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EFFECT OF PLANTING DEPTHS AND FOLIAR APPLICATION WITH SALICYLIC AND GIBBERELLIC ACIDS ON PEPPER PLANTS GROWN IN ALKALINE SOIL UNDER GREENHOUSE CONDITION

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ABSTRACT: *The response of pepper plants to transplanting depths and foliar application with salicylic acid (SA) and gibberllic acid (GA) were determined under plastic greenhouse. The experiment was carried out in alkaline clay soil at Kaha Vegetable Research Station, Kalubia, Egypt, during the two successive autumn seasons of 2009/2010 & 2010/2011. Data revealed that deeper transplanting of seedling at the first true leaf or the cotyledon leaves had a greater vigor root (length and weight) which led to more rapid on vigor plant stand establishment when compared with plants that set at rootball depth (control). Transplant depth at the first true leaf followed with at the cotyledon leaves led to an increase in pepper growth in terms of plant height, number of leaves, number of branches, fresh and dry weights per plant as compared with the control. The deeper transplanting had also a positive effect on fruit quality (fruit length, fruit diameter, and fruit weight), yield (early yield, number of fruits per plant and total yield) and plant chemical contents (fruit ascorbic acid and leave NPK contents).*

Foliar application with salicylic acid (SA) and gibberellic acid (GA) had a positive effect on the vegetative growth characters, fruit quality, yield and plant chemical contents (fruit TSS and ascorbic acid contents and leave NPK contents). The maximum values of the previous characters were found in application of (GA) at 30 and 50 ppm followed by the application of (SA) at low concentration of 300 ppm when compared with non foliar application treatment (control). These results may be due to that the GA is regulates growth that has a profound effect on plant growth and fruit yield characters and due to that the SA is enhancing stress tolerance in pepper plants. At the same time, the vegetative growth characters, fruit quality, yield and plant chemical content of pepper plants grown at Kaha Station soil without foliar application of (SA) and (GA) were lowered compared with the other treatments and this due to the effect of soil salt and alkalinity stress which has adversely affect on the pepper plants growth.

The most favorable beneficial interactions between transplant depths and foliar application of SA and GA regarding the most previous growth characters were transplanting plants with seedling depth to the first true leaf or to the cotyledon leaves beside the foliar application of GA at 30 or 50 ppm. Moreover, all the interaction treatments of transplanting depth beside the application of SA at 300 or 500 ppm gave significantly affected on previous characters as compared to the control.

Key words: *sweet pepper - gibberellic acid- salicylic acid - planting depth - alkaline soil-greenhouse*

INTRODUCTION

Sweet pepper (*Capsicum annum* L.) is one of the important popular vegetable crops grown in Egypt for local consumption as well as exportation. The total growing area increased during the few last years, but its yield did not behave the same trend. However, the fruits yield could be enhanced by two main ways, i.e. horizontally or vertically, where the 2nd way, could be expected by improving the agricultural treatments and treating the plants by antioxidants and activated substances which causing an enhancement on plant metabolism and reflex on plant growth and its yield.

Root growth, development and architecture are important aspects of seedling growth. Vavrina *et al.,* (1994) reported that the bell pepper seedlings set to the cotyledon leaves, or to the first true leaf gave a more fruits than seedlings set to the top of the rootball. Moreover, these transplanting depths led to increased pepper yield and early stand establishment criteria (plant height, number of leaves, leaf area and plant weight). They also suggested that deeper planting may place pepper roots in a cooler environment that reduce fluctuations in soil temperature and in conjunction with earlier fertilizer and water acquisition, that gave a competitive edge in growth. Also, Kelly and Granberry (1995) found that the transplanting pepper deeper at the cotyledons, and the first true leaf increased the earlier yield and plant height. Vavrina *et al.,* (1996) recorded that the tomato transplants set to a depth of the first true leaf and a depth of the cotyledon leaves gave a more fruits at first harvest than plants set to the top of the rootball. Almasoum (2000) reported that root growth is important aspects of tomato seedling growth, in addition the deeper planting of tomato transplanted at the first true leaf the earlier of flowering and increase the marketable fruits than the planted to root ball or cotyledon leaves, while this planted depth was not affected on fruit diameter.

Enhancing stress tolerance plants has major implications in agriculture and horticulture (Senaratna *et al*., 2000). Salt stress has toxic effects on plants and led to metabolic changes, like loss of chloroplast activity, decreased photosynthetic rate and increased photorespiration rate which then led to an increased reactive oxygen species production (Parida and Das, 2005). Salicylic acid (SA) naturally occurs in plants, it has been found to generate a wide range of metabolic and physiological responses in plants thereby affecting their growth and development (Hayat *et al*., 2010). Salicylic acid has been shown as an important signal molecule for modulating plant responses to environmental stress (Breusegem *et al*., 2001); resistance response after a pathogen attack of plants (Alvarez, 2000 and Kachroo *et al*., 2005). heat stress (Shi *et al*., 2006 and Horvath *et al*., 2007); biotic stresses (Korkmaz *et al*., 2007 and Horvath *et al*., 2007); salt and osmotic stresses (Eraslan *et al*., 2007); In addition, Dursun and Yldrm (2009) found that foliar applications of salicylic acid (SA) gave positive effect on some fruit characteristics ,plant growth, and chlorophyll content in leaves, early yield and total yield of tomato plants grown under greenhouse conditions. Elwan and El-Hamahmy (2009) reported that SA at low concentration positively increased the foliage fresh and dry weight, fruit number, average fruit weight, fruit yield and vitamin C. They added that SA at low concentration treatment caused a reduction in peroxidase and increasing of inverts activities of pepper leaves and fruits which led to reduce the stress that induced inhibition of plant growth. Karlidag *et al*., (2009) found that the application of SA on strawberry plants gave greater shoot fresh weight, shoot dry weight, higher chlorophyll content as well as increased almost contents of all nutrients in leaves than the control plants under salt stress.

