CROWN DIAMETER, CHILLING, AND GIBBERELLIC ACID INTERACTIONS INFLUENCE GROWTH AND REPRODUCTIVE OF STRAWBERRY CV. FESTIVAL.

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ABSTRACT

An experiment was conducted in unheated greenhouse units of the Department of Horticulture and Landscape -College of Agriculture- University of Baghdad on the first of October, to observe the effects of amony interaction of crown diameter, chilling, and foliar application of gibberellic acid on vegetative growth, and reproductive in cv. 'Festival' of strawberry (*Fragaria x ananassa* (Duch)). Using randomized Complete Block Design (RCBD), Plants were sorted into two groups according to crown diameter (11-15mm (Cd1) and 6-10 mm (Cd2)), each of them sorted into two groups [Ch0 (without cold storage) and Ch1 (kept in a cold storage for three weeks at 1-2°C), gibberellic acid was sprayed on plants, with concentration treatments included a control (G0) (distilled water), 150 mg. L^{-1} (G1) and 300 mg. L^{-1} (G2).The results showed the highest leaf number and Leaf area. $Plant^{-1}$, (26.33), (29.70 dcm^2) in (Cd1.Ch1.GA0) and (Cd1.Ch1. GA1) respectively, Number of stolon increased significantly by GAs application, the highest number were (8.3) in (Cd1.Ch1. GA2). The highest value of the TSS % was produced from the plants under the effect of the treatment (Cd1.Ch1. GA0) (8.5%) and the highest pH were 3.70 from the treatment (Cd2.Ch0.GA2). The results indicated the superiority of treatment (Cd1.Ch0.GA0) in fruit number (22.4), weight (17.77g) and a plant yield (398.2g).

Key word: *Fragaria ananassa*, Festival, chilling, GA, Crown diameter

تاثير تداخل قطر التاج والتبريد والجبرلين في نمو وانتاج الشليك صنف الفيستفال

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المستخلص

نفذ البحث في بيت بلاستيكي في قسم البستنة وهندسة الحدائق – كلية الزراعة– أبو غريب– جامعة بغداد بهدف دراسة تاثير تداخل قطر تاج نباتات الشليك (*Fragaria x ananassa* (Duch)) صنف Festival وتعريضها لدرجات الحرارة المنخفضة والمعاملة بالجبرلين. استعمل تصميم القطاعات الكاملة المعشاةRCBD ، واختيرت شتلات شليك صنف فيستيفال بقطرين مختلفين للتاج 11–15ملم (Cd1) او 6–10ملم (Cd2) وتم تعريض نصف عدد الشتلات من الحجمين الى درجة حرارة منخفضة (1– 2°م) لمدة ثلاثة اسابيع Ch1 اما النصف الاخر فزرعت دون التعريض للحرارة المنخفضة (Ch2) وبعد الزراعة بشهرين تم معاملة النباتات بالجبرلين بثلاثة تراكيز، الماء المقطر GA0 والمعاملة بالجبرلين بتركيز 150 ملغم. لتر$^{-1}$ GA1 وتركيز 300 ملغم. لتر$^{-1}$ GA2، اظهرت النتائج تاثيرات حصلت معنويا لتداخل عوامل البحث في الصفات الخضرية والثمرية لنباتات الشليك، اظهرت النتائج زيادة معنوية في عدد الاوراق والمساحة الورقية بلغت (26.33) و(29.70 دسم^2) في المعاملتين (Cd1.Ch1.GA0) و(Cd1.Ch1. GA1) على التوالي، ازداد عدد المدادات معنويا مع زيادة تركيز الجبرلين في المعاملات بلغ 8.33 في المعاملة (Cd1.Ch1. GA2). اعلى نسبة مواد صلبة ذائبة سجلت في المعاملة (Cd1.Ch1. GA0) بلغت 8.5 % فيما سجلت المعاملة (Cd2.Ch0.GA2) اعلى نسبة حموضة كانت 3.70، فيما تفوقت المعاملة (Cd1.Ch0.GA0) بعدد ووزن الثمرة وحاصل النبات الواحد بلغت (22.4) و(17.77 غم) و(398.2 غم) بالتتابع.

الكلمات المفتاحية: *Fragaria x ananassa*، Festival، التبريد ، الجبرلين، قطر التاج.

