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RESPONSE OF STRAWBERRY PLANTS TO SOME GROWTH REGULATORS

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ABSTRACT

This experiment was carried out during 2002/2003 and 2003/2004 seasons at the Experimental Farm of the Strawberry and Non Traditional Crops Improvement Center at El-Nubaria, Behira Governorate. This work aimed to study the effect of ethrel {ethephon} (50, 100, 250 ppm), GA_3 (10, 30, 50 ppm) and uniconazole (10, 15, 20 ppm) on strawberry plant growth characters (plant, leaf petiole and crown length, leaf area and plant dry matter %), chemical contents of the plants, number of flowers and fruits, monthly yield, total yield and fruit quality (fruit weight, TSS, total sugars and ascorbic acid content). The results indicated that GA_3 application increased plant, petiole and crown length as well as plant dry matter % in most treatments. Growth regulators did not reflect significant differences concerning leaf area as compared to the control in most cases. GA_3, ethrel and uniconazole increased total carbohydrate percentage in the foliage of strawberry plants while they did not affect nitrogen content. GA_3 at 10 ppm or ethrel at 250 ppm increased number of flowers and fruits as well as the monthly and total yield. TSS was not affected by growth regulators, while untreated plants recorded the highest values of average fruit weight, total sugars and ascorbic acid content.

Keywords: Strawberry, Growth regulators, GA_3, Ethrel, Uniconazole, Yield, Fruit quality.

INTRODUCTION

There are some factors affect yield and quality of strawberry. Growth regulators are considered one of the most important factors which should be taken in consideration for increasing the production and fruit quality.

Growth regulators, *i.e.*, gibberellic acid (GA_3**)**, ethrel (ethephon) and uniconazole are very important. Application of GA_3 to some plants may induce growth responses similar to those caused by certain natural environmental factors. As for strawberry, GA_3 treatment may substitute for the long day and chilling requirements for flower and growth development. Singh *et al.* (1960) reported that spraying plants with gibberellic acid at advanced harvesting times by three weeks and increased yield. Porlingis and Boynton (1961) found that application of GA at 50 or 200 ppm increased petiole length and the main axis of the plants. Turner (1963) noted that application of 12.5, 25, 50 and 75 ppm GA_3 at different times accelerated flowering, increased number of flower clusters, total yields were not significant improved but the number of berries increased with increasing concentrations up to 50 ppm. Tafazoli and Shaybany (1978) found that GA_3 at 100 ppm increased leaf area while, the leaf N percent was not affected by applying GA_3 at 50 or 100 ppm. Also, Tafazoli and Vince-Prue (1978) noted that application of GA_3 at 20 mg/l increased leaf area, petiole length, the length of the main axis and number of flowers per plant. In this respect, Weidman and Stang (1983) mentioned that applied GA_{4+7} at the rate of 250 ppm caused more crown elongation, increased foliage dry weight in cv. Scott.

Okasha *et al*. (1985) stated that spraying Pajaro plants with GA_3 at 50 ppm caused significant increases in leaf area, early yield, average fruit weight, ascorbic acid and P content while, plant dry weight, total yield, TSS % as well as N and K contents in plant were not affected by applying GA_3. Lopez-Galarza *et al.* (1989) mentioned that spraying cv. Pajaro with 40 ppm GA_3 and cv. Douglas with 20, 50 and 80 ppm caused significant increases in early yield. GA_3 caused significant increase in fruit size of cv. Douglas while this parameter was not affected in cv. Pajaro. Sugar content in cv. Douglas was also not affected. Pipattanawong *et al*. (1996) reported that foliar spraying of 50 ppm GA_3 significantly increased petiole length, while leaf area was not affected. Applying GA_3 at the rates 50, 150 and 450 ppm caused an increase in vegetative vigor, GA_3 at 50 ppm gave the highest yield and the highest number of fruits (Tehranifar and Battey, 1997). Also, Dwivedi *et al*. (1999) indicated that GA_3 at 50 ppm resulted in the maximum petiole length and leaf area. Ozguven and Yilmaz (2002) indicated that applied GA_3 at 5, 10 and 20 ppm had no effect on the average fruit weight and total soluble solid content in cv. Camarosa. Paroussi *et al.* (2002) proved that application GA_3 at 50 or 200 mg/l increased petiole length and leaf area, accelerated flowering and increased the number of flower buds and flowers, also they found that GA_3 at those concentrations did not have a positive effect on total marketable yield.