Gibberellic acid (GA) is a very potent hormone whose natural occurrence in plants controls their development. GA regulates growth; applications of very low concentrations can be a profound effect on plant. Belakbir *et al.,* (1998) revealed that sprayed gibberellic acid on pepper plants at flower initiation, followed by two additional applications at 30-day intervals was increased fruit ascorbic acid concentrations. Tofanelli *et al*., (2003) found that GA decreased fruit production, increased plant height and reduced the fruit quality, Gaafer (2006) reported that spraying of GA at 30 ppm on pepper plants three times onto the plants at 7 day intervals was increased the plant height, leaf number and improved deformed fruit during the harvest period. Also, El-Al (2009) found that the foliar spraying of sweet pepper by gibberellic acid gave the best plant growth and the heaviest tonnage of total, early fruit yield and enhanced its physical and chemical consistent of fruits..

The present study was undertaken to examine the effects of planting depths, foliar application of salicylic and gibberellic acids for enhancing the bell pepper growth, yield, fruit quality and as well as nutrient uptake of plants grown under plastic greenhouse condition.

MATERIALS AND METHODS

This study was carried out at Kaha Research Station, Kalubia Governorate during the two successive seasons of 2009/2010 and 2010/2011 to study the effect of planting depth and foliar application with salicylic and gibberellic acids on sweet pepper plants grown under greenhouse condition. The characteristics of the soil of Kaha by the analysis of soil according to the methods described by Black (1965) is clay, the pH tends to be alkaline (pH 8.08 - 8.09), and have high salinity (EC 3.39 – 3.47 mmhos).

Pepper seeds of Khairat F_1 hybrid were sown on August 11, 17 for the first and the second seasons, respectively. Pepper seedlings with three true leaves were transplanted in ridges inside the greenhouse under natural light and seasonal temperature, on September 12 and 19 for the first and the second seasons, respectively. Two rows of plants were transplanted on each ridge. The distance between plants was 50cm apart, with plant population of 2.2 plants/m^2.

The experiment was designed in a split plot arrangement with three replicates, each replicate included 9 treatments which were the combination of three planting depths as a main plots and foliar application of salicylic, gibberellic acids and water as a control were arranged within the sub- plots. Each treatment consists of ten plants per replicate.

Transplant depth treatments:

Three transplanting depths were used according to morphological positions of the plant, the first depth was to the root ball (control), the second was to the cotyledon leaves level and the third was to the first true leaf level.

Salicylic and gibberellic acids application:

The foliar application of salicylic acid (SA) and gibberellic acid (GA) were done at three times starting 60 days after transplanting or at the first fruit set and every 10 days intervals. SA was applied at 300 and 500 ppm while GA was applied at 30 and 50 ppm. The previous applications were made early morning. Fertigation, pesticide and fungside were applied as recommended by Ministry of Agriculture. Data were recorded for the different characters as follows:

1- Root distribution

Root length and weight of pepper seedling was recorded in the upper 30 cm of soil after 4 weeks from planting.

2- Vegetative growth characters:

Samples of pepper plants were taken after 95 days from transplanting from each sub-plot to estimate plant height (cm), number of branches and leaves per plant, leaf area (cm^2) for the above six leaves from the top of plant, that measured by using LI 3000 Portable Area Meter (PAM) No. 5, produced by Li-cor Pennsylvania, fresh and dry weights (g/plant) which determined for three plants pulled up of randomly from each replicate and dried at 70ºC.

3- Early and total yield:

Data were recorded on early and total yield as a number and weight of picked fruits. Early yield was recorded for picked fruits of the first four harvests, while total yield was recorded for all pickings during the harvesting period.

4- Fruit quality:

Data concerning fruit characters were collected when the market stage reached the marketing fruit size. Data were recorded on average fruit length (cm), average fruit diameter (cm), flesh thickness (cm) and average fruit weight (g).

5- Chemical contents of plant and fruits:

Data were recorded on fruits from the third picking for total soluble solids (TSS) and ascorbic acid contents (mg\100g fresh weight); also leave NPK and chlorophyll contents that were determined according to AOAC (1990).

6- Statistical analysis:

The obtained data were subjected to the analysis of variance procedure and means and compared using the L.S.D. method at 5% level of significance according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1- Effect of transplanting depth on root distribution:

The data in Table (1) and Figure (1) revealed that deeper levels of pepper seedling transplanting had a greater vigor root length and weight in the upper 30 cm of the soil after 4 weeks from planting than plants set at rootball depth. At the same time, the depth of transplanted seedlings led to the adventitious roots sprouting along the main stem of pepper seedling which involved in early stand establishment. Moreover, the deeper pepper transplanting resulted in more rapid and vigor stand establishment than plants set at rootball depth. These finding suggest that root proliferation of deeper transplanting of pepper plant, may be an important factor in their earlier establishment due to the increasing of the root length. Similar result was obtained by Vavrina *et al.,* (1994) who reported that the bell pepper transplants set to the cotyledon leaves, or to the first true leaf increased the pepper stand establishment.

