Effect of gibberellic acid and zinc sulphate on vegetative, flowering, seed yield and chemical consistent of jojoba plant (*Simmondsia chinensis*)

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ABSTRACT

This experiment was conducted to study jojoba response (*Simmondsia chinensis*) evergreen dioecious shrub to zinc sulphate plus gibberellic acid foliar application on vegetative, flowering, seed yield and seed chemical composition at private farm during two successive seasons of 2015 and 2016 in the Egypt. An experiment was laid out in randomized complete block design with three replications. In this study, jojoba plants were sprayed with all combination treatments of zinc sulphate (0, 25, 50 and 75ppm) plus gibberellic acid (0, 50, 100 and 150ppm) thrice in the beginning of December, March and May. There results revealed that all combination treatments showed a significant improvement in all examined parameters with an increase in ZnSO₄ / GA₃ levels in comparison with untreated trees. Therefore, the maximum significant branch length (99.36 and 103.46 cm), secondary branches length (55.82 and 58.36 cm) obtained by application of 75ppm ZnSO₄ plus 150ppm GA₃ treatment, so this combination recorded the highest percentage of flowering (%), final fruit set (95.01, 95.24%), total chlorophyll, mineral% content, seed yield per feedan (2200, 2145 kg) and seed lipid content(57.6%, 58.55%) at first and second terms respectively. The application of 75ppm ZnSO₄ plus 150ppm GA₃ treatment is recommended to improve jojoba traits which lead to raise its economic value as a promising tree which potentially useful as a biofuel with multi chemical and pharmaceuticals industries uses.

Key words: Flowering, Gibberellic acid (GA₃), Jojoba, Seed chemical constituent, Seed yield, Zinc sulphate.

INTRODUCTION

Jojoba (*Simmondsia chinensis*) belongs to Simmondsiaceae family. Jojoba is a precious, drought resistant shrub, evergreen dioecious. It accumulates a unique storage lipid wax in its seeds consisting of long-chain esters of monounsaturated FA and alcohols (Gohil et al., 2010).

Jojoba seed contains a high content liquid wax with a wide variety of applications as a biofuel and a pure natural product for cosmetic products and medical application as antioxidant, antimicrobial activities human burn actions effect, also used for multi-industrial-related products (Al-Obaidi et al., 2017). Jojoba plant appears to tolerant soil salinity and drought resistant, so jojoba can grow with a little water for survival (Abobatta, 2017). Swielik, (2002) specified that Zinc applications on soil are not so effective since fruit crops roots occupy deeply in soil layers and zinc would not be easily removed from the soil. Zinc improves the biological machines, and these are consisting of proteins and enzymes (Stout, 1962). Since no studies has been done about the effect of zinc and gibberellic acid interaction on plant growth, flowering, seed yield in jojoba plants. The purpose of this research is to investigate the opportunity of improving the flowering, vegetative growth and seed yield as well as its oil yield and chemical consistent in jojoba plants by using gibberellic acid, zinc sulphate combination applied as a solution of foliar spray.

MATERIALS AND METHODS

This experiment was conducted to find out foliar application effect of zinc sulphate and gibberellic acid interaction on Jojoba tree traits at private farm in EL-Bahira governorate, Egypt. Jojoba similar age trees (nine years old) and size were nominated for sprays treatments in 2015 and 2016 seasons. The experiment laid out to a factorial arranged in randomized complete block design (RCBD) with three replications. For each treatment replication of same shoot was nominated. The orchard was irrigated by drip system, with weed and pest control, and fertilization conducted according to the standard agro-practices. The analysis of soil shown in Table 1, 2 and analysis of water irrigation is given in according to the certified procedures (Chapman and Pratt, 1961).