As reviewed by Perkins-Veazie (1995), ethephon is a synthetic hormone that releases ethylene when applied to plants. In greenhouse experiment, Blatt and Sponagle (1973 and 1974) noted that ethephon applications of 960 and 1920 ppm significantly increased strawberry fruit yield and these treatments increased the percent of the total crop harvested in the first four pickings by an average of 44 % above the control. Sachs and Iszak (1974) reported that total yield did not differ between treatment with ethephon at 1000 ppm and control. Tafazoli and Shaybany (1978) noted that application of ethephon at 50 and 100 ppm did not affect leaf area, leaf N % and number of clusters in cv. Gem. Choma and Himelrick (1982) found that application of ethephon at 500 and 1000 ppm decreased petiole length. Cain *et al*. (1983) found that strawberry cultivars vary in their response to ethephon. Fruit yield and number were increased in cv. Centennial by spraying with 100 ppm, while these measurements were not affected by ethephon sprays in cv. Redcoat and the Selection 31B38. Fruit yield was increased in the Selection 107 M6 by spraying with 1000 ppm.

Some triazoles already have commercially important applications. For example, uniconazole (trade names= S3307, XL-019) which inhibit endogenous gibberellin biosynthesis (Davis *et al*., 1988). In this respect, Miura *et al.* (1995) noted that application of 12.5 ppm uniconazole on strawberry plants increased early yields in December and January. In pot experiment, Imam and Bekheta (1997) showed that spraying broad bean (*Vicia faba*) plants with uniconazole at 5, 10, 20 or 40 ppm decreased stem length while plant dry weight after seven weeks from sowing was slightly affected by the treatments. K content of shoot system increased due to treatments. Also, Imam *et al.* (1997) indicated that spraying broad bean plants with uniconazole at 5, 10, 20 or 40 ppm increased yield and total N of the seeds (except 40 ppm), total carbohydrates and total soluble sugars

content of the harvested bean seeds showed non significant increase. Gharib *et al.* (2005) observed that spraying potato plants with 500, 1000 and 2000 ppm uniconazole depressed plant height.

MATERIALS AND METHODS

Two experiments were conducted at the Experimental Farm of the Strawberry and Non Traditional Crops Improvement Center, Fac. Agric., Ain Shams University at El-Nubaria, Behira Governorate during the two growing seasons of 2002/2003 and 2003/2004. The soil was sandy in texture with pH 8.14, EC 1.14 (ds/m). "Sweet Charlie" strawberry cultivar was used in this study. Dates of transplanting were September 27 and 26 in 2002 and 2003 for the first and the second seasons, respectively. All agricultural practices for cultivation were performed as recommended by Ministry of Agriculture and Land Reclamation.

The experiment included ten treatments which arranged in a randomized complete blocks design, with three replicates.

The treatments were 50, 100 or 250 ppm of ethrel; 10, 30 or 50 ppm of GA_3 (Gibberellic acid); 10, 15 or 20 ppm of uniconazole and control. These spraying treatments were carried out 30, 45 and 60 days after transplanting with the application of Triton B as a wetting agent at 0.1%.

The experimental plot area was 14 m^2 (two beds with 4 m length x 1.75 m width). Fresh transplants were planted in four rows on top of ridges of 120 cm with two drip irrigation tubes and plant distances were 25 cm apart. Beds were covered with plastic mulch and tunnels.

Data recorded:

Three plants were randomly uprooted from each experimental plot after 12 and 16 weeks from transplanting to determine:

a.Vegetative growth measurements: Plant, petiole and crown length (cm), total leaf area/plant (cm^2) and whole plant (roots and foliage) dry matter %.

b.Chemical content: Total carbohydrates were determined colorimetrically as g. glucose/100 g. dry matter of the foliage (leaves and crowns) according to James (1995). Total nitrogen, phosphorus and potassium were determined in dry matter of the foliage according to A.O.A.C. (1990). C/N ratio was calculated from the results of total carbohydrate and Total nitrogen.

Flowers and fruits number:

Non accumulated counting of flower and fruit numbers per plant were measured on five randomly selected plants at 12, 16, 20 and 24 weeks age from transplanting.

Fruit yield:

a.The monthly fruit yield: due to the very low harvested yield in the early and late season, yield was calculated monthly except those two periods, yield was determined in November and December as well as in April and May together.

b.Total yield was calculated by the summation of all fruit pickings.

Fruit quality:

a. Average fruit weight (g) was determined in random samples of ten fruits from each experimental plot after 13 weeks of transplanting.

b. Total soluble solids (TSS) were determined in random samples of five ripe fruits from each experimental plot using a hand refractometer after 13 weeks of transplanting.
c. Total sugars was determined in dry samples of ripe fruits from each experimental plot colormetrically by the method described by Somogyi (1952) and Nelson (1974) after 13 weeks of transplanting.
d. Ascorbic acid content was determined according to A.O.A.C. (1990) after 18 weeks of transplanting.