2- Vegetative growth characters:

Data in Table (2) showed that there were significant differences between the three tested transplant depths on vegetative growth characters. Transplant depth to the first true leaf followed with the cotyledon leaves led to an increase in the pepper growth in terms of plant height, number of leaves, number of branches, fresh and dry weights per plant compared with the plants set at rootball depth during the two studied seasons. No significant differences were shown between treatments on plant leaf area during the two studied seasons. The increasing of the number of leaves per plant may be due to the increasing of the plant height and number of branches per plant as shown in Table (2). Similar results were found by Vavrina *et al.,* (1994) who reported that the bell pepper transplants set to the cotyledon leaves, or to the first true leaf gave early stand establishment criteria (plant height, number of leaves and plant weight). Also, Kelly and Granberry (1995) found that the deeper transplanting roots increased the pepper plant height. Also, Almasoum (2000) reported that the root growth is important aspects of tomato seedling growth. These findings suggest that rapid root growth of deeper transplanted pepper may be an important factor for increasing vegetative growth characters especially number of leaves which led to enhancing the photosynthesis and nutrient uptake in plants. These results may be due to the deeper transplanting which placed the pepper roots in a cooler environment that led to reduce the fluctuations in soil temperature. Moreover, this moderated soil temperature, in conjunction with earlier fertilizer and water acquisition, gave the deeper-planted a competitive edge in growth as reported by Vavrina *et al.,* (1994).

Table (1): Effect of transplanting depth on root distribution of pepper plants under greenhouse condition.

Depth transplanting at:	2009/2010	
	Root length (cm)	Root fresh weight(g)
First true leaf	28.3	9.23
Cotyledon leaves	23.3	7.95
Root ball	13.0	4.22
L.S.D at 5%	3.29	1.25
	2010/2011	
First true leaf	27.77	8.93
Cotyledon leaves	23.00	6.89
Root ball	12.67	4.02
L.S.D at 5%	1.72	1.19

Figure (1): Effect of transplanting depth on pepper root distribution
1: Bell pepper transplants set to the root ball.
2: Bell pepper transplants set to the cotyledon leaves.
3: Bell pepper transplants set to the first true leaf

Table (2): Effect of transplanting depth and foliar application with SA and GA on vegetative growth characters of pepper plants under plastic greenhouse condition.

Transplanting depth / SA&GA Foliar applications	2009/2010					
	Plant height (cm)	Leaf area (cm^2)	No. of Leaves / plant	No. of branches / plant	fresh Weight (g)/plant	Dry weight (g)/plant
True leaf	107.4	39.50	199.27	30.61	859.56	216.97
Cotyledons	93.87	37.41	179.58	27.8	560.40	136.22
Rootball	85.20	35.63	151.59	26.27	512.00	119.91
L.S.D. 5%	3.15	N.S	6.06	0.14	104.77	10.76
SA 300	94.22	37.03	182.55	26.62	603.99	148.61
SA 500	87.89	35.26	160.42	26.72	500.00	120.62
GA_3 30	110.2	42.68	222.45	32.11	1042.22	261.09
GA_3 50	104.0	39.35	181.05	30.89	687.04	163.56
Control	81.11	32.94	137.59	25.44	386.68	94.96
L.S.D. 5%	3.32	1.45	4.83	0.77	48.96	9.70
2010/2011						
True leaf	106.89	39.35	194.60	29.25	869.47	238.09
Cotyledons	93.87	36.61	180.25	28.38	580.91	154.98
Rootball	82.05	35.75	147.95	26.48	537.40	140.39
L.S.D. 5%	7.5	N.S	3.5	0.45	24.92	7.18
SA 300	92.78	35.59	177.59	27.55	628.84	167.45
SA 500	86.00	35.87	155.17	26.22	526.22	138.90
GA_3 30	109.56	42.04	219.44	33.36	1039.56	286.91
GA_3 50	103.29	40.13	177.78	29.25	720.34	191.69
Control	79.71	32.55	141.34	23.93	398.00	104.16
L.S.D. 5%	5.8	1.7	4.82	0.55	168.10	7.90

Concerning the foliar application of salicylic acid (SA) and gibberellic acid (GA) on vegetative growth characters in terms of plant height, leaf area, number of leaves and branches per plant, fresh and dry weights per plant were recorded in Table (2). Data indicated a positive effect of the foliar application of (SA) and (GA) on the previous vegetative growth characters compared with non application (control) during the two studied seasons. Data revealed that maximum values of the previous vegetative growth characters were found when GA was sprayed at the rate of 30 or 50 ppm followed by the application of (SA) at low concentration (300 ppm) compared with (control). Similar results were found by Gaafer (2006) who reported that foliar application of (GA) on pepper at 30 ppm has increased the plant height and leaves number per plant. Also, El-Al (2009) found that foliar application of (GA) on pepper gave the best plant growth. At the same time, these results were agreed with those of Dursun and Yldrm (2009) and Hayat *et al*., (2010) who reported that (SA) gave positive effect on plant growth. Also, Elwan and El-Hamahmy (2009) and Karlidag *et al*., (2009), found that (SA) application increased the foliage fresh and dry weights. Moreover, foliar applications of SA gave the higher values for vegetative growth parameters as compared to the control under salt and alkalinity stress. These results may be due to the effect of (SA) which may be responsible for inducing tolerance to a number of biotic and abiotic stresses (Korkmaz *et al*., 2007 and Horvath *et al*., 2007), induces the expression of pathogenesis (Kachroo *et al*., 2005) and response of plants to salt and osmotic stresses (Eraslan *et al*., 2007). On the other hand, the vegetative growth characters of pepper plants grown in the salty and high alkalinity soil at Kaha Research Station with no foliar application of (SA) and (GA) were lower compared with the other treatments. These results may be due to the salt and alkalinity stress which has adversely effect on plant growth through osmotic inhibition of water uptake by roots or specific ion effects. Also, salt stress has toxic effects on plants and led to metabolic changes, like the loss of chloroplast activity, which decreased photosynthetic rate and increased photorespiration rate which then led to an increase reactive oxygen species (ROS) production as reported by Parida and Das (2005).

