiment

Delinted fungicide-free cotton seeds of Carmen and Acala SJ2 cultivars were sown four per plastic pot (10 cm diameter) containing an autoclaved soil–sand–peat (1:1:1) mixture. Then, when the cotton seedlings reached the cotyledon stage, thinning was performed, and two seedling was left in each plastic pot. These plants were grown in the plant growth room for 35-40 days. Then, cotton plants were sprayed with the doses of plant activators given in Table 1 as the first application (Figure 1). The second application was made seven days after the first application and the third application was made fourteen days later at the same doses. Plastic pots sprayed only with sterile destile water were used as a control. One week after the third application, plant height (cm above the soil) and root length (cm) of Carmen and Acala SJ2 cotton cultivars were measured with a ruler and plant wet

weight (g) and root wet weight (g) were weighed with a digital precision libra (Figure 2). The pot experiment was performed with five replicates in a fully randomized parcels design. (Figure 3).

Figure 1: Spraying of plant activators on cotton cultivars.

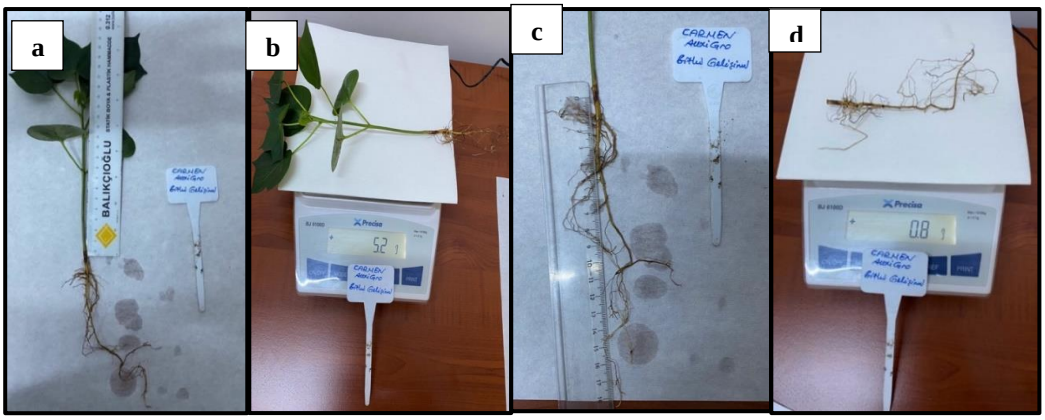

Figure 2: In cotton plants treated with plant activators; (a) plant height, (b) plant wet weight, (c) root length, (d) root wet weight counts.

Figure 3: View of cotton plants sprayed with plant activators in the plant growth room; (a).cv Carmen, (b). cv Acala SJ2.

Statistical analysis

All statistical analyses were performed using JMP software version 13 (SAS Institute Inc., Cary, NC, USA). One-Way ANOVA (analysis of variance) was carried out to determine the effects of the treatments. The Least Significant Differences (LSD) test was used to examine the significance level (P) of 0.01 for the differences.

3. Results and Discussion

The effects of plant activators on plant growth of Carmen and Acala SJ2 cultivars are given in Table 2. In the statistical analysis of the effects of plant activators on plant height, plant wet weight, root length and root wet weight in pot trials, treatment x variety was found significant (P≤0.01). When the effects of plant activators on plant growth were evaluated separately according to cultivars, auxiGRO (22.06 cm) plant activator ranked first in cv Carmen according to plant height (Figure 4), while other plant activators were in the same group statistically. All plant activators applied in cv Acala SJ2 were found to be different from the control. According to plant wet weight, ProAct Plus (7.02 g) plant activator ranked first in cv Carmen (Figure 4.), while all plant activators sprayed in cv Acala SJ2 were found different from the control. According to root length, ProAct Plus (24.40 cm; 23.56 cm) ranked first in cv Carmen and cv Acala SJ2 (Figure 5). According to root wet weight, ProAct Plus (1.45 g) and Sojall Vitanal (1.41 g) plant activators ranked first in cv Carmen (Figure 6), while all plant activators applied in cv Acala SJ2 were in the same group compared to the control (Table 2).