Statistical analysis.

The data were exposed to proper statistical analysis of combined analysis as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Vegetative growth measurements
Plant length

Data in Table (1) show clearly that the highest values of plant length were obtained with GA_3 at 50 ppm at the two investigated samples which showed significant increment as compared with all other treatments including the control. While the lowest values were noticed from ethrel at 50 ppm and uniconazole at 10 ppm in the first and second samples, respectively. These two treatments showed significant decreases as compared to the control.

Table 1. Effect of growth regulators on plant length, petiole length, total leaf area/plant, crown length and whole plant dry matter (%) of strawberry plant (combined analysis of 2002/2003 and 2003/2004 seasons).

Treatments (ppm)	Plant length (cm)		Petiole length (cm)		Leaf area/plant (cm^2)		Crown length (cm)		Plant dry matter (%)	
	weeks after transplanting									
	12	16	12	16	12	16	12	16	12	16
Control	14.72	16.67	7.39	6.94	409.3	558.9	1.82	2.30	32.36	26.51
Ethrel 50	12.58	15.72	6.15	6.17	391.5	409.8	1.84	2.30	32.24	30.49
Ethrel 100	13.54	15.25	7.02	6.61	427.6	448.1	1.52	2.14	32.58	32.98
Ethrel 250	14.22	14.88	6.93	6.30	393.5	396.6	2.10	2.60	33.02	32.63
GA_3 10	16.05	18.23	8.98	8.52	421.9	578.6	2.10	2.68	35.25	32.36
GA_3 30	16.08	18.78	9.24	8.66	377.3	467.6	1.81	2.63	30.95	31.93
GA_3 50	17.95	21.00	10.55	9.88	408.7	602.8	1.89	2.78	34.79	35.81
UCZ 10	14.61	14.78	6.84	6.40	395.2	500.2	2.08	2.37	32.12	31.94
UCZ 15	13.67	15.02	6.56	6.21	405.3	492.2	2.04	2.50	32.48	32.44
UCZ 20	13.97	15.95	6.50	6.28	344.2	498.3	1.91	2.55	33.17	32.38
L.S.D. 5%	1.39	1.79	0.89	0.80	56.7	93.1	0.36	0.39	3.21	2.21

UCZ: uniconazole

In general, treatments of GA_3 increased plant length, while treatments of ethrel and uniconazole decreased this measurement. Such results are in harmony with those reported by Tehranifar and Battey (1997) who suggested that applying GA_3 caused an increase in vegetative vigor in the absence of chilling. Also, the current results are in agreemet with the findings of (Imam and Bekheta, 1997 on broad bean; Gharib *et al.*, 2005 on potato) who found

that plant length depressed with uniconazole treatments. The growth-retarding properties of the triazoles are largely attributed to interference with gibberellin biosynthesis (Davis *et al*., 1988).

Petiole length

It is obvious from Table (1) that the highest significant values were observed by GA_3 at 50 ppm, while the lowest values were noticed by ethrel at 50 ppm. In general, GA_3 treatments showed a gradual increase in petiole length as the level of applied GA_3 increased, while ethrel and uniconazole treatments had no significant effects as compared to the control except ethrel at 50 ppm and uniconazole at 20 ppm in the first sample only, which indicated significant reduction in petiole length as compared to the control. Similar results with GA_3 were reported by (Porlingis and Boynton, 1961; Tafazoli and Vince-Prue, 1978; Pipattanawong *et al.,* 1996; Dwivedi *et al*., 1999; Paroussi *et al.*, 2002). The increase of the petiole length of the strawberry following GA treatment was found to involve increases in both the number and the length of cells in epidermis (Guttridge and Thompson, 1959). Also, the current results are in agreement with those of Choma and Himelrick (1982) who observed an increase in petiole length of strawberry when using ethrel.

Leaf area

Data shown in Table (1) indicate that growth regulators had no significant effect on leaf area except uniconazole at 20 ppm in the first sampling date and ethrel at all doses during the second sampling date. These four treatments caused significant decreases in leaf area as compared to the control. Such results are in agreement with those of Pipattanawong *et al*. (1996) upon GA_3 and Tafazoli and Shaybany (1978) upon ethrel, while these results are not in agreement with those obtained by using GA_3 (Tafazoli and Vince-Prue, 1978; Okasha *et al*., 1985; Dwivedi *et al*., 1999; Paroussi *et al.*, 2002).

