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# Effect of Foliar Application of $GA_3$ and Zinc on Growth, Yield and Quality of Strawberry (*Fragaria x ananassa* Duch) Tioga cv.

Naji Isam Barwary* Hasan Salim Nabi**
Shawkat Mustafa Atrushy***

* Department of Horticulture / College of Agriculture / University of Duhok. / Kurdistan Region/ Republic of Iraq
** Department of Horticulture / College of Agriculture / University of Duhok. / Kurdistan Region/ Republic of Iraq
*** Department of Horticulture / College of Agriculture / University of Duhok. / Kurdistan Region/ Republic of Iraq

## Abstract

This investigation was carried out during growing season (2015 – 2016) on Strawberry (*Fragaria X ananassa* Duch) Tioga cv. Planted in the farm of college of Agriculture, university of Duhok, Kurdistan regions / Iraq to study the effect of $GA_3$ with concentration (0, 100, 200 and 300 $mg.L^{-1}$), and Zinc with concentration (0, 2 and 4 $g.L^{-1}$), on growth, yield and quality of strawberry plant. According to the obtained results the $GA_3$ and Zinc spraying especially at (300 $mg.L^{-1}$ and $4g.L^{-1}$) respectively caused to improve most of the studied parameters, except of total acidity, decreased with increasing $GA_3$ and Zinc concentrations. The interaction between $GA_3$ and Zinc at high concentration resulted in the maximum values of leaf area (30.81cm), leaf chlorophyll content (42.53 SPAD), number of fruit per plant (21.07), yield (269.63$g.plant^{-1}$), Total soluble solids (8.00 %) and anthocyanin (25.43 $mg.100^{-1}$ g F. Wt).

Keyword: strawberry, $GA_3$, Zinc.

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## Introduction

Strawberry *Fragaria X ananassa* Duch is one of the over ripe fruit among perennial fruits in spring season. The first crop production is earlier about a month of planting; Strawberry has the ability to form vegetative and reproductive components easily, this characteristic make this kind of fruit become an ideal crop for investigation of nutrient combinations (7). Gibberellins belonged to the group of plant hormones, which promote growth especially for rosette plant, increase runner production, flowers and yield.

Asadi *et. al.*(7) Found that application of GA3 at (0, 25 and 50 $mg.L^{-1}$) lead to increase number of flower per inflorescence, fruit weight and total yield, especially at third level (50 $gm.L^{-1}$). Perez de Camacaro *et. al.*(12) Studied the influence of plant growth regulator GA3 at varies concentrations of GA3 (25, 50 and 75 $mg.L^{-1}$), he found that the number of fruit, yield and leaf nutrient status was increased at (75 $mg.L^{-1}$), the TSS and total sugar content in fruit was decreased with increasing the concentration of GA3. Abdollahi *et.al.*(3) Found that application of $ZnSO_4$ leads to increasing total yield and fruit quality of Silva strawberry.

The aim of this study was to investigate the effect of foliar application of $GA_3$, Zinc and their interaction on growth, yield and quality of strawberry (*Fragaria X ananassa* Duch) Tioga cv. to enhance fruit quality and yield.

## Materials and Methods

This study was carried out in the farm of the college of Agriculture, University of Duhok, Kurdistan regions / Iraq to study the effect of four concentration of $GA_3$ (0, 100,200 and 300 $mg.L^{-1}$) and three concentration of pure Zinc (0, 2 and 4$g.L^{-1}$) on strawberry plant, in addition to the control for each of them. The transplant of strawberry planted in 1/10/2015 in the farm at the distance 30 cm between plant