Regarding the interactions between all transplanting depths and foliar application with SA and GA data in (Table, 3) showed significant effects on some growth characters in terms of plant height, number of leaves and branches per plant, fresh and dry weights per plant comparing with the control. The most favorable beneficial interaction treatments regarding the previous growth characters were treating plants when transplanting depth reach to the first true leaf or to the cotyledon leaves with application of GA at 30 or 50 ppm. Moreover, all the interaction treatments of transplanting depths to the first true leaf or to the cotyledon leaves with foliar application of SA at 300 and 500 ppm gave significantly effects on the previous growth characters compared to the control. Furthermore, the transplanting depth to the root ball beside the application of GA or SA at both concentrations affected positively the growth of the pepper plants compared to the control. On the other hand, the interaction between all transplanting depths and foliar application of SA and GA not show any significant effect on the leaf area.

3- Early and total yield

Results in Table (4) revealed that deeper planting (first true leaf followed by the cotyledon leaves) was more performance than rootball depth in yield characters, i.e. early yield, number of fruits per plant and total yield during the two studied seasons.

Table (3): Effect of the interactions between transplanting depth and foliar application with SA and GA on vegetative growth characters of pepper plants under plastic greenhouse condition.

Transplanting depth \ SA&GA foliar application		Plant height (cm)	Leaf area (cm^2)	No. of Leaves / plant	No. of branches / plant	Fresh weight (g)/plant	Dry weight (g)/plant
		2009/2010					
True leaf	SA 300	107.00	39.56	200.78	27.20	816.67	209.25
	SA 500	102.67	36.56	173.67	28.83	606.67	152.67
	GA_3 30	120.00	45.47	246.00	35.33	1500.0	385.73
	GA_3 50	111.00	39.82	222.00	34.67	927.78	225.99
	Control	96.33	36.07	153.89	27.00	446.67	111.22
Cotyledons	SA 300	95.33	35.85	181.88	26.33	525.30	126.79
	SA 500	83.33	37.24	168.59	25.67	493.33	119.12
	GA_3 30	109.67	41.50	233.67	32.00	850.00	211.32
	GA_3 50	105.33	39.93	183.44	29.00	576.67	136.35
	Control	75.67	32.53	130.33	26.00	356.70	87.54
Rootball	SA 300	80.33	35.67	165.00	26.33	470.00	109.79
	SA 500	77.67	31.98	139.00	25.67	400.00	90.07
	GA_3 30	101.00	41.08	187.67	29.00	776.67	186.32
	GA_3 50	95.67	38.30	137.71	27.00	556.67	127.33
	Control	71.33	30.23	128.56	23.33	356.67	86.12
L.S.D. 5%		3.75	NS	8.371	1.33	84.80	9.70
Constituents		2010/2011					
True leaf	SA 300	105.00	39.34	195.0	28.23	783.33	212.87
	SA 500	101.67	38.04	170.0	26.90	618.67	165.45
	GA_3 30	117.67	44.95	243.33	35.17	1466.67	415.92
	GA_3 50	114.33	40.54	210.0	31.57	1016.67	274.57
	Control	95.78	33.86	154.67	24.37	462.00	121.65
Cotyledons	SA 300	93.67	33.78	172.78	28.00	588.87	155.26
	SA 500	82.67	36.07	166.44	26.22	490.00	129.23
	GA_3 30	111.00	41.13	232.67	35.00	866.67	237.43
	GA_3 50	107.33	40.10	187.67	28.67	585.67	155.32
	Control	74.67	31.98	141.67	24.00	373.33	97.68
Rootball	SA 300	79.67	33.65	165.0	26.43	514.33	134.22
	SA 500	73.67	33.51	129.07	25.53	470.00	122.01
	GA_3 30	100.0	40.04	182.33	29.50	785.33	207.38
	GA_3 50	88.22	39.75	135.67	27.50	558.67	145.19
	Control	68.67	31.81	127.67	23.43	358.67	93.14
L.S.D. 5%		3.73	N.S	8.94	0.96	291.1	.5.76

Table (4): Effect of the transplanting depth and foliar application with SA and GA on early and total yield of pepper plants under plastic greenhouse condition.

Transplanting depth / SA&GA foliar applications	2009/2010			2010/2011		
	Early yield g/plant	Total yield as number	Total yield kg/plant	Early yield g/plant	Total yield as number	Total yield kg/plant
True leaf	935.27	31.91	4.035	950.11	33.08	4.040
Cotyledons	834.14	30.14	3.420	846.71	30.08	3.560
Rootball	696.53	26.73	3.064	666.53	26.99	3.217
L.S.D. 5%	103.04	2.75	0.110	107.68	1.62	0.15
SA 300	802.22	30.50	3.636	813.66	30.36	3.459
SA 500	777.00	28.92	3.330	767.96	28.55	3.233
GA_3 30	980.69	32.74	4.180	964.30	35.67	4.610
GA_3 50	827.11	30.21	3.590	837.44	32.33	3.970
Control	722.89	25.60	2.796	721.56	24.74	2.790
L.S.D. 5%	114.64	2.28	0.070	52.13	1.54	0.18

Seedlings pepper transplants to the first true leaf followed by transplants to the cotyledon leaves gave the best results when compared with transplanting to the rootboll. The increasing of total yield regarding to the transplanting depth was due to the increasing of number of branches and fruits per plant and fruit weight. These findings suggest that rapid root proliferation of deeper transplanted may be an important factor in their extensive root growth as shown in Table (1) and earlier establishment which increased the early yield, number of fruits and total yield as compared to rootball transplanting depth. These results agreed with those found by Kelly and Granberry (1995) and Vavrina *et al.,* (1996), they reported that the transplanting pepper and tomato respectively deeper at the first true leaf or cotyledon leaves increased the early yield. Moreover, similar conclusions were recorded on increase the number of fruits due deeper planting at the cotyledon leaves, or to the first true leaf (Vavrina *et al.,* 1994) and increase the marketable fruits (Almasoum, 2000). The larger and earlier fruit yield from deeper transplant depth may be due to the result of improved temperature conditions for root growth as reported by Vavrina *et al.,* (1994).