Crown length

The results in Table (1) show that the highest values of crown length were observed from GA_3 at 10 ppm as well as ethrel at 250 ppm in the first sampling date and from GA_3 at 50 ppm in the second date, while the lowest values were noticed from ethrel at 100 ppm in both samples. These differences were not significant as compared to the control except 50 ppm GA_3 at the second sampling date which showed significant increase. Similar results were reported by using GA_3 (Tafazoli and Vince-Prue, 1978; Weidman and Stang, 1983). In addition, Porlingis and Boynton (1961) revealed that GA treatments caused elongation in the main axis (crown) of the plants. The elongation caused the axis to have long internodes.

Plant dry matter (%)

It is obvious from Table (1) that during the first date, the highest value of plant dry matter was obtained from GA_3 at 10 ppm, while the lowest value was noticed from GA_3 at 30 ppm, without significant differences between them and the control. At the second investigated sample, GA_3 at 50 ppm showed the highest significant value of plant dry matter while untreated plants (control) scored the lowest value. This result may be due to the influences of growth regulators in carbohydrates accumulation (Table, 2).

Similar results were reported by using GA_{4+7} (Weidman and Stang, 1983), while these results are not in agreement with those of Okasha *et al*. (1985) upon GA_3 and Imam and Bekheta (1997) upon treatment with uniconazole on broad bean plants.

From the previously mentioned results, it could be suggested that application of exogenous gibberelic acid (GA_3), especially at its higher concentration (50 ppm) promoted vegetative growth of strawberry plants, expressed as plant, petiole and crown length as well as plant dry matter %.

Chemical contents of strawberry plants

Total carbohydrates

Data presented in Table (2) obviously indicated that both GA_3 at 50 or 30 ppm in the first sample and all growth regulators treatments in the second sample gave a significant increase of total carbohydrates comparing to the control. On the other hand, the lowest value of this parameter in the first sample was observed with uniconazole at 20 ppm, without significant differences between it and the control. Also, control plants showed the lowest percentage of total carbohydrates at the second sampling date. Data indicates also that the growth regulator treatments promote accumulation of carbohydrates in the foliage of strawberry plants. In this respect, Ragab (1996) mentioned that, GA_3 increased significantly total carbohydrates content in roots and crowns of strawberry transplants. El-Sayed and Shehata (1996) reported that, uniconazole at 500 ppm led to a significant increase in the carbohydrates content in heads of globle artichocke plants. Imam *et al*. (1997) stated that, the total carbohydrates content in broad bean seeds showed nonsignificant increase due to uniconazole treatments.

Table 2. Effect of growth regulators on chemical contents of the foliage of strawberry plant (combined analysis of 2002/2003 and 2003/2004 seasons).

Treatments (ppm)	Carbohydrates (g/100g d.w.)		N (%)		C/N ratio		P (%)		K (%)	
	Weeks after transplanting									
	12	16	12	16	12	16	12	16	12	16
Control	8.16	8.90	2.52	2.56	3.24	3.64	0.48	0.54	1.50	1.57
Ethrel 50	8.21	10.15	2.89	2.74	2.88	3.78	0.65	0.47	1.48	1.46
Ethrel 100	8.73	12.18	2.36	2.46	3.83	5.09	0.57	0.46	1.45	1.49
Ethrel 250	8.44	9.80	2.71	2.76	3.33	3.61	0.66	0.50	1.50	1.46
GA_3 10	8.73	10.69	2.68	2.61	3.30	4.14	0.59	0.49	1.51	1.51
GA_3 30	8.92	11.26	2.29	3.09	3.98	3.88	0.56	0.63	1.53	1.55
GA_3 50	8.94	12.09	2.56	2.55	3.53	4.87	0.52	0.63	1.57	1.51
UCZ 10	8.34	9.38	2.52	2.46	3.42	3.81	0.60	0.53	1.49	1.53
UCZ 15	8.55	9.70	2.25	2.41	3.84	4.12	0.65	0.57	1.48	1.57
UCZ 20	7.55	10.59	2.44	2.99	3.12	3.95	0.62	0.51	1.52	1.50
L.S.D. 5%	0.69	0.45	0.48	N.S.	0.66	0.97	0.10	0.12	0.04	0.04

UCZ: uniconazole

Total nitrogen content

Data presented in Table (2) show that during the first investigated sample the highest level of nitrogen in dry matter of the foliage was detected from ethrel at 50 ppm, while the lowest level of nitrogen was detected from uniconazole at 15 ppm, without significant differences between them and the control. Concerning the second sampling date, there was no significantly effect by growth regulators on nitrogen content. Results emphasized that, the treatments of GA_3, ethrel and uniconazole had no effects on nitrogen content. Okasha *et al*. (1985) upon GA_3 and Tafazoli and Shaybany (1978) upon GA_3 and ethephon, came to the same conclusion. On the contrary, these results are not in agreement with those of Imam *et al*. (1997) upon treatment with uniconazole on broad bean plants.