and 45 cm between the rows, and then was sprayed with $GA_3$ and Zinc three times per growth, first 15 days after planting, second first week of March and month later. The date of spraying of $GA_3$ and Zinc was done until runoff. Therefore, the experiment consisted of twelve treatments (four concentration of $GA_3$, three concentrations of Zinc) with three replication and five plants for each experimental unit. (Randomize complete block design) design was used to arrange the treatments for analyzing and means were compared according to Duncan's multiple range tests at 5% level of portability (5) by using SAS (2002) program. The following Parameter was measure by (Single Leaf Area $cm^2$) Estimated leaf area = length × width × 0.75 (2), dry Weight of Shoot System (g. $plant^{-1}$) they were oven dried at 70 $^0C$ until the weight was fixed (6), leaf chlorophyll content by using chlorophyll meter (SPAD), number of Fruits ($Plant^{-1}$), average of Fruit Weight (g), fruit Yield (g. $Plant^{-1}$), total soluble solid % using the table Refractometer (16), total Acidity % using titration with NaoH (0.1 N) and phenolphthalein index (1). and Anthocyanin content (mg.100g-1 F. Wt.) (15).

**Results and Discussion**

Vegetative Growth Properties of Strawberries:

1- Single Leaf Area ($cm^2$. Plant-

Data in table (1) revealed that the spraying of $GA_3$ at all concentration lead to increase TSS % in the fruit of strawberry Tioga cv. compared to control. Moreover, the best result obtained at 4 $g.L^{-1}$ of Zinc which was (26.66) compared to other treatments. The interaction between (300 $mg.L^{-1}$ of $GA_3$ and 4 $g.L^{-1}$ of Zinc) was influence positively on total soluble solid % in fruit of strawberry Tioga cv.

2-Dry Weight of Shoot System (g. $plant^{-1}$):

The dry weight of shoot system of strawberry plant was significantly affected by $GA_3$

spraying at (200 and 300 $mg.L^{-1}$) and Zinc spraying at (4 $g.L^{-1}$) in comparison to the control treatment clear in (table 2). In case of interaction, there were also significant differences in term of dry weight of shoot system especially at (200 $mg.L^{-1}$ of $GA_3$ and 4 $g.L^{-1}$ of Zinc) in comparison with most of the other interaction treatments.

**Table (1) Effect of foliar application of $GA_3$ and Zinc on single leaf area (leaf $cm^2$. $Plant^{-1}$) of strawberry Tioga cv.**

| $GA_3$ | Zinc ($g.L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| ($mg.L^{-1}$) | 0 | 2 | 4 | ($mg.L^{-1}$) |
| 0 | 16.52 g | 19.82 e-g | 23.85 b-d | 20.06 b |
| 100 | 18.11 fg | 23.98 b-d | 25.12 bc | 22.40 a |
| 200 | 22.16 c-e | 23.06 b-d | 26.88 b | 24.04 a |
| 300 | 21.12 c-f | 19.97 d-g | 30.81 a | 23.97 a |
| Zinc | 19.48 c | 21.71 b | 26.66 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

3-Total leaf chlorophyll content.(SPAD):

Table (3) shows significant differences of $GA_3$ spraying on total chlorophyll content in leaf. The $GA_3$ at concentration (200 and 300 $mg.L^{-1}$) had significant differences compared with control. Similarly Zinc spraying, increased leaf chlorophyll content as

compared to control. Concerning the interaction between $GA_3$ and Zinc spraying the best data were measured for total chlorophyll content in leaves on 300 $mg.L^{-1}$ of $GA_3$ with 4 $g.L^{-1}$ of Zinc which was (44.73 SPAD) compared with some of interaction treatments.

**Table: (2) Effect of foliar application of $GA_3$ and Zinc on dry weight of shoot system ($g.plant^{-1}$) of strawberry Tioga cv.**

| $GA_3$ | Zinc ($g.L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| ($mg.L^{-1}$) | 0 | 2 | 4 | ($mg.L^{-1}$) |
| 0 | 14.34 ef | 18.13 c-e | 15.78 d-f | 16.08 b |
| 100 | 14.35 ef | 14.04 f | 23.38 ab | 17.26 b |
| 200 | 15.44 ef | 21.02 bc | 24.88 a | 20.45 a |
| 300 | 16.13 d-f | 19.42 cd | 24.68 ab | 20.07 a |
| Zinc | 15.07 c | 18.15 b | 22.18 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Fruit Yield Properties of Strawberry:

3- Number of fruits per plant**:**

The $GA_3$ spraying, as shown in table (4), significantly effected on number of fruit per plant with the superiority for 200 and 300 $mg.L^{-1}$ compared to control. Also spraying of Zinc at $4g.L^{-1}$ had significantly increased number of fruits

per plant which was (16.77 $fruit.plant^{-1}$) compared to control

(9.75 fruit.plant$^{-1}$). The interaction between spraying $GA_3$ at 300 mg.L$^{-1}$ and Zinc at 4g.L$^{-1}$ obtained the best record that was (21.07) compared to all other interaction treatments.

**Table (3): Effect of foliar application of $GA_3$ and Zinc on Total leaf chlorophyll Content (SPAD) of strawberry Tioga cv.**

| $GA_3$ | Zinc (g.L$^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| (mg.L$^{-1}$) | 0 | 2 | 4 | (mg.L$^{-1}$) |
| 0 | 34.73 f | 39.20 c-e | 41.33 a-d | 38.42 b |
| 100 | 35.70 ef | 37.73 d-f | 39.10 c-e | 37.51 b |
| 200 | 39.33 c-e | 41.10 a-d | 42.53 a-c | 40.99 a |
| 300 | 39.83 b-d | 43.53 ab | 44.73 a | 42.70 a |
| Zinc | 37.40 b | 40.39 a | 41.93 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

4-Average of fruit weight (g)

Result in table (5) revealed that the $GA_3$ spraying had significant impact on average fruit weight of strawberry especially at high concentration (300 mg.L$^{-1}$) that was (11.83g). The same is true for Zinc spraying that high concentration (4g.L$^{-1}$) had significant effect on weight of strawberry fruits. The interaction between $GA_3$ and Zinc had significant effect on weight of fruit as compared with most of other interaction treatments.

**Table (4): Effect of foliar application of $GA_3$ and Zinc on number of fruits per plant of strawberry Tioga cv.**

| $GA_3$ ($mg.L^{-1}$) | Zinc ($g.L^{-1}$) | | | $GA_3$ ($mg.L^{-1}$) |
|---|---|---|---|---|
| | 0 | 2 | 4 | |
| 0 | 9.33 g | 11.53 ef | 12.73 de | 11.20 b |
| 100 | 9.67 g | 10.73 fg | 14.47 c | 11.62 b |
| 200 | 10.47 fg | 11.93 d-f | 18.80 b | 13.73 a |
| 300 | 9.53 g | 13.20 cd | 21.07 a | 14.60 a |
| Zinc | 9.75 c | 11.85 b | 16.77 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

5.Plant Yield ($g.Plant^{-1}$):

It is obvious from results in table (6) that the $GA_3$ spraying at 300 $mg.L^{-1}$ had significant influence on the yield (174.64g). Also zinc spraying at $4g.L^{-1}$ significantly improve the yield that record (207.750g). The interaction between high concentration of both factors (300 and $4g.L^{-1}$) gave the superior yield which recorded (269.63g) as compared to all other interaction treatments.

Fruit Quality Properties

6- Total Soluble Solid Percentage**.**

The results in table (7) show clearly that the $GA_3$ concentration had no significant effect in altering the Total Soluble Solids % in strawberry fruit. Zinc spraying at $4g.L^{-1}$ to increase the Total Soluble Solids % in strawberry fruits, the interaction between $GA_3$ and Zinc at 300 and $4g.L^{-1}$ of Zinc significantly improved Total Soluble Solids % in fruits as

compared to some of the other interactions.