INTRODUCTION

Strawberry (Fragaria ananassa Duch.) belongs to the Rosaceae family, it is a perennial rosette plant with short internodes in its crown. Crown branching is necessary for competent flowe - ring, and as a result, for berry crop production (13). A crown diameter higher than 8.0 mm has been considered as a good vigor indicator (11). The earlier and higher fruit yield resulted by larger crowns which indicate higher vigor and faster initial growth, (2, 10). Johnson et al. (14) pointed that 'Chandler' transplants with larger crown diameters produced significantly early and total marketable yield. To ensure high production it should be use medium and large fresh plant with a crown diameter from 8 to 14 mm (6). Strawberries produce flowers and fruit continuously during the growing season and, produce stolons (runners) sparsely, (23). The Chilling of strawberry plants was an important factor to promote both reproductive and vegetative responses (7, 17, 24). Low temperature in strawberry environments is related to chilling, a varying period of expo - sure to temperatures below 7°C that break bud dormancy (8). Lieten 15) revealed that chilled and non-chilled plants of 'Elsanta' both produced flower trusses, but the shorter trusses, smaller berry size and poorer fruit quality were in non-chilled plants. Bish et al. (3) found that the higher, earlier fruit production resulted from the lower temper - ature conditioning treatment. Gibber -ellins are plant hormones that regulate growth, have an important role in several important bioche - mical and morphogenetic responses in plants, GAs increase growth of most plant species especially rosette plants (26). The GA3 application of strawberry reacted as similar as environmental factors such as low temperature and long days (25). Application of exogenous gibberellic acid (GA3) is a common agricu - ltural practice to break flower bud dormancy early. GAs needed for stolons (runner) initiation in strawberry, and the inhibition of GA biosynthesis leads to the formation of crown branches. Hytönen et al. (12) indicated that GAs enhanced runner formation from axillary buds of the strawberry crown. Paroussi et al. (21) observed that 200 mg. L-1 of GA3 application increased the percentage of malformed fruits, resulting in a significant decrease in total marketable yield. Results indicated that the treatment of Gibberellic acid (150) mg. L-1 have the greatest effect on leaf and fruit number, GA3 due lower this contain and higher acidity that delayed fruit ripening (18, 20). GA3 (100 mg. L-1) application increased runner in Merak species (9). The objective of this research was to evaluate the synergistic effects of crown diameters, chilling requirement and application of exogenous gibberellic acid on the vegetative growth and Strawberry production cultivar 'Festival'.

MATERIALS AND METHODS

Plants of 'Strawberry, Cv. Festival' which originated from a 1995 cross between 'Rosa Linda' and 'Oso Grande' (4), were planted in an unheated greenhouse unit of the Department of Horticulture and Landscape - College of Agriculture - University of Baghdad in the first of October 2013. Plants were sorted into two groups according to crown diameter [11-15mm (Cd1) and 6-10 mm (Cd2)], each of them sorted into two groups, without cold storage (Ch0) and kept in a cold storage (Ch1) for three weeks at 1-2°C (19). Exogenous GA was sprayed on plants, treatment concentr - ations included control (G0) (distilled water), 150 mg. L–1 (G1) and 300 mg. L–1 (G2), Five plants were sprayed for each treatment, GA sprays were repeated after two weeks. The first application on the first week of December, Each treatment was replicated three times, plants arranged in a completely randomized design. Data on vegetative parameters taken on, number of leaves, alive area, total area of the leaf. Plant^{-1} (dcm^2), number of stolons, number of crowns, and chlorophyll content. Data on reproductive parameters were taken with a number of fruit, fruit weight, fruit firmness, fruit, dry matter (%), and total yield plant^{-1}. Fruit quality was also monitored to determine total soluble solids (TSS), pH (as total acidity) and TSS: pH of the fruit. All data were analyzed by analysis of variance (ANOVA) using the program Ginstat.

RESULTS AND DISCUSSION Vegetative parameters

The results in the table 1, indicated that the highest leaf number (26.3) was obtained in chilled plants with larger crown diameters (Cd1.Ch1.GA0), the greatest Leaf area. Plant^{-1} 29.70 dcm^2 were in chilled plants, large crown

diameter, which treated with150 mg. L^{-1} of GA (Cd1.Ch1. GA1). Number of stolon increased significantly by GAs application at 150 and 300 mg. L^{-1}, the highest number was (8.3) in (Cd1.Ch1. GA2) compared to the other treatments, the results may due to GAs that promote cell division and cell elongation (1), but Dale et al. (5) found that may caused by growth regulators, which can induce stolons formulation by activating dormant buds to grow or by preventing the flower bud initiation.