Carbohydrate/Nitrogen (C / N ratio)

It is obvious from data presented in Table (2) that the highest values of C/N ratio at the first and second sampling dates resulted from treatments of 30 ppm GA_3 and 100 ppm ethrel, respectively. These two treatments showed significant increment as compared to control. On the other hand, the lowest values of this ratio at the first and second sampling dates were detected from 50 and 250 ppm ethrel, respectively. These two inferior treatments showed non-significant reduction as compared to the control. In general, growth regulators treatments increased C/N ratio during the two ages; this increment was significant only at 30 ppm GA_3 (during the first sampling date), 100 ppm ethrel and 50 ppm GA_3 (during the second sampling date). These results were parallel with those of total carbohydrates.

Phosphorus content

Data in Table (2) revealed that, ethrel at 250 ppm gave the highest level of phosphorus in dry matter of the foliage, while the lowest level was associated with untreated plants (control). All growth regulator treatments showed significant increases in P content when compared to their control except ethrel at 100 ppm and GA_3 at 30 and 50 ppm which showed non-significant increment. These results were held true during the first sampling date. Concerning this parameter during the second sampling date, no significant differences were observed between control and all growth regulator treatments. In this respect, Okasha *et al*. (1985) stated that GA_3 at 50 ppm caused significant increase in P content in strawberry plants.

Potassium content

Data in Table (2) showed that the highest level of potassium was detected from GA_3 at 50 ppm which showed significant increment as compared to the control, while the lowest level of potassium was detected from ethrel at 100 ppm which showed significant reduction as compared to the control. All other treatments of growth regulators had no significant effects on K content. These results were true during the first sampling date. Concerning the effect of growth regulators during the second sampling date, data showed that the highest value was observed from uniconazole at 15 ppm or control without significant difference between them, while the lowest value was obtained from ethrel at 250 ppm. Generally, treatments of growth regulators indicated significant reduction in potassium content. These results were in the same line with those obtained by Okasha *et al*. (1985) upon GA_3.

On the contrary, these results are not in agreement with the findings of Imam and Bekheta (1997) who found that K concentration in shoot system of broad bean plants increased due to the uniconazole treatments.

Flowering and fruiting

Number of flowers

Data in Table (3) indicated that GA_3 at 10 ppm and ethrel at 250 ppm scored higher number of flowers at 12 and 16 weeks from transplanting, respectively. While the lowest number of flowers at these two ages resulted from GA_3 at 50 ppm. Such data also, revealed that the maximum number of flowers at 20 and 24 weeks from transplanting were obtained from GA_3 at 10 ppm, followed by the treatment of ethrel at 250 ppm. While the lowest number was recoded from uniconazole at 20 ppm at these two ages. Generally, in most cases, 10 ppm GA_3 and 250 ppm ethrel gave significant increases in number of flowers as compared to the control. In this connection, Tafazoli and Vince-Prue (1978) and Paroussi *et al.* (2002) previously reported that with other strawberry cultivars GA_3 increases the rate of flower buds and opened flowers. In addition, Turner (1963) and Ozguven and Yilmaz (2002) found that GA_3 accelerated flowering and increased the number of flower clusters, whereas it breaks flower bud dormancy early. Tehranifar and Battey (1997) mentioned that GA_3 reduced the time needed for inflorescence emergence and it could be a substitute for chilling in strawberry cv. Elsanta. Also, Porlingis and Boynton (1961) found that GA enhanced the emergence of inflorescences and increased the number of plants which flowered during 45 days subsequent to GA treatment in cv. Sparkle. Tafazoli (1975) pointed out that GA_3 completely prevented flower initiation when applied before initiation but increased the rate of flower emergence when applied after initiation.

Table 3. Effect of growth regulators on number of flowers and fruits of strawberry plant (combined analysis of 2002/ 2003 and 2003/2004 seasons).

Treatments (ppm)	Number of flowers				Number of fruits			
	Weeks after transplanting							
	12	16	20	24	12	16	20	24
Control	1.40	3.03	2.20	2.60	2.67	2.37	1.73	1.63
Ethrel 50	1.30	3.03	2.20	2.59	1.60	1.77	2.47	2.37
Ethrel 100	1.70	3.37	2.52	3.08	2.00	2.90	3.27	3.17
Ethrel 250	1.57	3.50	2.83	3.58	0.87	2.30	3.47	3.37
GA_3 10	2.23	3.03	2.93	3.74	2.87	2.83	4.53	4.43
GA_3 30	1.80	2.30	2.40	2.91	3.33	1.90	2.80	2.70
GA_3 50	1.30	2.23	2.67	3.32	2.53	2.10	1.67	1.57
UCZ 10	2.30	2.90	2.60	3.22	2.00	2.10	2.60	2.50
UCZ 15	1.63	3.07	2.47	3.01	1.93	2.43	3.00	2.90
UCZ 20	1.77	3.37	2.13	2.49	0.93	2.63	2.27	2.17
L.S.D. 5%	0.41	0.26	0.33	0.52	0.84	0.45	0.68	0.70