**Table: (5) Effect of foliar application of $GA_3$ and Zinc on Average of fruit weight (g) of strawberry Tioga cv.**

| $GA_3$ | Zinc ($g.L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| ($mg.L^{-1}$) | 0 | 2 | 4 | ($mg.L^{-1}$) |
| 0 | 10.36 cd | 11.23 b | 11.19 bc | 10.93 b |
| 100 | 10.28 d | 10.50 b-d | 12.62 a | 11.13b |
| 200 | 10.73 b-d | 10.71 b-d | 12.59 a | 11.34 b |
| 300 | 12.38 a | 10.31 d | 12.80 a | 11.83 a |
| Zinc | 10.94 b | 10.69 b | 12.30 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

7- Fruit total acidity (%)

Data in table (8) clarified that $GA_3$ spraying at 300$mg.L^{-1}$ had no significant differences with control but significantly differ with 100 and 200 $mg.L^{-1}$ of $GA_3$. Zinc spraying at both concentrations caused to decrease total acidity (%) in fruit as compared with control. In correlation to dual interactions, the control interaction treatment between $GA_3$ and Zinc spraying recorded highest value that was (0.89 %) and significantly differ from all other interaction treatments.

8- Fruit anthocyanin content ($mg.100g^{-1}$ F.Wt.):

Results in table (9) clearly show that the $GA_3$ spraying at 300 $mg.L^{-1}$ had significant differences in enhancing Anthocyanin percentage

in strawberry fruit that (20.36 %) compared to control. In addition, both concentration of Zinc spraying (2 and 4g.$L^{-1}$) significantly improve Anthocyanin percentage in fruit. Relating to interaction between two factors, the ($GA_3$ * Zinc) was effective in enhancement of Anthocyanin percentage and this was obvious in interaction treatment of 300mg.$L^{-1}$ of $GA_3$ and 4g.$L^{-1}$ of Zinc that was (25.43 %) compared to all other interactions.

**Table :( 6) Effect of foliar application of $GA_3$ and Zinc on Plant yield (g. plant$^{-1}$) of strawberry Tioga cv.**

| $GA_3$ | Zinc (g.$L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| (mg.$L^{-1}$) | 0 | 2 | 4 | (mg.$L^{-1}$) |
| 0 | 96.43 h | 129.60 d-f | 142.28 d | 122.77 c |
| 100 | 99.35 gh | 112.43 f-h | 182.40 c | 131.39 c |
| 200 | 112.07 f-h | 127.70 d-f | 236.69 b | 158.82 b |
| 300 | 118.09 e-g | 136.20 de | 269.63 a | 174.64 a |
| Zinc | 106.49 c | 126.48 b | 207.75 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

It's clear from tables (1-9) that both $GA_3$ and Zinc had significant effect on mostly all vegetative growth, yield and quality parameters undertaken in this study of strawberry plant cv. Tioga, the positive effect o $GA_3$ might be attributed to the role of $GA_3$ in stimulating vegetative growth Tables (1-3) which increased

carbohydrate formation in addition to its direct effect on stimulating fruit growth (13; 12). Also may be due to its role in increasing cell division and cell elongation (11 ; 14), also This effect may be due to an increase on the total sugars content, which, in turn, increases total water content in berries measured as sugar uptake, and thus, increase fruit weight(18). besides, sugars bear osmotic driving force for cellular expansion (17) and modulation of gene expression (10) through signaling mechanisms.

**Table (7) Effect of foliar application of $GA_3$ and Zinc on Total Soluble Solid Percentage (Total Soluble Solids %) of strawberry Tioga cv.**

| $GA_3$ | Zinc ($g.L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| ($mg.L^{-1}$) | 0 | 2 | 4 | ($mg.L^{-1}$) |
| 0 | 7.33 a-d | 7.00 a-e | 7.00 a-e | 7.11 a |
| 100 | 6.50 c-e | 7.50 a-c | 7.33 a-d | 7.11 a |
| 200 | 7.33 a-d | 6.17 e | 7.73 ab | 7.08 a |
| 300 | 6.33 d-e | 6.83 b-e | 8.00 a | 7.06 a |
| Zinc | 6.88 b | 6.88 b | 7.52 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

The positive role of spraying with Zinc may be due to that Zinc involved in many physiological functions. Its inadequate supply will reduce crop yields (9), since Zinc plays very important roles in plant metabolism by influencing the activities of hydrogenise and carbonic anhydrate, stabilization of ribosomal fractions and synthesis

of cytochrome (4). Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of Auxin synthesis and pollen formation (3). Furthermore, the regulation and maintenance of some genes required for the tolerance of environmental stresses in plants are Zinc dependent (8).

