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RESPONSE OF TOMATO (*LYCOPERSICUM ESCULENTUM* L.) TO IMBIBING SEEDS BY GA3, AND FOLIAR SPRAYING BY BORON AND A-TOCOPHEROL

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ABSTRACT

This study was carried out from March to October 2021 at two different locations in Sulaimani governorate, the first location was the University of Sulaimani, College of Agricultural Engineering Sciences, and the second location located in Sulaimani, Sitak, Kani Naz, the study aimed to indicated the impact of gibberellic acid on seed germination of local tomato seeds, and evaluated the effect of foliar application of boric acid and alpha-Tocopherol (α-Tocopherol) on the vegetative growth and yield of tomato plants. The seeds were soaked in gibberellic acid at different concentrations (0 ppm, 50 ppm, and 100 ppm), and foliar spraying of boric acid at various levels (0 ppm, 15 ppm, and 30 ppm) started two weeks after transplanting. Also, another foliar applied was α-Tocopherol at different levels (0 ppm, 125 ppm, and 250 ppm) when the plants start to flowering. The results showed that gibberellic acid had a significant effect on the tomato seed germination. Additionally, the result about the interaction between all factors revealed that the interaction among (S1*B2 *E3) had a height significant ($p \leq 0.05$) role on the vegetative growth, plant height (135.000 cm), number of branches. Plant^{-1} (57.000), the highest content of boron in leaves when using (S2*B3*E1) (0.460 mg. kg^{-1}), and the highest yield. Plant^{-1} when using (S3*B2*E1) (3.187 kg). Whereas, all of the factors with all different concentrations had no significant ($p>0.05$) effect on leaf area surface in tomato plants.

KEY WORDS: Tomato, Seed, Gibberellic acid, Boric acid, α-Tocopherol .

INTRODUCTION

Tomato (*Solanum Lycopersicum* L.), belongs to Solanaceae (nightshade) family. Tomato is one of the main vegetables in world cuisine. It is essential in most foods and it also has much interest in the human body because it contains many nutrients (Abd Kadhum *et al*., 2019). Tomato is the most important vegetable crop and is considered the first rank in some countries whereas in others it will be the second in rank after potatoes (Gunawan, 2013). Tomato fruit also contains vitamins, salt, and many phytochemicals such as Lycopene, B-carotene, flavonoids, and many important nutrients (Jyoti and Pant, 2016).

The plant growth regulators (PGRs) available are often inadequate in the plant and directly responsible for the promotion, inhibition, or modification of the physiological processes. The growth is directly related to the yield(Tomar *et al.,* 2016). Gibberellic acid has a great role in the speed of seed germination. It is mostly used on seed that is difficult to germinate or that takes a long time to germinate, the physiological effect of Gibberellic acid on seed germination is stimulating the production of some messenger RNAs and then hydrolytic enzymes like amylases, lipases, and proteases (Vishal and Kumar 2018).

Boron (B) is an essential micronutrient to the growth and health of all crops. It is a component of plant cell walls and reproductive structures. It is a mobile nutrient within the soil, meaning it can move within the soil and is required in small amounts(Ashraf *et al*., 2010). The base function of boron relates to cell wall strength and development, cell division, fruit and seed development, sugar transport, and hormone development, adequate B nutrition is important for high yields and the quality of crops(Nejad and Etesami, 2020).

Tocopherol is a chemically lipophilic compounds-antioxidants belonging to the vitamin E family, they are naturally produced in green photosynthetic organisms, such as algae and all higher plants(Falk and Munné-Bosch, 2010). Tocopherol plays a vital role in adaptation to stress conditions such as drought, salinity, extreme temperature, radiation, and toxic metals(Li *et al.,* 2008). α-Tocopherol was found that leaf transpiration and respiration rate were affected significantly by the level of cellular tocopherol that effectively improved the tolerance to various stresses(Ali *et al*., 2019).

Our hypothesis is that seed germination of local tomato variety may be improved by using GA3 and plant yield and quality of yield increase by using Boron and Tocopherol, so the aim of this study was seed socked in GA3, and foliar spraying boron and α-Tocopherol for improved quality and quantity of fruit under the different climatic conditions.

MATERIALS AND METHODS

Study Location:

A field experiment was conducted from March to October 2021 at two locations in Sulaimani Governorate, Kurdistan Region- Iraq. The first location is the University of Sulaimani, College of Agricultural Engineering Sciences located on(35° 32′ 15.3" N), (45° 21′ 51.9" E) with an altitude of (732 meters above mean sea level), the first location was a greenhouse in collage, the seeds were treated by the gibberellic acid to different concentrations at (0, distilled water, 50, and100 ppm) for one hour, and after that planted in a plastic box, that the seeds grown in a greenhouse for six weeks, after that the seedling transplanted to the second location, the second location was open field experiment. The second location, located in Sulaimani, Sitak, Kani Naz, on (35°, 39′, 11.8” N), (45°, 30′, 15.3” E) with an altitude of (1046 m above sea level), by 14 km the from the center of Sulaimani.

Soil Analysis

A random sample of the studied area soil were taken before preparing the field in Sitak, Kani Naz location at depth of approximately (0-30 cm) and shown in (Table 1).

Table (1): Some chemical and physical properties of the experiment location soil.