UCZ: uniconazole

In this experiment ethrel at 250 ppm caused a significant increase in number of flowers. These findings are not agree with those of Tafazoli and Vince-Prue (1978) who reported that ethephon at 2000 mg/l decreased the

number of flowers in cv. Redgauntlet. Moreover, Tafazoli and Shaybany (1978) noted that application of ethephon at 50 and 100 ppm did not affect the number of clusters in cv. Gem.

Number of fruits

Data presented in Table (3) indicated that both GA_3 at 30 or 10 ppm caused nonsignificant increase in number of fruits counted at 12 weeks from transplanting, while ethrel at 250 ppm showed significant reduction as compared to the control. At 16 weeks from transplanting, the number of fruits was significantly higher for plants from the 100 ppm ethrel or 10 ppm GA_3 treatments than in untreated plants, while 50 ppm ethrel treatment showed the lowest significant number of fruits. Concerning the effect of growth regulators after 20 and 24 weeks from transplanting, the highest number of fruits was resulted from GA_3 at 10 ppm which showed significant increment as compared with all other treatments including the control, followed by the treatment of ethrel at 250 ppm which came in second rank in this respect. While GA_3 at 50 ppm recorded the lowest number of fruits, without significant difference between it and the control. The results seemed generally that, GA_3 at 10 ppm cased significant increases in number of fruits as compared to the control. Such results are similar to those published by Turner (1963) and Tehranifar and Battey (1997) but with other cultivar and different concentration of GA_3. In this regard, it could be suggested that the cultivars varied in its response to GA. Also, the results are in agreement with those of Cain *et al*. (1983) who found that ethephon at 100 ppm increased the number of fruits in Centennial cultivar.

According to the previously mentioned results, vegetative growth and fruit production have different GA_3 optima, which are reflected at the antagonistic relationship between vegetative growth and fruit development. Besides, the good balance between vegetative growth and fruit development was more achieved by using GA_3 with low concentration (10 ppm).

Fruit yield

The combined analysis of both seasons on the monthly fruit yield and total yields as affected by growth regulators are shown in Table (4).

Monthly fruit yield

Concerning the summation of all fruit pickings during months of November/December, the highest values were obtained from ethrel at 250 ppm and GA_3 at 10 ppm without significant differences between them and the control, while the lowest value was observed from ethrel at 100 ppm. This reduction was significant as compared to the control. Generally, the differences were not significant between the growth regulator treatments and the control except ethrel at 100 ppm, GA_3 at 30 ppm and uniconazole at 20 ppm which showed significant reduction.

Concerning the summation of all fruit pickings during month of January, the highest value was obtained by using GA_3 at 10 ppm, while the lowest value was noticed from uniconazole at 15 ppm without significant differences between them and the control. The differences were not significant between treatments of growth regulators and the control**.**

Table 4. Effect of growth regulators on the monthly fruit yield and total yield (ton/feddan) during season (combined analysis of 2002/ 2003 and 2003/2004 seasons).

Treatments (ppm)	P1	P2	P3	P4	P5	Total yield
Control	1.690	4.284	2.547	2.255	0.801	11.577
Ethrel 50	1.494	4.334	2.936	2.484	0.971	12.386
Ethrel100	1.394	4.420	2.814	2.753	0.901	12.282
Ethrel 250	1.791	4.367	3.074	3.030	1.002	13.265
GA_3 10	1.720	4.661	3.428	3.081	0.990	13.879
GA_3 30	1.407	4.294	3.308	2.530	0.796	12.334
GA_3 50	1.610	3.879	2.331	1.716	0.727	10.263
UCZ 10	1.542	4.163	2.685	2.591	0.896	11.876
UCZ 15	1.554	3.874	2.706	2.543	0.853	11.529
UCZ 20	1.444	3.931	2.644	2.416	0.802	11.237
L.S.D. 5%	0.219	0.446	0.551	0.518	0.134	1.472

UCZ: uniconazole
P1: yield of months November and December
P2: yield of month January
P3: yield of month February
P4: yield of month March
P5: yield of months April and May

As for the summation of all fruit pickings during month of February, the highest values were recorded from GA_3 at 10 and 30 ppm. These two treatments gave significant increases of yield in this month over the control by 34.6 % and 29.9 %, respectively. Contra result was obtained by using GA_3 at 50 ppm. In general, the differences were not significant between treatments of growth regulators and the control except GA_3 at 10 and 30 ppm were significant.