Foliar spray with both GA and SA, (Table, 4) showed that the previous growth regulators specially at the low concentration increased yield characters, i.e. early yield, number of fruits per plant and total yield (kg per plant) when compared with non foliar spray treatment (control) during the two studied seasons. Similar results were found by El-Al (2009). These results may be due to that the GA is regulating growth that has a profound effect on plant and the applications of it will improved the deformed fruit as reported by Gaafer (2006). At the same time, the foliar applications with (SA) at both concentrations have increased the yield characters, i.e. early yield, number of fruits per plant and total yield (kg per plant) when compared with non foliar spray treatment (control) during the two studied seasons. Similar results were found by Elwan and El-Hamahmy (2009) concerning number of fruits and fruit yield of pepper, Dursun and Yldrm (2009) concerning early yield and total yield of tomato. These results may be due to the application of SA which could be provide protection against several types of stresses as reported by Alvarez (2000); Breusegem *et al*., (2001); Kachroo *et al*., (2005); Shi *et al*., (2006); Eraslan *et al*., (2007); Horvath *et al*., (2007) and Korkmaz *et al*., (2007).

The interactions between all transplanting depths and foliar application with SA and GA, are shown in (Table, 5), the data showed significant effects on early yield, number of fruits per plant and total yield as compared to the control. The most favorable beneficial interaction treatments regarding the previous characters were treating the deeper transplanting i.e. depth at the first true leaf or to the cotyledon leaves with the applications of GA at 30 or 50 ppm. Moreover, all the interaction treatments; i.e. transplanting depth at the first true leaf or to the cotyledon leaves with the applications of SA at 300 and 500 ppm gave significantly effects on the previous characters as compared to the control. Furthermore, the transplanting depth at the root ball with the applications of GA or SA at both concentrations affected positively the early yield, number of fruits per plant and total yield compared to the control.

4- Fruit quality

Data in Table (6) indicated positive effect of deeper pepper transplanting on fruit quality, i.e. fruit length and fruit diameter during the two studied seasons. Moreover, deeper planting led to produce heavier fruit weight on the first season only. No significant was determined in all tested fruit from treatments by means wall thickness. The increasing of fruit length, fruit diameter and fruit weight may be due to the increase of plant stand establishment and increased of vegetative growth characters in deeper transplanting pepper. These results may be due to the early plant establishment (plant height and number of leaves) and due to the effect of deeper plantings that place pepper roots in a cooler environment which reduce fluctuations in soil temperature in conjunction with earlier fertilizer and water acquisition, thus give a competitive edge in growth as reported by Vavrina *et al.,* (1994).

Table (5): Effect of the interactions between transplanting depth and foliar application with SA and GA on early and total yield of pepper plants under plastic greenhouse condition.

Transplanting depth	SA&GA foliar application	2009/2010			2010/2011		
		Early yield g/plant	Total yield as number	Total yield kg/plant	Early yield g/plant	Total yield as number	Total yield kg/plant
First true leaf	SA 300	910.00	31.33	3.978	910.23	33.20	3.820
	SA 500	884.67	30.93	3.900	955.33	31.00	3.760
	GA_3 30	1112.0	36.07	4.760	1076.00	41.67	5.320
	GA_3 50	927.67	34.07	4.340	930.33	33.40	4.352
	Control	842.00	27.13	3.198	878.67	26.13	3.050
Cotyledons	SA 300	840.33	31.18	3.490	744.33	30.98	3.340
	SA 500	733.33	30.53	3.090	802.33	29.64	3.100
	GA_3 30	1023.39	33.07	4.400	1036.89	35.00	4.610
	GA_3 50	857.00	29.27	3.360	913.33	30.57	3.840
	Control	716.67	26.67	2.760	736.67	24.67	2.910
Rootball	SA 300	656.33	29.00	3.440	649.33	26.90	3.219
	SA 500	713.00	25.30	3.000	683.33	25.00	2.840
	GA_3 30	806.67	29.07	3.380	782.00	30.33	3.900
	GA_3 50	696.67	27.30	3.070	668.67	29.33	3.718
	Control	610.00	23.00	2.430	549.33	23.43	2.410
L.S.D 5%		87.23	2.33	0.12	90.29	2.66	0.26

Table (6): Effect of transplanting depth and foliar application with SA and GA on fruit characters of pepper plants under plastic greenhouse condition.