Characteristics	Measuring Unit	Value
Ec (Electrical conductivity) 1:1	dsm^{-1}	1.6
pH 1:1		7.11
Sand		480
Silt		256
Clay		264
O.M		7.2
CaCO3	$g\ kg^{-1}$	212.1
Texture		Sandy Clay loam
Mn		18.314
Zn		22.411
Fe	ppm	99.423
S		3.14
B		0.83
N		24
P	$mg\ kg^{-1}$	3.32
K		445.22
Ca^{+2}(Calcium soluble)		3.8
Mg^{+2} (Magnesium soluble)		6.15
Na+ (sodium soluble)	meq/L^{-1}	6.27
HCO_3 (Bicarbonate soluble)		1.1
CL (soluble chlor)		21.25
K (soluble Potassium))		0.88

This analysis was done by the soil and plant Analysis Laboratory in the College of Agricultural Engineering Sciences, University of Baghdad.

Treatment and Experimental Design

Study factors:

In this study we will use three factors and their interactions as follows:

Factor 1: Gibberellic acid (Tomato seeds soaking) with 3 concentrations ((0ppm , soak with distilled water, 50, and 100 ppm) for one hours.

Factor 2: Boric acid (foliar application) with 3 concentrations (0, 15, and 30 ppm) started two weeks after transplanting, for three times with 15 days intervals.

Factor 3: α-Tocopherol (foliar application) with 3 concentrations (0, 125, and 250 ppm) started at the beginning of flowering, for two times with 15 days intervals.

Experimental design:

The experiments were arranged in a randomized completed block design (RCBD) including (27) treatments with three replications, the distance between adjacent blocks was (1m).

Plant Source

The local Tomato seeds (Sangaw (local)) (*Lycopersicum esculentum* L.) were used in this experiment, the seeds were produced by local farmers in Sulaimani, and the seeds were purchased from the local market in Sulaimani.

Seed sowing and transplants production:

In the first location in the College of Agricultural Engineering Sciences, on (March 31, 2021) the seeds were local tomato seeds (*Lycopersicum esculentum* L), and the seeds were soaked in different concentrations of gibberellic acid (0, distilled water, 50, and100 ppm) for one hour, after that the seeds sown in the greenhouse with three replicates. The seeds were sown in a plastic box, and the medium of seeds was included (pet moss and sand) (2:1), first the seeds were irrigated with the same solution when the seeds were soaked by, for a period of six times for each treatment.

The seedling was transplanted on (May 16, 2021), hardening were carried out before transplanted seedling.

Preparation of the Field and Experimental Units:

The soil was plowed and smoothed twice, the first plowing was on March $15^{th,}$ 2021, and the second plowing on May $5^{th,}$ 2021, with the plow, it was adding the fertilizer Bicarbonate sodium to the soil. The field was prepared for seedling and the field area was (249.6 m^2), the seedling was planted on one side of the row at (40 cm) apart, and (80 cm) between the rows each experimental unit contain 2 rows and each rows contain (8 plants) and each experimental unit include 16 plants.

Agricultural Processes:

All the agricultural processes used in the production of Tomato (*Lycopersicum esculentum* L.), and drip irrigation system was used in the field with eradicating the weed. Irrigation was carried out according to the need of the plant. The process of hoeing and weeding were carried out by hand tools after two weeks of transplanting. The processes of fertilization were used in two stages of plant growing, the first stage for the seedlings was used (water soluble fertilizer NPK 20-20-20) added, and the second stage for the plant when transplanted, and (Bio fertilizer) was added by foliar application for all treatments.

Laboratory Measurements:

Germination parameters:

After completing the experiment, the seeds were collected from the crops last season, the seeds were sown directly without soaking, on March 1^{st}, 2022, the seeds start germinating after three days at a temperature of 18-29°C, time was calculated until 10 days.

1. Germination percentage (GP %)(Kujur and Lal 2015).
2. Germination speed (GS)(Kurtar *et al*, 2004)
3. Mean germination time (MGT) (Kujur and Lal 2015).
4. Time to 50% germination ($T_{50)}$ (Farooq *et al.*, 2005).

Experimental Measurements:

Data was taken for five tomato plants which randomly selected from each experimental unit.

Field experiments parameter:

Data collected after 30 days after transplanting for a period of 16 weeks.

1-Plant height (cm): (Rab and Haq 2012).

2- No. of branches number.$plant^{-1}$

3- Total leaf area.$plant^{-1}$ (cm^2) (Zhang 2020).

4- Boron content % (Sun *et al.,* 2012).

Characteristics of yield Quantity:

1- Yield.$plant^{-1}$ (gm):

2- Yield.ha^{-1}(ton):

Statistical Analysis

SAS program was used to do a one-way analysis of variance (ANOVA) on the data in this investigation. Duncan's multiple range tests were used to calculate the differences between the means. The significance level was set at (P≥0.05)(Duncan 1955).

RESULT AND DISCUSSION

Data in (table 2) showed that the highest germination percentage (GP%) was shown in the seeds which is not treated (control) and treated with (50 ppm GA3) was (99.00 and 98.33%) respectively, and the lowest germination percentage in (100 pm) was (91.66%).

For germination speed (GS), the positive result recorded at concentration (50 ppm) of gibberellic acid were (23.74), however the lowest recorded at control, it was (14.55). Imbibing seeds had the positive result on seed germination energy (GE) at concentration (0 and 50 ppm) by (94.44 and 95.00 %) respectively, but the lowest at level (100 ppm) was (80.00%). Mean germination time (MGT) was observed in control was (7.31), and the lowest was showed at concentration (50 ppm and 100 ppm) were (5.71 and 5.76) respectively. For (Time to 50% of seed germination T50, data revealed that the highest data recorded in control treatment by (4.47) and the lowest was (3.43 and 3.23) when the seed treated with (50 and 100 ppm) respectively.