Regarding the summation of all fruit pickings during month of March, the highest values were more achieved using GA_3 at 10 ppm, followed by the treatment of ethrel at 250 ppm. These two treatments gave significant increases of yield in this month over the control by 36.6 % and 34.4 %, respectively. On the other hand, the lowest value was resulted from GA_3 at 50 ppm with significant differences between it and the control. In general, the differences were not significant between treatments of growth regulators and the control except GA_3 at 10 ppm, ethrel at 250 ppm and GA_3 at 50 ppm.

With regard to the summation of all fruit pickings during months of April/May, the highest values were obtained from ethrel at 250 ppm and GA_3 at 10 ppm. These two treatments gave significant increases of yield during this period over the control by 25.1% and 23.6%, respectively. On the contrary, the lowest value was recorded from GA_3 at 50 ppm without significant difference between it and the control.

Total fruit yield

The highest total fruit yield was more achieved via spraying of strawberry plants with GA_3 at 10 ppm. Such treatment gave significant increase of total yield over the control by 19.9 %. Also, using ethrel at 250 ppm increased significantly the yield in relation to the control by 14.6 %. On the contrary, the lowest value was detected from GA_3 at 50 ppm without significant difference between it and the control.

From the above mentioned results, it could be suggested that spraying of strawberry plants with GA_3 at 10 ppm or with ethrel at 250 ppm showed better results of monthly fruit yield and total yield. Whereas, the inferior effect was associated with using GA_3 at 50 ppm and uniconazole at all used doses.

The results of GA_3 in the present study are in agreement with those of Singh *et al*. (1960) and Lopez-Galarza *et al.* (1989), while these results are not in agreement with those of Okasha *et al*. (1985) and Paroussi *et al.* (2002). In addition, the current results are in harmony with those obtained by Blatt and Sponagle (1973 and 1974) and Cain *et al*. (1983) upon ethrel, but these results are not in accordance with those obtained by Sachs and Iszak (1974) upon ethephon and Miura *et al.* (1995) upon uniconazole.

This differences in the results reported in the current experiment in respect to the results had been reported by other researchers may be due to the dissimilarity of the studied cultivars and the response sensitivity of this cultivars to the applied doses of this growth regulators.

The superiority of GA_3 at 10 ppm and ethrel at 250 ppm in increasing the monthly fruit yield and total yield could be attributed to their effect in increasing the number flowers and fruits.

Fruit quality

The effects of growth regulators on average fruit weight, total soluble solids, total sugars and ascorbic acid content are presented in Table (5) as follows:

Average fruit weight

Data show that the check plants exhibited the highest average fruit weight, while GA_3 at 50 ppm showed the lowest fruit weight. Generally, treatments of growth regulators gave significant reduction in average fruit weight as compared to the control except ethrel at 50 ppm and uniconazole at all used doses. Similar results were reported using GA_3 (Lopez-Galarza *et al*., 1989 on cv. Pajaro; Ozguven and Yilmaz, 2002 on cv. Camarosa**)** but the current results are in contrast to those of Okasha *et al*. (1985) on cv. Pajaro and Lopez-Galarza *et al*. (1989) on cv. Douglas.

Total soluble solids (TSS)

Total soluble solids are considered as one of the contributed factors in maximizing the taste of strawberry fruits.

Data show that the highest value was observed from GA_3 at 30 ppm, while the lowest value was noticed from uniconazole at 10 ppm, these differences were not significant as compared to the control. In general, differences were not significant between treatments of growth regulators and the control. Such results are in agreement with those of Okasha *et al*. (1985) and Ozguven and Yilmaz (2002) who reported that GA_3 did not affect TSS.

Total sugars

Results clearly indicate that the highest value of total sugars was obtained from check plants while the lowest value was noticed from ethrel at 250 ppm. In general, the differences were not significant between treatments of growth regulators and the control except GA_3 at 10 and 50 ppm and ethrel at 50 and 250 ppm showed significant reduction as compared to the control.

These results are similar to those obtained by Lopez-Galarza *et al*. (1989) upon GA_3 and Imam *et al.* (1997) upon uniconazole on broad bean.

Table 5. Effect of growth regulators on fruit quality of strawberry fruits (Combined analysis of 2002/2003 and 2003/2004 seasons).