Table 2: Mean values of plant growth effect of plant activators sprayed on leaves in Carmen and Acala SJ2 cultivars

Plant activators	Carmen				Acala SJ2			
	PH (cm)*	PWW (g)*	RL (cm)*	RWW (g)*	PH (cm)*	PWW (g)*	RL (cm)*	RWW (g)*
auxiGRO	22,06 a**	6,36 c	21,70 bc	1,19 b	19,44 a	6,58 a	22,00 ab	1,17 a
Green Miracle	20,73 b	6,56 bc	20,70 cd	1,21 b	20,29 a	6,83 a	22,82 ab	1,23 a
MaxiCrop	20,26 b	6,75 abc	22,40 b	1,19 b	19,12 a	6,79 a	21,10 b	1,24 a
ProAct Plus	20,72 b	7,02 a	24,40 a	1,45 a	19,35 a	6,72 a	23,56 a	1,26 a
Sojall Vitanal	20,57 b	6,96 ab	22,90 b	1,41 a	19,28 a	6,86 a	21,28 b	1,22 a
Control	19,90 b	5,44 d	19,60 d	1,00 c	17,20 b	5,54 b	19,01 c	0,95 b
CV	3,9	4,9	4,3	8,6	4,8	6,1	6,4	9,2
LSD	1,07	0,42	1,24	0,14	1,21	0,52	1,82	0,14

*Data are means of five replicates, **Means followed by different letters within a column are significantly different according to LSD test (p≤0.01), PH: Plant hight (cm), PWW: Plant wet weight (g), RL: Root lenght (cm), RWW: Root wet weight (g). CV: Coefficient of variation

In the pot experiment, plant activators sprayed on leaves had a positive effect on plant height, root length and root wet weight values of Carmen cultivar compared to Acala SJ2 cultivar. When the effects of plant activators on plant growth were evaluated separately according to the cultivars, auxiGRO (22.06 cm) plant activator ranked first in cv Carmen according to plant height, while other plant activators were in the same group statistically. In cv Acala SJ2, all plant activators applied were found to be different from the control. In terms of plant wet weight, ProAct Plus (7.02 g) plant activator was ranked first in cv Carmen, while all plant activators sprayed in cv Acala SJ2 were found different from the control. In terms of root length, ProAct Plus (24.40 cm; 23.56 cm) plant activator ranked first in Carmen and Acala SJ2 cultivars. In terms of root wet weight, ProAct Plus (1.45 g) and Sojall Vitanal (1.41 g) plant activators ranked first in cv Carmen, while all plant activators applied in cv Acala SJ2 were in different groups compared to the control (Table 2). Among the plant activators applied in the study, harpin protein, *Lactobacillus acidophilus*, GABA + L-Glutamic acid plant activators were found to stimulate plant growth especially in cv Carmen. Hunt and Ryals [18] detected that harpin protein should be used at 14-day intervals during the vegetation period with foliar applications, when sprayed on plants,