Moro evidence in Balaguera-López et al. (2009) was reported the best germination percentage was observed when used gibberellic acid at different concentrations (0, 300, 600, and 900 mg L^{-1}) for 36 h, the result showed the highest germination percentage at dose (900 mg L^{-1}) of gibberellic acid. This could occur because imbibition promotes the rapid activation of the pregerminative metabolic system and enzymatic auto repairing of cellular membranes while maintaining the same moisture level for a larger number of seeds(Burgass and Powell 1984).

Table (2): Impact of gibberellic acid on tomato seed germination

Factors	0 ppm	50 ppm	100 ppm
GP%	99.00a	98.33a	91.66b
GS	14.55c	23.74a	21.36b
GE(7 days)%	94.44a	95.00a	80.00b
MGT	7.31a	5.71b	5.76b
T50	4.47a	3.43b	3.23b

Different letter in the same row means significant differences (P<0.05).

Plant height (cm)

The results in the table (3), showed that treated seeds with gibberellic acid at a concentration of (0, 50, and 100 ppm) had no significant (p > 0.05) effect on plant height.//////The foliar application of boric acid was significantly (p ≤ 0.05) affected on plant height and the maximum result was recorded at concentration (30 ppm) that was (106.000 cm) and the minimum at control that was (90.111 cm).

Also, the table shows, that foliar application of α-Tocopherol had no significant (p > 0.05) effect on plants height. The same table reveals the interaction effect of soaking seeds in gibberellic acid with boric acid was a highly significant (p ≤0.05) role on increasing plant height, the maximum height recorded in plant of (S1*B3) treatments, that was (109.500 cm) and the lowest recorded in plants of (S3*B1) treatment by (74.000 cm). The interaction result of soaking seeds in gibberellic acid with spraying α-Tocopherol was significant (p ≤0.05) effect on plant height, the maximum mean recorded in plants of (S1*E1) and (S2*E2) treatments, that were (112.000 and 110.833 cm) respectively, and the minimum data was recorded in plants (S1*E2) and (S3* E1) treatments, that were (90.333 and 89.167 cm) respectively. The interaction results of the foliar application of boric acid and α-Tocopherol were a significant (p ≤0.05) effect on plant height, the highest mean recorded in plants (B2*E3) that was (120.500 cm) and the lowest recorded in plant of (B1*E3) treatment, by (82.833 cm). Additionally, the results in table 3 indicates that triple interaction among (S*B*E) factors has a significant (p ≤0.05) effect on plant height, the highest mean recorded in plants of (S1*B2*E3) treatment that was (135.000 cm), and the lowest mean was recorded in plant of (S1*B2*E2) treatment that was (65.000 cm). This study had the same result of (Shabana et al. 2015) when foliar applied of vitamin E on tomato plant at dose (20 mg/L), they had a significant effect on the plant height was (79.17 cm) compared with control was lowest (51.10 cm). This result agreed with Mushtaq et al. (2016) results, which used different level of boron (50 ppm and 100 ppm), the concentration (100 ppm) had significant effect on the plant height was (49.90 cm), while the lowest plant height were recorded at control by (45.12 cm) of tomato plant.

Additionally, boron is related to cell wall development and differentiation, which promotes the growth of shoots and increases plant height. Also the same result found by Verma et al. (2018), they foliar applied (100 ppm) of boron, had a significant effect on the plant height of tomato plant, the highest result of plant height (160.15 cm) compared with another micronutrient such us (Zn, Cu, Mo, Ca and Control) were lowest (131.83 cm) . The results show that spraying α-Tocopherol has increased vegetative growth rate and tomato component levels due to its critical role in preventing light oxidation of plastid membranes, which produces the optimum conditions for photosynthesis and stimulates metabolic product accumulation. This promotes cell elongation and growth (Munné-Bosch and Alegre 2002).

Table (3): Impact of Imbibing Tomato Seeds by GA3 on Seed Germination and Foliar Spraying of Boron and α-Tocopherol on plant height(cm)

Soaking	Boric acid	α-Tocopherol			Average of Soaking and Boric Acid	Average of Boric Acid and α-Tocopherol			Total Average of Soaking
		E1	E2	E3					
S1	B1	127.500 abc	79.000 g-j	82.000f-j	96.1167 a	B1	E1	100.667 bc	100.889 a
	B2	91.000 e-j	65.000 j	135.000 a	97.000 a		E2	86.833 cd	
	B3	117.500 a-e	127.000 a-d	84.000 f-j	109.500 a		E3	82.833 d	
Average of Soaking and α-Tocopherol		112.000 a	90.333 b	100.333 ab					
S2	B1	92.000 e-j	112.500 a-f	96.000 c-j	100.167 a	B2	E1	91.167 cd	103.722 a
	B2	92.500 e-j	130.000 ab	96.500 c-j	106.333 a		E2	99.000 bcd	
	B3	122.500 a-e	90.000 e-j	101.500 b-i	104.667 a		E3	120.500 a	
Average of Soaking and α-Tocopherol		102.333 ab	110.833 a	98.000 ab					
S3	B1	82.500 f-j	69.000 ij	70.500 h-j	74.000 b	B3	E1	111.667 ab	95.056 a
	B2	90.000 e-j	102.000 b-h	130.000 ab	107.333 a		E2	109.833 ab	
	B3	95.000 d-j	112.500 a-f	104.000 b-g	103.833 a		E3	96.500 bcd	
Average of Soaking and α-Tocopherol		89.167 b	94.500 ab	102.500 ab					
Total Average of α-Tocopherol		E1	E2	E3					
		101.167 a	98.556 a	99.944 a					
Total Average of Boric Acid		B1	B2	B3					
		90.111 b	103.556 a	106.000 a					