**Table (8) Effect of foliar application of $GA_3$ and Zinc on Fruit total acidity (%) of strawberry Tioga cv.**

| $GA_3$ | Zinc ($g.L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| ($mg.L^{-1}$) | 0 | 2 | 4 | ($mg.L^{-1}$) |
| 0 | 0.89 a | 0.71 cd | 0.75 bc | 0.78 a |
| 100 | 0.77 bc | 0.62 e | 0.67 de | 0.68 b |
| 200 | 0.73 bc | 0.73 bc | 0.63 e | 0.70 b |
| 300 | 0.78 b | 0.86 a | 0.61 e | 0.75 a |
| Zinc | 0.79 a | 0.73 b | 0.66 c | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

**Table (9) Effect of foliar application of $GA_3$ and Zinc on Fruit anthocyanin content (mg/100 g F. Wt.) of strawberry Tioga cv.**

| $GA_3$ | Zinc ($g.L^{-1}$) | | | $GA_3$ |
|---|---|---|---|---|
| ($mg.L^{-1}$) | 0 | 2 | 4 | ($mg.L^{-1}$) |
| 0 | 14.43 f | 17.52 cd | 18.57 c | 17.51 b |
| 100 | 16.51 ef | 17.67 cd | 21.55 b | 17.58 b |
| 200 | 16.44 ef | 18.44 c | 23.40 b | 18.43 b |
| 300 | 18.29 de | 19.36 bc | 25.43 a | 20.36 a |
| Zinc | 19.42 b | 22.50 a | 23.49 a | |

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

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# تأثير الرش بحامض الجبريليك والزنك على نمو وحاصل ونوعية ثمار الشليك ( *Fragaria x ananassa* Duch) صنف Tioga

ناجي عصام حسين * حسن سليم نبي** شوكت مصطفى الاتروشي

*قسم البستنة/كلية الزراعة/جامعة دهوك/ اقليم كردستان/ جمهورية العراق

**قسم البستنة/كلية الزراعة/جامعة دهوك/ اقليم كردستان/ جمهورية العراق

***قسم البستنة/كلية الزراعة/جامعة دهوك/ اقليم كردستان/ جمهورية العراق

**المستخلص**

أجريت هذه التجربه خلال الموسم الزراعي 2015 – 2016 على نبات الشليك ( *Fragaria X ananassa* Duch) صنف Tioga مزروعة في حقل كلية الزراعة/ جامعة دهوك لدراسة تاثير تراكيز حامض الجبريليك والزنك (صفر و 100 و 200 و300 ملغ.لتر$^{-1}$)،(صفر و2 و 4 غم.لتر$^{-1}$) على التوالي على نمو وكمية ونوعية حاصل نبات الشليك. النتائج أظهر ان رش حامض الجبريليك والزنك خاصة عند تراكيز (300 ملم.لتر$^{-1}$ و 4 غم.لتر$^{-1}$) على التوالي ، ادت الى تحسين معظم الصفات المدروسة ما عدا النسبة المئوية للحموضة الكليةانخفضت مع زيادة تراكيز حامض الجبريليك والزنك. التداخل بين حامض الجبريليك والزنك عند التركيز العالي اعطت اعلى القيم من مساحة الورقة (30,81 سم$^2$) ومحتوى الورقة من الكلوروفيل (42,53 سباد) وعدد الثمار لكل نبات (27,07) والحاصل الكلي (269,63 غم.نبات$^{-1}$) ونسبة المواد الصلبة الذائبة الكلية (8,00%) والانثوسيانين (ملغ.100 غم وزن طري).

كلمات مفتاحيه: شليك ، حامض الجبريليك ، الزنك

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