Treatments (ppm)	Average fruit weight (g)	Total soluble solids (%)	Total sugars (g/100g D.W.)	Ascorbic acid (mg/100g F.W.)
Control	15.39	٨,٤٠	٢٤,٨٦	٧٤,٥٥
Ethrel ٥٠	14.37	٧,٩٧	٢٢,٥٠	٦١,٣٨
Ethrel ١٠٠	13.07	٨,٢٨	٢٣,٥٧	٦١,٦٧
Ethrel ٢٥٠	13.85	٨,٥٤	٢١,٣٥	٦٢,٠٣
GA_3 ١٠	13.08	٧,٨٥	٢٢,١٣	٦٣,٢٩
GA_3 ٣٠	12.60	٨,٨٠	٢٣,٥٣	٦٨,٩٣
GA_3 ٥٠	12.17	٨,٢٤	٢٢,٣٢	٦٧,٠٣
UCZ ١٠	14.26	٧,٦٩	٢٣,٩٤	٦٧,٠٣
UCZ ١٥	14.88	٨,٤٨	٢٣,٦٦	٦٨,٣٥
UCZ ٢٠	14.71	٧,٨٥	٢٣,٧٧	٧١,٩٣
L.S.D. 5%	1.35	٠,٧٨	١,٥٥	٥,٨٣

UCZ: uniconazole

Ascorbic acid content

Data indicate that the highest value of ascorbic acid content was detected at the control while the lowest value was noticed from ethrel at 50 ppm. In general, all treatments of growth regulators reduced ascorbic acid content, this reduction was significant except GA_3 at 30 ppm and uniconazole at 20 ppm. Such results are not in agreement with those obtained by using GA_3 (Okasha *et al*., 1985).

Generally, growth regulators slightly affect fruit quality expressed as weight, total soluble solids (TSS), total sugars and ascorbic acid.

Finally, it could be concluded from the forgoing results and discussion that applying exogenous gibberellic acid (GA_3) at concentration of 10 ppm to "Sweet Charlie" strawberry plants improved vegetative growth, encouraged flowering and fruit sitting with increasing monthly and total fruit yield.

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استجابة نباتات الفراولة لبعض منظمات النمو

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أجريت تجربتان حقليتان فى المزرعة البحثية التابعة لمركز تنمية الفراولة والمحاصيل غير التقليدية بالنوبارية, محافظة البحيرة خلال موسمي الزراعة المتتالين ٢٠٠٢/٢٠٠٣ و٢٠٠٣/٢٠٠٤. وتهدف الدراسة إلى بحث تأثير الإيثريل (الإيثيفون) بتركيزات ٥٠, ١٠٠, ٢٥٠ جزء فى المليون و حمض الجبريليك GA_3 بتركيزات ١٠, ٣٠, ٥٠ جزء فى المليون و يونيكونازول بتركيزات ١٠, ١٥, ٢٠ جزء فى المليون على صفات نمو نباتات الفراولة صنف سويت شارلى (طول النبات, طول عنق الورقة, المساحة الورقية, طول التاج والنسبة المئوية للمادة الجافة للنبات) والمحتوى الكيماوى للنبات و عدد الأزهار و الثمار والمحصول الشهري والمحصول الكلى و جودة الثمار(متوسط وزن الثمرة, المواد الصلبة الذائبة الكلية, السكريات الكلية و حمض الإسكوربيك).

أشارت النتائج إلى أن المعاملة بحمض الجبريليك زادت من طول النبات وطول عنق الورقة وطول التاج وكذلك النسبة المئوية للمادة الجافة للنبات فى معظم المعاملات. منظمات النمو لم تعكس فروق معنوية فيما يتعلق بالمساحة الورقية وذلك مقارنة بالكنترول فى معظم الحالات. منظمات النمو الثلاثة (حمض الجبريليك, الإيثريل, اليونيكونازول) زادت من النسبة المئوية للكربوهيدرات الكلية فى المجموع الخضرى لنباتات الفراولة ولكنها لم تؤثر على المحتوى النيتروجيني. حمض الجبريليك GA_3بتركيز ١٠ جزء فى المليون أو الإيثريل بتركيز ٢٥٠ جزء في المليون زاد من عدد الأزهار و الثمار وكذلك المحصول الشهري و الكلي. المواد الصلبة الذائبة الكلية بالثمار لم تتأثر بمنظمات النمو، بينما سجلت نباتات المقارنه أعلى قيم لمتوسط وزن الثمرة والسكريات الكلية وحمض الإسكوربيك .

وتجمل النتائج في أن الرش بحمض الجبريليك GA_3 بتركيز ١٠ جزء في المليون ثلاث مرات بعد ٣٠, ٤٥, ٦٠ يوم من الشتل أعطى أفضل توازن بين النمو الخضري و الثمري أدي إلي زيادة المحصول الشهري و الكلي لنباتات الفراولة.