The averages with identical letters (same cells color) are not significantly different (P>0.05) between them

Branches number. plant^{-1}

The result in table (4), were indicated that the seeds were imbibed in gibberellic acid at (0, 50, and 100 ppm) concentration had a significant ($p \leq 0.05$) positive effect on the number of branches per plant. The highest number recorded in plant treated with (50 ppm), that was (42.611 branches. plant^{-1}), also the lowest number recorded in plant treated with (100 ppm) concentration of GA_3, was (34.444 branches. plant^{-1}). In the same table, the result appeared that foliar application of boric acid were a significant ($p \leq 0.05$) positive effect on the branches number per plant on a tomato plants, the highest result recorded that plant treated with (30 ppm) concentration was (42.000 branches. plant^{-1}), also the lowest number recorded at (control) level was (35.722 branches. plant^{-1}). α-Tocopherol foliar application, had a significant ($p \leq 0.05$) negative role on number of branches per plant, that highest number recorded at control treatment was (43.833 branches. plant^{-1}), while the lowest number recorded on plant treated with (125 ppm and 250 ppm) concentrations, were (37.056 and 36.500 branches. plant^{-1}) respectively.

The interaction between soaking in gibberellic acid and foliar application of boric acid (S*B) has a significant ($p \leq 0.05$) positive effect on the number of branches per plant on the tomato plant. The interaction of (S1*B3) recorded highest branches. plant^{-1} was (44.833 branches. plant^{-1}), the lowest results recorded in plant of (S3*B1) treatment was (27.833 branches. plant^{-1}). Furthermore, the result indicated that interaction of soaking in gibberellic acid and foliar application of α-Tocopherol (S*E), negatively effect on the branches number per plant. The highest result recorded in plant that not treated (control) which gave (46.167 branches. plant^{-1}), and the lowest result recorded in plant of (S3*E3) treatment, that was (31.333 branches. plant^{-1}). In addition, the result of interaction of Boric acid and α-Tocopherol (B*E) was a significantly ($p \leq 0.05$) positive role on the branches number on tomato plant, the highest result recorded in plant of (B3*E1) treatment, that was (50.667 branches. plant^{-1}), while the lowest numbers recorded in plants of (B3*E3) treatment, that was (32.833 branches. plant^{-1}). In the same table the result revealed that interaction among soaking in gibberellic acid and foliar application of boric acid and α-Tocopherol (S*B*E) has positive effect on the branches number per plant, the highest result found in plants of (S1*B2*E3) treatment by (57.000 branches. plant^{-1}). However, the lowest number recorded in plant of (S3*B1*E3) treatment, that was (22.000 branches. plant^{-1}).

This result agreed with Rab and Haq (2012), that using different level of boric acid (0.2% and 0.4%), the two levels affected significantly on the number of branches, (6.41 branches .plant $^{-1}$) and the lowest recorded at control (5.37 branches. plant $^{-1}$) of tomato plant.

Boron enhanced tomato plant height and number of branch by stimulating root growth, which improves nutrient absorption (Under et al. 2021). The calcium and boron combinations were more efficient than solitary treatment in raising the number of branches per plant because boron promotes calcium metabolism, especially in the cell wall(Asad et al. 2003).

Our results agreed with AL Katia and ALMharib (2020) results, which found that foliar applied of α-Tocopherol at (0, 100mg.L^{-1} , and 200 mg.L^{-1}), significantly effect on the branches number of tomato plant, the highest number recorded at dose (200 mg.L^{-1}) α-Tocopherol (14.14 branches. plant $^{-1}$), and the lowest at control (11.78 branches. plant $^{-1}$). α-Tocopherol stimulates physiological processes, cell elongation and division, and higher vegetative development(El-Tohamy, 2007). α-Tocopherol works to prevent increased free radicals (ROS) in the plant, by removing the roots of the proxy Thyloquide membranes in the cell that keep the integrity and carry out vital plant activities(Orabi *et al.*, 2015).

Total leaf area per. plant^{-1} (cm^2)

The data result appears in table (5), explain that treated tomato seed soaked in gibberellic acid and plants, and foliar application of tomato plants with boric acid and α-Tocopherol , also (interaction among treatments) had no significant effect ($p >$ 05) on the leaf area surface.

Boron content %

In table (6), the result revealed that soaked seeds in gibberellic acid, and foliar application of boric acid and α-Tocopherol had no significant ($p >$ 05) effect on boron content in leaves. However, the interaction between soaking in gibberellic acid and foliar application of boric acid (S*B) had significant ($p \leq 0.05$) effect on the boron content in leaves, the highest percentage recorded in plant of (S2*B3) treatment, that was (0.448 %), and the lowest percentages recorded in plant of (S2*B2) treatment, that was (0.250 %). Nevertheless, the interaction of soaking in gibberellic acid and foliar application of α-Tocopherol (S*E),also the interaction between Boric acid and α-Tocopherol (B*E) had no significant effect on boron content in leaves, but interaction among soaking in gibberellic acid and foliar application of boric acid and α-Tocopherol (S*B*E) had a significant ($p \leq 0.05$) effect on boron content in leaves. The highest percentage recorded in (S2*B3*E1) treatment, that was (0.460 %), and the lowest percentage recorded in (S1*B3*E1) treatment, which was (0.200 %).