Transplanting depth / Foliar applications	2009/2010				2010/2011			
	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	Fruit weight (g)
True leaf	10.86	6.55	0.51	147.61	11.09	6.42	0.49	136.63
Cotyledons	10.08	6.05	0.44	135.37	10.24	6.05	0.47	125.35
Rootball	9.71	5.63	0.43	120.15	9.77	5.76	0.43	115.91
L.S.D. 5%	0.29	0.18	N.S	14.48	0.29	0.17	N.S	9.20
SA 300	10.31	6.18	0.49	126.91	10.38	6.09	0.47	122.20
SA 500	10.21	6.07	0.45	118.64	9.77	5.92	0.46	116.85
GA_3 30	11.22	6.81	0.53	168.83	12.35	6.47	0.51	148.70
GA_3 50	10.59	5.88	0.44	147.60	10.40	6.21	0.49	132.64
Control	8.76	5.45	0.38	109.88	8.94	5.69	0.38	109.44
L.S.D. 5%	0.41	0.25	0.05	8.57	0.31	0.24	N.S	7.88

Concerning the foliar application of (SA) and (GA) on fruit quality, data in Table (6) indicated a positive effect of foliar application with these compounds on fruit length, fruit diameter and fruit weight compared with non application (control) during the two studied seasons. Moreover, data showed that these foliar applications led to significant effect on flesh thickness concerning the first season only. Data revealed that maximum values of the previous fruit quality were found with application of (GA) at 30 ppm compared with the other treatments. Similar results were found by El-Al (2009) who reported that foliar application of (GA) on sweet pepper gave the best physical consistent of fruits. On the other hand, these results disagreed with that obtained by Tofanelli *et al*., (2003).

At the same time, foliar application of (SA) at both concentrations gave a positive effect on fruit length, fruit diameter and fruit weight compared with non application (control) during the two seasons. Similar results were found by Elwan and El-Hamahmy (2009); they reported that foliar application with (SA) was positively increased the pepper fruit weight. Also, Dursun and Yldrm (2009) reported that foliar application with (SA) gave the best positive effect on some fruit characteristics on tomato. These results may be due to the application of SA which could be provide protection against several types of stresses as reported by Alvarez (2000); Breusegem *et al*., (2001); Kachroo *et al*., (2005); Shi *et al*., (2006); Eraslan *et al*., (2007); Horvath *et al*., (2007) and Korkmaz *et al*., (2007).

Concerning the interactions between all transplanting depths and foliar application of SA and GA, data in (Table, 7) showed significantly effects on some fruit characters in terms of fruit length and weight as compared to the control. The most favorable beneficial interaction treatments regarding the previous fruit characters were treating plants at transplanting depths to the first true leaf or to the cotyledon leaves with the application of GA at 30 or 50 ppm. Moreover, all the interaction treatments as transplanting depths to the first true leaf or to the cotyledon leaves with the application of SA at 300 and 500 ppm gave significantly effects on the previous fruit characters as compared to the control. Furthermore, the transplanting depths to the root ball beside the application of GA or SA at both concentrations affected positively the fruit characters of the pepper plants compared to the control.

Table (7): Effect of the interactions between transplanting depth and foliar application with SA and GA on fruit characters of pepper plants under plastic greenhouse condition.

Transplanting depth	SA&GA foliar application	2009/2010 Fruit length (cm)	2009/2010 Fruit diameter (cm)	2009/2010 Flesh thickness (cm)	2009/2010 Fruit weight (g)	2010/2011 Fruit length (cm)	2010/2011 Fruit diameter (cm)	2010/2011 Flesh thickness (cm)	2010/2011 Fruit weight (g)
First true leaf	SA 300	11.20	6.62	0.53	135.73	10.74	6.42	0.50	135.77
	SA 500	10.73	6.31	0.50	130.70	9.87	6.13	0.50	132.00
	GA_3 30	11.42	7.30	0.57	191.00	13.97	6.83	0.53	161.53
	GA_3 50	11.04	6.69	0.53	164.93	11.60	6.60	0.50	140.33
	Control	9.91	5.83	0.43	115.67	9.27	6.10	0.40	123.53
Cotyledons	SA 300	10.51	6.30	0.47	134.33	10.63	6.17	0.47	123.77
	SA 500	10.10	6.27	0.43	115.03	9.83	5.93	0.47	117.40
	GA_3 30	11.30	6.76	0.53	173.97	12.77	6.47	0.50	153.90
	GA_3 50	10.30	5.63	0.40	145.80	9.89	6.93	0.50	129.60
	Control	8.20	5.28	0.37	107.70	8.08	5.31	0.40	102.10
Rootball	SA 300	9.23	5.63	0.47	110.67	9.77	5.69	0.43	111.00
	SA 500	9.80	5.62	0.43	110.20	9.60	5.96	0.40	107.20
	GA_3 30	10.93	6.37	0.50	141.53	10.30	6.10	0.50	130.67
	GA_3 50	10.43	5.32	0.40	132.07	9.70	5.63	0.47	128.00
	Control	8.16	5.23	0.33	106.27	9.47	5.67	0.33	102.00
L.S.D. 5%		0.54	N.S	N.S	14.84	0.50	N.S	N.S	13.6

5- Chemical contents of plant and pepper fruits:

Data in Table (8) indicated positive effect for deeper pepper transplanting on fruit ascorbic acid content (vitamin C) and the leave contents from N, P and K in pepper plants during the two studied seasons. Data revealed that maximum values of vitamin C and NPK contents were found in deeper planting at the first true leaf followed by the cotyledon leaves. These results may be due to the increasing of the root distribution and vegetative growth characters as shown in Tables (1 and 2) which increased the water and nutrients uptake. On the other hand, the deeper planting not show any significant effect on fruit total soluble solids (TSS) and leave chlorophyll content. These findings suggest that rapid root proliferation of deeper transplanting pepper may be an important factor in increasing the vegetative growth character especially the number of leaves which led to enhancing the photosynthesis and nutrient uptake in plants.