Table 1. Crown diameter, chilling, and gibberellic acid interactions affect the number of leaves, leaf area. Plant^{-1} (dcm^2), chlorophyll contents, number of crowns, and stolon.

Treatment	Number of leaves	Leaf area. Plant^{-1} (dcm^2)	Chlorophyll content mg. 100g^{-1}	Number of crowns	Number of stolon
Cd1	18.9	22.08	240.0	4.1	3.9
Cd2	14.4	18.87	229.9	2.8	3.3
Ch0	13.7	18.75	239.8	3.3	2.9
Ch1	19.6	22.20	230.1	3.6	4.3
GA0	18.3	18.98	213.3	4.3	0.3
GA1	15.9	21.19	250.4	3.4	4.1
GA2	15.7	21.26	241.2	2.6	6.4
Cd1*Ch0* GA0	16.3	23.38	270.4	5.7	0.7
Cd1*Ch0* GA1	10.3	14.14	274.0	2.7	3.7
Cd1*Ch0* GA2	15.0	22.88	192.3	2.3	5.7
Cd1*Ch1*GA0	26.3	20.51	181.8	5.3	0.3
Cd1*Ch1* GA1	24.3	29.70	233.7	5.0	4.7
Cd1*Ch1* GA2	21.0	21.88	287.7	3.3	8.3
Cd2*Ch0* GA0	13.3	17.03	240.6	3.7	0.0
Cd2*Ch0* GA1	14.3	15.83	260.4	3.3	3.0
Cd2*Ch0* GA2	13.0	19.27	201.0	2.3	4.3
Cd2*Ch1*GA0	17.3	15.01	160.6	2.7	0.0
Cd2*Ch1* GA1	14.7	25.07	233.4	2.7	5.0
Cd2*Ch1* GA2	14.0	21.02	283.7	2.3	7.3
L.s.d	2.846	1.032	13.32	1.049	1.073

The treatment (Cd1.Ch0. GA0) Showed the highest number of crowns (5.7). The results indicated a high content of chlorophyll in plants with a large crown diameter when treated by GA1and GA2, So the treatment (Cd1.Ch1. GA2) showed a significant increasing in chlorophyll (287.7 mg. 100g^{-1}), While treatment (Cd2. Ch1. GA0) showed less content of chlorophyll was 160. 6 mg. 100g^{-1}, that may Due to a movement of photosynthetic material by GAs causing a spurt in the processes of growth (Lolaei, et al. 2013).

Fruit quality parameters

TSS%, pH and TSS: pH

The results in the table 2 observed that TSS was decreased as GA3 concentration increased in treatments, it showed the superiority of a TSS % in the treatment (Cd1.Ch1. GA0) 8.5%, while treatment (Cd1.Ch0. GA2) had the lowest value of TSS, 3.4%. The fruit′s pH (TA) of plants treated with GA at 300 mg. L^{-1} increased significantly as it had shown in table 2 the high value of pH 3.70 was in treatment (Cd2.Ch0.GA2) as compared to lower pH 3.34 in (Cd2.Ch0.GA2). The ratio of TSS: pH was also affected by interaction of factors, (Cd1.Ch0. GA2). The results agreed with (16,18).

Table 2.Crown diameter, Chilling, and Gibberellic Acid interactions affect fruit TSS, pH and TSS: pH.

Treatment	TSS	pH	TSS :PH
Cd1	5.9	3.48	1.69
Cd2	4.9	3.56	1.39
Ch0	4.7	3.50	1.74
Ch1	6.0	3.54	1.35
GA0	6.7	3.45	1.95
GA1	5.5	3.55	1.54
GA2	4.0	3.56	1.14
Cd1*Ch0* GA0	6.7	3.50	1.93
Cd1*Ch0* GA1	4.4	3.38	1.28
Cd1*Ch0* GA2	3.4	3.52	0.99
Cd1*Ch1*GA0	8.5	3.47	2.52
Cd1*Ch1* GA1	7.2	3.51	2.04
Cd1*Ch1* GA2	5.0	3.55	1.42
Cd2*Ch0* GA0	5.7	3.63	1.56
Cd2*Ch0* GA1	4.7	3.34	1.29
Cd2*Ch0* GA2	3.8	3.70	1.08
Cd2*Ch1*GA0	6.0	3.64	1.80
Cd2*Ch1* GA1	5.6	3.53	1.58
Cd2*Ch1* GA2	3.9	3.53	1.06
L.s.d	0.738	0.030	0.167