Table (4): Impact of Imbibing Tomato Seeds by GA3 on Seed Germination and Foliar Spraying of Boron and α-Tocopherol on branches number per. plant $^{-1}$

Soaking	Boric acid	α-Tocopherol			Average of Soaking and Boric Acid	Average of Boric Acid and α-Tocopherol			Total Average of Soaking
		E1	E2	E3					
S1	B1	43.500 a-f	31.000 e-h	32.000 d-h	35.500 bc	B1	E1	40.667 bc	40.333 a
	B2	42.500 a-f	22.500 gh	57.000 a	40.667 ab		E2	33.333 c	
	B3	52.500 ab	48.000 a-d	34.000 c-h	44.833 a		E3	33.167 c	
Average of Soaking and α-Tocopherol		46.167 a	33.833 cd	41.000 abc					
S2	B1	44.500 a-e	41.500 a-f	45.500 a-e	43.833 ab	B2	E1	40.167 bc	42.611 a
	B2	40.000 b-f	49.500 abc	35.000 c-h	41.500 ab		E2	35.333 bc	
	B3	52.000 ab	44.500 a-f	31.000 e-h	42.500 ab		E3	43.500 ab	
Average of Soaking and α-Tocopherol		45.500 ab	45.167 ab	37.167 bcd					
S3	B1	34.000 c-h	27.500 fgh	22.000 h	27.833 c	B3	E1	50.667 a	34.444 b
	B2	38.000 b-g	34.000 c-h	38.500 b-f	36.833 ab		E2	42.500 b	
	B3	47.500 a-d	35.000 c-h	33.500 c-h	38.667 ab		E3	32.833 c	
Average of Soaking and α-Tocopherol		39.833 a-d	32.167 d	31.333 d					
Total Average of α-Tocopherol		E1	E2	E3					
		43.833 a	37.056 b	36.500 b					
Total Average of Boric Acid		B1	B2	B3					
		35.722 b	39.667 ab	42.000 a					

The averages with identical letters (same cells color) are not significantly different (P>0.05) between them

Table (5): **Impact of Imbibing Tomato Seeds by GA3 on Seed Germination and Foliar Spraying of Boron and α-Tocopherol on total leaf area per.plant^{-1} (cm^2)**

Soaking	Boric acid	α-Tocopherol	Average of	Average of Boric Acid and	Total Average

		E1	E2	E3	Soaking and Boric Acid	α-Tocopherol			of Soaking
S1	B1	64.197 a	60.140 a	60.498 a	61.611 a	B1	E1	64.324 a	60.194 a
	B2	46.698 a	42.500 a	64.924 a	51.374 a		E2	52.542 a	
	B3	66.953 a	55.847 a	79.986 a	67.595 a		E3	55.209 a	
Average of Soaking and α-Tocopherol		59.283 a	52.829 a	68.469 a					
S2	B1	57.322 a	47.817 a	58.375 a	54.505 a	B2	E1	64.345 a	58.686 a
	B2	74.488	62.165 a	51.413 a	62.689 a		E2	61.647 a	
	B3	56.718 a	54.193 a	65.682 a	58.864 a		E3	54.948 a	
Average of Soaking and α-Tocopherol		62.842 a	54.725 a	58.490 a					
S3	B1	71.452 a	49.670 a	46.753 a	55.959 a	B3	E1	62.906 a	62.381 a
	B2	71.848 a	80.277 a	48.507 a	66.877 a		E2	59.374 a	
	B3	65.046 a	68.082 a	59.794 a	64.307 a		E3	68.487 a	
Average of Soaking and α-Tocopherol		69.449 a	66.009 a	51.685 a					
Total Average of α-Tocopherol		E1	E2	E3					
		63.858 a	57.854 a	59.548 a					
Total Average of Boric Acid		B1	B2	B3					
		57.358 a	60.313 a	63.589 a					

The averages with identical letters (same cells color) are not significantly different (P>0.05) between them

Table (6): Impact of Imbibing Tomato Seeds by GA3 on Seed Germination and Foliar Spraying of Boron and α-Tocopherol on boron content in leaves (%)

Soaking	Boric acid	α-Tocopherol			Average of Soaking and Boric Acid	Average of Boric Acid and α-Tocopherol			Total Average of Soaking
		E1	E2	E3					
S1	B1	0.345 a-d	0.300 a-d	0.285 a-d	0.310 bcd	B1	E1	0.342 a	0.318 a
	B2	0.405 abc	0.320 a-d	0.240 bcd	0.322 bcd		E2	0.315 a	
	B3	0.200 d	0.365 a-d	o.400 a-d	0.322 bcd		E3	0.297 a	
Average of Soaking and α-Tocopherol		0.317 a	0.328 a	0.308 a					
S2	B1	0.390 a-d	0.335 a-d	0.395 a-d	0.373 abc	B2	E1	0.330 a	0.357 a
	B2	0.265 a-d	0.210 cd	0.275 a-d	0.250 d		E2	0.303 a	
	B3	0.460 a	0.430 ab	0.455 a	0.448 a		E3	0.322 a	
Average of Soaking and α-Tocopherol		0.372 a	0.325 a	0.375 a					
S3	B1	0.290 a-d	0.310 a-d	0.210 cd	0.270 cd	B3	E1	0.338 a	0.336 a
	B2	0.320 a-d	0.380 a-d	0.450 a	0.383 ab		E2	0.407 a	
	B3	0.355 a-d	0.425 ab	0.280 a-d	0.353 a-d		E3	0.378 a	
Average of Soaking and α-Tocopherol		0.322 a	0.372 a	0.313 a					
Total Average of α-Tocopherol		E1	E2	E3					
		0.337 a	0.342 a	0.332 a					
Total Average of Boric Acid		B1	B2	B3					
		0.318 a	0.318 a	0.374 a					