Concerning the foliar application with (SA) and (GA) on plant chemical contents, data recorded in Table (8), indicated a positive effect of the foliar application of (SA) and (GA) on the fruit TSS, ascorbic acid contents and leave NPK only. Data revealed that maximum values of the previous chemical contents were found with application of (GA) at 30 and 50 ppm followed by the application of (SA) at low concentration (300 ppm) for fruit TSS and ascorbic acid and for leave NPK compared with (control). Similar results were found by El-Al (2009) who reported that the foliar application of (GA) on pepper gave the best chemical consistent of fruits. Also, Belakbir *et al.,* (1998) revealed that foliar spraying of GA on pepper plants has increased fruit ascorbic acid concentration. Moreover, these results on the effect of foliar application of (SA) were agree with those finding of Elwan and El-Hamahmy (2009) on the vitamin C, and Karlidag *et al*., (2009) on the contents of all nutrients in leaves. These findings suggest that the increasing of nutrient content in pepper plants seems to be involved with stress-tolerance mechanism.

Table (8): Effect of the transplanting depth and foliar application with SA and GA on chemical content of pepper plants under plastic greenhouse condition.

Transplanting depth / SA&GA foliar applications	2009/2010					
	Fruit chemical		Plant chemical			
	TSS	V.C Mg/100 f.w.	N%	P%	K%	Chlorophyll In spade
True leaf	3.66	134.34	2.36	0.29	1.90	54.65
Cotyledons	3.54	118.58	2.27	0.26	1.76	53.46
Rootball	3.44	108.58	2.04	0.25	1.65	53.27
L.S.D.5%	N.S	10.23	0.11	0.02	0.03	N.S
SA 300	3.68	117.15	2.25	0.26	1.76	52.02
SA 500	3.18	113.71	2.29	0.28	1.79	53.44
GA_3 30	3.94	143.88	2.36	0.29	1.87	54.15
GA_3 50	3.82	124.06	2.44	0.31	1.94	57.05
Control	3.12	103.70	1.78	0.21	1.48	46.03
L.S.D. 5%	0.12	10.44	0.13	0.01	0.04	N.S
2010/2011						
True leaf	3.53	136.36	2.45	0.30	2.17	54.05
Cotyledons	3.46	122.55	2.29	0.28	1.95	52.53
Rootball	3.33	112.55	2.10	0.24	1.70	40.91
L.S.D.5%	N.S	10.30	0.02	0.01	0.04	N.S
SA 300	3.59	120.58	2.27	0.25	1.93	50.28
SA 500	3.13	117.03	2.30	0.28	1.96	53.49
GA_3 30	3.84	150.23	2.38	0.31	2.10	54.70
GA_3 50	3.47	137.13	2.47	0.34	2.10	56.27
Control	3.08	93.84	1.97	0.20	1.62	43.37
L.S.D. 5%	0.12	10.39	0.02	0.01	0.03	N.S

Regarding to the interactions between all transplanting depths and foliar application with SA and GA, data in (Table 9) were differed between the first and second seasons. Data indicated that the most significant favorable beneficial interaction treatments regarding the fruit ascorbic acid and leaf K content were obtained from plants which transplanted at depth of the first true leaf or at the cotyledon leaves and treated with GA at 30 or 50 ppm at the first and the second seasons. On the other hand, the most significant favorable beneficial interaction treatments in the second season regarding the fruit TSS and leave N.P contents were obtained from treating plants with transplant depth at the first true leaf or to the cotyledon leaves beside the application of GA at 30 or 50 ppm.

Table (9): Effect of the interactions between transplanting depth and foliar application with SA and GA on chemical content of pepper plants under plastic greenhouse condition

Transplanting depth \ SA&GA foliar application		2009/2010					
		Fruit chemical		Plant chemical			
		TSS	V.C Mg/100	N%	P%	K%	Chlorophyll in spade
First true leaf	SA 300	3.80	140.07	2.32	0.28	1.90	52.68
	SA 500	3.28	130.03	2.36	0.30	1.95	54.55
	GA_3 30	4.08	150.17	2.41	0.31	2.01	55.46
	GA_3 50	3.91	140.81	2.50	0.34	2.07	61.73
	Control	3.22	110.60	2.21	0.23	1.55	48.84
Cotyledons	SA 300	3.68	110.79	2.25	0.25	1.75	52.16
	SA 500	3.16	110.27	2.28	0.27	1.78	54.30
	GA_3 30	3.96	140.88	2.36	0.29	1.87	55.08
	GA_3 50	3.80	120.60	2.43	0.31	1.94	57.46
	Control	3.10	110.37	2.05	0.20	1.48	48.29
Rootball	SA 300	3.57	100.60	2.15	0.25	1.63	51.23
	SA 500	3.09	100.83	2.22	0.26	1.65	51.48
	GA_3 30	3.78	140.59	2.32	0.28	1.73	51.90
	GA_3 50	3.74	110.77	2.40	0.29	1.82	51.97
	Control	3.03	90.13	1.07	0.18	1.40	40.97
L.S.D.5%		NS	10.77	NS	N. S	0.05	N.S
		2010/2011					
First true leaf	SA 300	3.68	140.57	2.43	0.28	2.17	53.17
	SA 500	3.16	130.20	2.45	0.32	2.19	55.49
	GA_3 30	3.93	160.03	2.50	0.34	2.27	56.70
	GA_3 50	3.73	150.29	2.62	0.37	2.31	59.60
	Control	3.16	100.69	2.23	0.21	1.90	45.31
Cotyledons	SA 300	3.66	110.90	2.29	0.24	1.92	49.17
	SA 500	3.13	110.66	2.31	0.28	2.00	55.26
	GA_3 30	3.80	150.23	2.40	0.33	2.05	56.17
	GA_3 50	3.69	150.19	2.49	0.34	2.14	57.97
	Control	3.04	90.77	1.89	0.20	1.65	44.10
Rootball	SA 300	3.44	110.27	2.10	0.23	1.69	48.49
	SA 500	3.09	110.23	2.15	0.25	1.70	49.17
	GA_3 30	3.78	140.42	2.25	0.26	1.97	51.24
	GA_3 50	3.31	110.90	2.30	0.30	1.84	55.13
	Control	3.03	90.07	1.70	0.18	1.30	40.71
L.S.D.5%		0.21	10.86	0.03	0.01	0.05	N.S