it binds to plant receptors, stimulates multiple biochemical reactions with the participation of hundreds of genes in the plant, as a result of the reaction, the defense system is activated and growth is promoted, accelerates salisilic acid (SA) and Jasmonic acid (JA) synthesis and plant growth mechanism in plants. Wright et al. [19] determined a study to determine the effect of harpin protein application on plant growth in cotton and reported that harpin protein caused an increase in plant height in cotton, but it was not statistically significant. It was reported that GABA, the active ingredient of AuxiGRO plant activator, regulates mineral uptake in plants, accelerates photosynthesis and increases plant growth [12]. Another study conducted, researchers reported that plant activators with *L. acidophilus* active ingredient contain a natural binder and nitrogen catalyst together with combinations of high-performance mineral vitamins. [15]. In other studies, similar to our findings, Bishnoi and Pavyavula [20] investigated that the effects of plant activators on yield in three tomato and two canola varieties and found that harpin protein and A-S-M increased yield by 10-13% in tomato and harpin protein (567.0 g/ha dose) increased plant height in canola varieties. Appa and Podile [21] found that application of 20 ppm harpine to seeds positively affected crop yield by increasing shoot elongation and biological efficiency in peanut by 13% and 36%, respectively. Demiraslan and Akı [22] determined that POX activity increased significantly in *Capsicum annuum* L. grossum and longum pepper cultivars according to exposure time in AuxiGro and Crop-Set applications. Zhou et al. [23] reported that the application of harpin protein significantly increased the root length and seedling weight of the mango plant. Liu et al. [24] found that higher quality and yield were obtained in harpin-treated plants and harpin proteins could potentially have many valuable agricultural applications. Dayan (2020) determined that plant activators gave better results when applied together with organic fertilizer to Matador spinach variety. The highest yield was obtained from the plot where Crop-Set and organic fertilizer were applied together.

Figure 4: (a) Effect of auxiGRO plant activator on plant height in cv Carmen, (b) Effect of ProAct Plus plant activator on plant wet weight in cv Carmen.

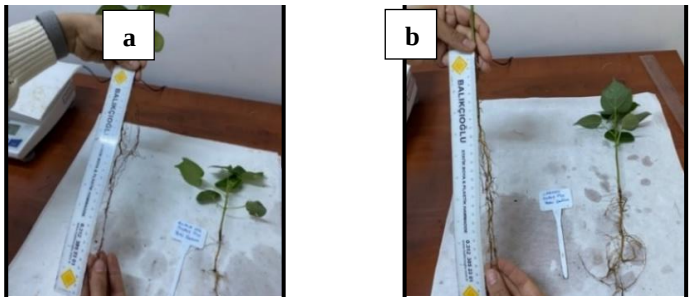

Figure 5: Effect of ProAct Plus plant activator on root length, (a) cv Acala SJ2, (b) cv Carmen.

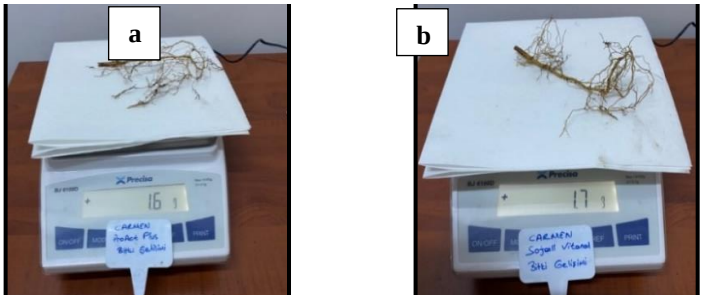

Figure 6: Effect of plant activators on root wet weight in cv Carmen; a) ProAct Plus and b) Sojall Vitanal.

4. Conclusion

In the pot experiment, the effects of plant activators applied to leaves on plant height, plant wet weight, root length and root wet weight differed among cultivars. In Carmen cultivar, GABA+29,2% L-Glutamic acid (auxiGRO) gave the best results in terms of plant height, harpin protein (ProAct Plus) in terms of plant wet weight and root length and ProAct Plus and Sojall Vitanal (*L. acidophilus*) plant activators gave the best results in terms of root wet weight. In Acala SJ2 cultivar, there was no difference between all plant activators according to plant height, plant wet weight and root wet weight and these activators were statistically in the same group. In terms of root length, the best effect was again determined in ProAct Plus (harpin protein) plant activator. However, it would be useful to conduct detailed field trials to determine the application frequency, application time and phytotoxic effects of the promising Sojall Vitanal, ProAct Plus and auxiGRO plant activators.

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