The averages with identical letters (same cells color) are not significantly different (P>0.05) between them

Yield characterizes:

Plant Yield (kg. plant^{-1})

The result in table (7), explain that soaking seeds tomato in different levels of gibberellic acid (0, 50, and 100 ppm) had no significant (p > 05) effect on the tomato yield. plant^{-1}. Whereas, the foliar application of boric acid at different concentration (0, 15, 30 ppm) had significant ($p \leq 0.05$) effect on yield of tomato. The maximum result recorded in plants sprayed with (B2), that was (2.019 kg. plant^{-1}), and the minimum result in plant of (control) recorded was (1.506 kg. plant^{-1}). In the same table, the data declare that foliar application of α-Tocopherol had no significant (p > 05) effect on yield of tomato of one plant. However, the interaction of soaking in gibberellic acid and foliar application of boric acid (S*B) had a significant ($p \leq 0.05$) positive role on yield of tomato plant. The highest yield registered in plant of (S3*B2) treatment, that was (2.506 kg. plant^{-1}), while the lowest weight registered in plant of (S3*B1) treatment, that was (0.792 kg. plant^{-1}). In addition, interaction between seed soaking in gibberellic acid and foliar application of α-Tocopherol (S*E) had a significant ($p \leq 0.05$) impact on yield of plant, the highest weight registered in plant of (S2*E2) treatment, that was (2.544 kg. plant^{-1}), and the lowest recorded in plant of (S1*E2) treatment (1.009 kg. plant^{-1}). Additionally, interaction among soaking seeds in gibberellic acid and foliar application of boric acid and α-Tocopherol (S*B*E) had a significant ($p \leq 0.05$) impact on the yield of tomato plant, the maximum weight recorded in plant of (S3*B2*E3) treatment, that was (3.187 kg. plant^{-1}), and the lowest weight showed in plant of (S1*B2*E2) treatment, that was (0.0 kg. plant^{-1}). In Pandiyan et al. (2018) study, foliar applied (100 ppm) of boric acid, effect in yield of tomato plant, that was (2.07 kg. plant^{-1}) compared with another micronutrient and control were lowest (1.03 kg. plant^{-1}). Increased yield due to boron application and may be attributed to enhanced photosynthesis activity and increased production and accumulation of carbohydrates and favorable impact on vegetative growth, flowers and fruits, which increased number of fruits per plant in addition to increasing the size(Kavya et al. 2021). Additionally, α-Tocopherol functions as an antioxidant and protects cellular membranes to ensure that metabolic processes are carried out properly, promotes the representation of carbon, stimulates the accumulation of metabolism and carbohydrates, increases storage in fruits, and works to prevent plant tissues from harmful oxygen derivatives that interfere with the efficiency of numerous enzymes(Shao *et al.*, 2007).

Table (7): Impact of Imbibing Tomato Seeds by GA3 on Seed Germination and Foliar Spraying of Boron and α-Tocopherol on yield. plant^{-1}(kg)

Soaking	Boric acid	α-Tocopherol			Average of Soaking and Boric Acid	Average of Boric Acid and α-Tocopherol			Total Average of Soaking
		E1	E2	E3					
S1	B1	2.507 ab	1.069 b-e	1.478 a-e	1.685 abc	B1	E1	1.085 a	1.679 a
	B2	2.223 abc	0.000 e	2.271 abc	1.498 bc		E2	1.397 ab	
	B3	2.082 a-d	1.957 a-d	1.524 a-e	1.854 ab		E3	1.035 b	
Average of Soaking and α-Tocopherol		2.270 a	1.009 b	1.758 ab					
S2	B1	2.397 ab	2.704 ab	1.024 b-e	2.042 ab	B2	E1	2.235 a	1.927 a
	B2	2.532 ab	2.602 ab	1.025 b-e	2.053 ab		E2	1.660 ab	
	B3	1.484 a-e	2.357 ab	1.220 b-e	1.687 abc		E3	2.161 a	
Average of Soaking and α-Tocopherol		2.138 a	2.554 a	1.090 b					
S3	B1	1.352 b-e	0.420 de	0.603 cde	0.792 c	B3	E1	1.783 ab	1.746 a
	B2	1.952 a-d	2.378 ab	3.187 a	2.506 a		E2	2.156 a	
	B3	1.784 a-d	2.154 a-d	1.880 a-d	1.939 ab		E3	1.542 ab	
Average of Soaking and α-Tocopherol		1.696 ab	1.651 ab	1.890 ab					
Total Average of α-Tocopherol		E1	E2	E3					
		2.035 a	1.738 a	1.579 a					
Total Average of Boric Acid		B1	B2	B3					
		1.506 b	2.019 a	1.827 ab					