Fruit parameters

Fruit dry matter and firmness

The results indicated in Table 3 that the dry matter of fruits in non-chilled plants with small crown diameter and no GAs application had significantly decreased (Cd2. Ch0. GA0)

it was 3.94%, whereas chilled plants with large crown diameter and GA spraying significantly increased dry matter, the highest value was 8.08% in (Cd1.Ch1.GA2). The most fruit firmness 3.0kg. Cm^{-1} observed in (Cd2. Ch1.GA2) compared with (Cd1.Ch1.GA0) that had least firmness (0.9 kg. Cm^{-1}).

Fruit number, weight and yield

The Table 3 revealed that there were a significant relation between crown diameter and fruit number, weight and a plant yield, which may due to carbohydrate reserve in the crown, the results indicated the superiority of treatment (Cd1.Ch0.GA0) in fruit number (22.4), weight (17.77g) and a plant yield (398.2g), when compared to other treatments, whereas non-chilled plants with small crown diameter and GA application caused the least fruit number, weight and a plant yield. The results agreed with the results of Darnell and Hancock (7) who indicated that the crown diameter influenced strawberries productivity. GAs application 150 mg. L^{-1} and 300 mg. L^{-1} decreased significantly fruit number, weight and a plant yield, These results agree with the results of other researchers (3,9). Chilling affected fruit parameters, that agreed with Darnell and Hancock (7) who indicated that chilling is required for vegetative develop - pment, fruit production and quality.

Table 3.Crown diameter, Chilling, and Gibberellic Acid interactions affect a number of fruit, fruit firmness, dry matter, weight, and plant yield.

Treatment	Number of fruits	Fruit firmness $kg.cm^{-1}$	Fruit dry matter %	Fruit weight (g)	Yield (g. $Plant^{-1}$)
Cd1	**15.9**	**1.8**	**7.18**	**11.22**	**191.7**
Cd2	**12.7**	**1.9**	**5.68**	**10.31**	**138.9**
Ch0	**14.9**	**1.8**	**6.25**	**10.04**	**151.4**
Ch1	**13.6**	**1.9**	**6.60**	**11.49**	**179.2**
GA0	**16.4**	**1.2**	**5.49**	**14.63**	**250.6**
GA1	**16.6**	**1.9**	**6.66**	**10.56**	**174.4**
GA2	**9.9**	**2.5**	**7.13**	**7.12**	**70.9**
Cd1*Ch0* GA0	**22.4**	**1.5**	**7.57**	**17.77**	**398.2**
Cd1*Ch0* GA1	**15.9**	**1.8**	**7.38**	**10.73**	**170.3**
Cd1*Ch0* GA2	**7.5**	**2.2**	**7.37**	**6.48**	**48.4**
Cd1*Ch1*GA0	**14.3**	**0.9**	**5.70**	**14.79**	**211.6**
Cd1*Ch1* GA1	**21.0**	**2.1**	**6.95**	**10.31**	**216.4**
Cd1*Ch1* GA2	**14.5**	**2.5**	**8.08**	**7.24**	**105.0**
Cd2*Ch0* GA0	**18.6**	**1.3**	**3.94**	**15.38**	**285.8**
Cd2*Ch0* GA1	**11.4**	**1.5**	**5.35**	**11.11**	**127.3**
Cd2*Ch0* GA2	**6.1**	**2.4**	**5.87**	**7.50**	**45.4**
Cd2*Ch1*GA0	**10.1**	**1.0**	**4.74**	**10.58**	**106.7**
Cd2*Ch1* GA1	**18.3**	**2.3**	**6.97**	**10.08**	**183.5**
Cd2*Ch1* GA2	**11.7**	**3.0**	**7.19**	**7.24**	**85.0**
L.s.d	**1.328**	**0.18**	**1.472**	**1.275**	**23.23**

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