CONCLUSION

As a conclusion, transplanting depth with foliar application with salicylic acid and gibberellic acids on pepper plants under greenhouse has revealed that the deeper transplanting depth increased the root distribution patterns and resulted in more rapid and vigor stand establishment than plants set at rootball depth. The previous effect led to increase the plant height, leaf area, number of leaves, number of branches, fresh and dry weights per plant compared with the plants set at rootball depth. The foliar application with (SA) and (GA) had a positive effect on the vegetative growth characters, fruit quality, early yield, total yield as well as plant and fruit chemical contents. The maximum values of the previous characters were found by application with (GA) at 30 and 50 ppm followed by the application with (SA) at low concentration (300 ppm) when compared with non foliar application on plants (control). The most favorable beneficial interactions between all transplanting depths and foliar application with SA and GA regarding the previous characters were transplanting the seedlings at the depth of the first true leaf or at the cotyledon leaves beside application with GA at 30 or 50 ppm followed by transplanting the seedlings at the depth of the cotyledon leaves beside application with GA at 30 ppm. Moreover, all the interaction treatments plants with transplant depths to the first true leaf or to the cotyledon leaves beside application it with SA at 300 and 500 ppm gave significantly effected on the previous characters as compared to the control. This factor would be of considerable importance in pepper plantings grown under greenhouse which the soil tended to alkalinity.

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تأثير عمق الزراعة، والرش الورقى بحامض السالسيلك والجبريلك على نباتات الفلفل النامية في التربة القلوية تحت الصوب

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الملخص العربى

تم دراسة استجابة نباتات الفلفل إلى عمق الزراعة واستخدام الرش بحمض السالسيلك وحمض الجبريليك تحت الصوب البلاستيكية. تم تنفيذ التجربة فى التربة الطينية القلوية بمحطة بحوث قها، القليوبية، مصر، خلال الموسمين الخريفين المتعاقبين لعام 2010/2009 و 2011/2010. وقد أوضحت النتائج أن زراعة شتلات الفلفل عميقة عند الورقة الحقيقية الأولى و الأوراق الفلقية اعطت كثافة جذور طويلة قوية مما أدى الى زيادة الأسراع فى قوة ثبات النباتات بالمقارنة بالنباتات المنزرعة على عمق الجذور العادية (كنترول). وقد أدى الشتل

العميق عند الورقة الحقيقية الأولى يلية الورقتين الفلقيتين زيادة فى نمو نباتات الفلفل والمتمثلة فى طول النبات وعددالأوراق والفروع والوزن الطازج والجاف للنبات بالمقارنة بالكنترول.

ولقد كان لعمق زراعة الفلفل تأثير إيجابي أيضا على جودة الثمار (طول الثمرة، قطر الثمرة، وزن الثمرة)، والمحصول (المحصول المبكر، عدد الثمار للنبات والمحصول الكلي)، والمحتوى الكيميائي للنبات والثمار (محتوى حمض الاسكوربيك بالثمار ومحتوى النيتروجين والفوسفور والبوتاسيوم بالأوراق) وذلك بسبب زيادة ثبات النباتات وزيادة صفات النمو الخضرى والتي انعكست على زيادة امتصاص الماء والعناصر الغذائية.

ولقد ادى رش نباتات الفلفل بحمض السالسيلك وحامض الجبريليك إلى تأثير إيجابي على صفات النمو الخضري، ونوعية الثمار والمحصول والمحتوى الكيميائى للنبات (محتوى الثمار من المواد الذائبة الكلية وحمض الاسكوربيك ومحتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم). ولقد كانت أعلى قيم للصفات السابقة عند الرش بحامض الجبريليك بتركيز 30 و 50 جزءا في المليون يليها المعاملة بحامض السالسيلك بالتركيز المنخفض 300 جزء من المليون بالمقارنة بعدم رش النباتات (الكنترول). وهذه النتائج قد تكون راجعة إلى أن حامض الجبريلك هو منظم نمو والذى له أثر عميق على نمو النبات وصفات محصول الثمار، كما ان حامض السالسيلك يؤدى إلى التحفيز على تحمل الأجهاد بنباتات الفلفل. وفي الوقت نفسه، فأن صفات النمو الخضرى وجودة الثمار والمحصول والمحتوى الكيميائى بنبات الفلفل التى تنمو فى تربة محطة قها بدون المعاملة برش حامض السالسيلك و حامض الجبريلك كانت منخفضة بالمقارنة بالمعاملات الأخرى نتيجة اجهاد الملح والقلوية للتربة والتى تؤثر سلبا على نمو نباتات الفلفل.

ولقد كان من أكثر التفاعلات الملائمة بين عمق الزراعة والرش الورقى لحامض السالسيلك والجبريلك بخصوص معظم الصفات السابقة هو المعاملة بالشتل على عمق الورقة الحقيقية الأولى أو الأوراق الفلقية مع الرش بحامض الجبريلك بتركيز 30 أو 50 جزء في المليون. بالإضافة إلى ذلك فأن جميع تفاعلات معاملات عمق الزراعة مع الرش بحامض الساالسيلك بتركيز 300 أو 500 جزء فى المليون أعطت تأثير معنوى على الصفات السابقة بالمقارنة بالكنترول.