The averages with identical letters (same cells color) are not significantly different (P>0.05) between them

Yield. ha^{-1}(ton)

The result illustrated in table (8), show the yield .hectare (ton), in this table the averages indicated that soaking seed (S) with Gibberellic acid and Foliar spraying with α-Tocopherol (E) had no significant ($p > 05$) effect on the yield $hectare^{-1}$. However, the Foliar spraying with Boron (B), had a significant effect ($p \leq 0.05$) on the yield $hectare^{-1}$, the maximum yield by (B2) treatment, that was (63.089 t ha^{-1}), while the minimum yield on plant of (B1) treatment, which gave (47.066 t ha^{-1}). Additionally, the interaction between (S*B) factors had a significant ($p \leq 0.05$) impact on the yield $hectare^{-1}$, the maximum yield recorded by (S3*B2) plants, which was (78.309 t ha^{-1}), while the minimum yield recorded by (S3*B1) plants, was (24.743 t. ha^{-1}). Furthermore, the interaction between (S*E) factors had a significant ($p \leq 0.05$) effect on yield $hectare^{-1}$, the highest yield recorded by (S2*E2) plants by (79.826 t ha^{-1}), in contrast the minimum yield recorded by (S1*E2) plants which gave (31.521 t ha^{-1}). Moreover, the interaction between (B*E) factors had a significant ($p \leq 0.05$) positive role on the yield $hectare^{-1}$, the highest yield recorded by the plants of (B2*E1) which was (69.865 t ha^{-1}), while the lowest yield by (B1*E3) plants which was (32.351 t ha^{-1}). Also, the interaction (S*B*E) factors, had a significant ($p \leq 0.05$) positive role on the yield $hectare^{-1}$, the maximum yield recorded on (S3*B2*E3) treatment plant by (99.604 t ha^{-1}), while the minimum yield recorded on (S1*B2*E2) plants by (10.788 t ha^{-1}).

Table (8): Impact of Soaking Tomato Seeds by GA3 on Seed Germination and Foliar Spraying of Boron and α-Tocopherol on yield. ha^{-1}(ton) of Tomato

Soaking	Boric acid	α-Tocopherol			Average of Soaking and Boric Acid	Average of Boric Acid and α-Tocopherol			Total Average of Soaking
		E1	E2	E3					
S1	B1	78.344 ab	33.406 b-e	46.198 a-e	52.733 abc	B1	E1	65.170 a	52.469 a
	B2	69.469 abc	10.788 e	70.958 abc	46.809 bc		E2	43.677 ab	
	B3	65.062 a-d	61.156 a-d	47.625 a-e	57.948 ab		E3	32.351 b	
Average of Soaking and α-Tocopherol		70.958 a	31.527 b	54.927 ab					
S2	B1	74.917 ab	84.500 ab	32.000 b-e	63.806 ab	B2	E1	69.865 a	60.229 a
	B2	79.115 ab	81.313 ab	32.021 b-e	64.149 ab		E2	51.875 ab	
	B3	46.385 a-e	73.667 ab	38.146 b-e	52.733 abc		E3	67.528 a	
Average of Soaking and α-Tocopherol		66.806 a	79 826 a	34.056 b					
S3	B1	42.250 b-e	13.125 de	18.854 cde	24.743 c	B3	E1	55.7729 ab	54.551 a
	B2	61.010 a-d	74.312 ab	99.604 a	78.309 a		E2	67.378 a	
	B3	55.740 a-d	67.313 a-d	58.750 a-d	60.601 ab		E3	48.174 ab	
Average of Soaking and α-Tocopherol		53.000 ab	51.583 ab	59.069 ab					
Total Average of α-Tocopherol		E1	E2	E3					
		63.588 a	54.310 a	49.351 a					
Total Average of Boric Acid		B1	B2	B3					
		47.066 b	63.089 a	57.094 ab					

The averages with identical letters (same cells color) are not significantly different (P>0.05) between them

CONCLUSION

According to the result we can concluded that seeds imbibing in gibberellic acid in different concentrations were superior due to enhancing the germination, seed germination, and germination energy of tomato seeds. The foliar application of boric acid and α-Tocopherol has the best role on vegetative growth such as (plant height, number of branches, boron content in leaves), and the increased yield of tomato plants. All of the factors have no significant role on leaf area of tomato plants. It is evident that soaked seeds in gibberellic acid, there is no impact or no significant effect on the (plant height, branch no., boron content in leaves of tomato plants.

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کاردانەوەی خوساندنی تۆوی تەماتە Lycopersicon esculentum.L لە ترشی جبریلین دا وە پرژاندنی ڕووەکەکانی بە بۆرۆن وئەلفاتۆکۆفیرۆڵ

پوختە

ئەم توێژینەوەیە لەماوەی ئادار بۆ تشرینی دووەمی 2021 بەئەنجام گەیەنراوە لە دوو ناوچەی جیاواز سەر بە پارێزگای سلێمانی ،یەکەمیان لە زانکۆی سلێمانی، کۆلێجی زانستە ئەندازیارییە کشتوکاڵیەکان ، وە ناوچەی دووەم لە سلێمانی ،ناحیەی سیتەک دێی کانی ناز. ئامانج لەم توێژینەوەیە بۆ زانینی کاریگەری ترشی جبریلیک لەسەر چەکەرەی تۆوی چەشنی تەماتەی خۆماڵی وڕشاندنی گەڵای ڕووەکەکانی بە ترشی بۆریک و وئەلفاتۆکۆفیرۆڵ لەسەر سەوزە گەشەکردن وبەرهەمی ڕووەکی تەماتەکان ،تۆوەکان خوسێنران لە پەیتی جیاوازی ترشی جبریلیک بەبڕی (0، 50، 100 بەش لە ملیۆن) وە ڕوەکەکانیشی بە ترشی بۆریک بە بڕی جیاواز (0، 15، 30 بەش لە ملیۆن لە دوای دوو هەفتە لە شەتڵ کردن، هەروەها جۆرێکی تر لە ڕشاندن بۆ گەڵاکان کراوە بە و وئەلفاتۆکۆفیرۆڵ بەبڕی (0، 125، 150 بەش لە ملیۆن) لەگەڵ دەست کردن بە گوڵ کردن. ئەنجامەکان نیشانی دەدەن کە ترشی جبریلیک کاریگەریەکی بەرچاوی هەیە لەسەر چەکەرەی تۆو ڕووەکەکان. سەرەڕای ئەمانەش ئەنجامی تایبەت بەیەکداچونی نێوان فاکتەرەکانی (خوساندن لە پەیتی یەکەم، بۆرۆن بەپەیتی دووەم ، وئەلفاتۆکۆفیرۆڵ پەیتی سێهەم) زۆر کاریگەری بەرچاوی هەبووە لەسەر خەسڵەتەکانی سەوزە گەشە وەک بەرزی ڕوەک(135سم)، ژمارەی لقەکان بۆهەر ڕووەکێک(57.000لق) بەرزترین پێکهاتەی گەڵا لە بۆرۆن لە مامەڵەی بەیەکداچوی (خوساندن لەپەیتی دووەم،بۆرۆن پەیتی سێهەم وئەلفاتۆکۆفیرۆڵ پەیتی یەکەم) دا بریتی بووەکە(0.460ملگم.کگم-1)ە، وەبەرزترین بەرهەم بۆ ڕووەکێک لە مامەڵەی بەیەکداچوی (خوساندن لەپەیتی سێهەم ،بۆرۆن پەیتی دووەم وئەلفاتۆکۆفیرۆڵ پەیتی یەکەم) دا بووە کە(3.187کگم).لەکاتێکدا هیچ فاکتەرێک لەمانە کاریگەری نەبووە لەسەر ڕووبەری ڕووی گەڵاکان.

ووشەی دەستپێکردن : **تۆوی تەماتە، ترشی جبریلیک، ترشی بۆریک، α-Tocopherol**

استجابة الطماطة (*Lycopersicum esculentum* L) لنقع البذور بواسطة حامض الجبرليك، والرش الورقي بواسطة البورون و فيتامين اي (ألفا توكوفيرول).

الخلاصة

أجريت هذه الدراسة في الفترة من اذار إلى تشرين الاول 2021 في موقعين مختلفين في محافظة السليمانية ، الموقع الأول كان جامعة السليمانية ، كلية علوم الهندسة الزراعية ، والموقع الثاني في السليمانية ، سيتك ، كاني ناز ، هدفت الدراسة إلى معرفة تأثير حمض الجبريليك في إنبات بذور الطماطة المحلية ، وتقييم تأثير الرش الورقي لحامض البوريك وألفا توكوفيرول في النمو الخضري وإنتاجية نباتات الطماطة. تم نقع البذور في حمض الجبريليك بتركيزات مختلفة (0 جزء في المليون ، 50 جزء في المليون ، 100 جزء في المليون) ، وبدأ الرش الورقي لحامض البوريك بمستويات مختلفة (0 جزء في المليون ، 15 جزء في المليون ، 30 جزء في المليون) بعد أسبوعين من الزرع، أيضا تم تطبيق رش ورقي آخر باستخدام ألفا توكوفيرول بمستويات مختلفة (0 جزء في المليون ، 125 جزء في المليون ، 250 جزء في المليون) مع بداية التزهير. أظهرت نتائج الدراسة أن حامض الجبريليك كان له تأثير معنوي على إنبات بذور نباتات الطماطة. بالإضافة إلى ذلك ، أظهرت نتيجة التداخل بين جميع العوامل ، أن التداخل بين (النقع بالتركيز الاول، البورون بالتركيز الثاني وألفا توكوفيرول تركيز الثالث) كان له دور في التفوق المعنوي ($p \leq 0.05$) في النمو الخضري ، ارتفاع النبات (135.000 سم) ، عدد الأفرع. النبات$^{-1}$ (57.000) ، أعلى نسبة من البورون في الأوراق سجلت عند استخدام (النقع بالتركيز الثاني، البورون بالتركيز الثالث وألفا توكوفيرول التركيز الاول) (0.460 ملغم. كغم$^{-1}$) ، وأعلى محصول. نبات عند استخدام (النقع بالتركيز الثالث، البورون بالتركيز الثاني وألفا توكوفيرول تركيز الاول) (3.187 كغم). في حين أن جميع العوامل بجميع التركيزات المختلفة لم يكن لها تأثير معنوي ($p > 0.05$) على مساحة الأوراق في نباتات الطماطة.

الكلمات الرئيسية: الطماطة ، البذور ، حامض الجبريليك ، حامض البوريك ، ألفا توكوفيرول.