The zinc element plus GA₃ treatments were applied three times (at the beginning of December, March and May) in spread doses of 25, 50 and 75ppm. The gibberellic acid...
Table 2: Chemical characteristics of water weal used for the present study.

| Parameters | PH | EC(dSm⁻¹) | Ca++ | Mg++ | Na+ | K+ | HCO⁻ | Cl⁻ | SO³⁻ |
|------------|----|-----------|------|------|-----|-----|-------|-----|-----|
| values     | 7.45 | 3.44     | 5.42 | 3.64 | 21.88 | 3.24 | 1.98  | 29.24 | 3.25 |

(GA₃) treatment doses were 50, 100 and 150 ppm in addition to control treatment (0 GA₃ + 0 Zn). These parameters were measured and tagged for each treatment as nine plants (three plants for every replicate) by random choosing.

The Parameters: Data were collected from tagged trees of each treatment for each replicate.

Branch length (cm)

Length of secondary branches per every branch (cm)

Number of secondary branches per main branch.

Table 1: Some physical and chemical analysis of the experiment soil

| Parameters | PH | EC(dSm⁻¹) | Ca++ | Mg++ | Na+ | K+ | HCO⁻ | Cl⁻ | SO³⁻ |
|------------|----|-----------|------|------|-----|-----|-------|-----|-----|
| values     | 7.88 | 2.26     | 2.14 | 3.78 | 19.66 | 0.31 | 1.11  | 21.25 | 4.56 |

Chlorophyll a = 9.784 E.662 - 0.99E.644 = mg/gm.
Chlorophyll b = 21.426 E.644 - 4.65 E. 662 = mg/gm.
Total chlorophyll = Chl. a + Chl. b = mg/gm.

The Macro elements (N, P and K): In leaves, were determined according to the method of Chapman and Pratt (1961). The content of N, P and K per plant was calculated.

Table 2: Chemical characteristics of water weal used for the present study.

The Parameters: Data were collected from tagged trees of each treatment for each replicate.

Branch length (cm)

Length of secondary branches per every branch (cm)

Number of secondary branches per main branch.

Flowering percentage was defined by (Benzioni et al., 1999) as “the ratio of the number of flower buds to the number of nodes in the shoots of the current and previous year’s growth”.

Final fruit set % is a ratio of the number of fruitlet to the number of total flowers branch at the end of March.

Seed yield (kg/seed): Seeds were harvested from the previous tagged plants by hand in the two seasons at full maturity. Harvested seeds were cleaned, dried and weighted (gm).

Lipid content: Seeds of each treatment were randomly selected to determine oil content. Seeds were weighed and dried at 50 °C. The oil was extracted for 16 h with hexane by Soxhlet apparatus. A.O.A.C (1995).

Crude protein: Total organic nitrogen (N) was determined according to the method of Kjeldahl (AOAC, 1995) for dry material. Crude protein content was obtained by multiplying the nitrogen (N) value by 6.25.

Mineral content: To remove carbon, approximately 5 gm of each dry sample was ignited in a porcelain container and incinerated in the muffle furnace at about 55 °C. Mineral content was expressed as a percentage of dry matter. (AOAC, 1995).

Total carbohydrates: Total carbohydrates were estimated by the difference in the main values, i.e., 100 - (sum of concentrations of protein, ash and lipid).

Chlorophyll a and b and total chlorophyll: were assayed in the commercial harvest stage. They were determined according to Wintemans and Mats (1965). The optical density of constant volume of filtrate was measured at a wave length of 622 nm. for chlorophyll a, 644 nm. and for chlorophyll b using spectrophotometer. The following equation was used: -

RESULTS AND DISCUSSION

Vegetative parameters: Regarding the combined effect of Zn and GA₃ on branch growth(Table 3), the maximum significant branch length (99.36 and 103.46 cm), secondary branches length (55.82 and 58.36 cm) in both seasons, respectively, were observed in the treatment of Zn 75 ppm plus 150ppm GA₃. Moreover, the maximum numbers of secondary branches (7.49 and 6.58) were observed in the treatment of 75ppm Zn plus 0 ppm GA₃, in the first and second seasons, respectively. However, the control treatment (0ppm Zn plus 0ppm GA₃) recorded the lowest values of branch length (66.22 and 73.58 cm) and secondary branches length (22.88 and 24.55 cm). The number of secondary branches per main branch (2.15 and 2.16) was found in the 0ppm ZnSO₄ plus 150ppm GA₃, in the first and second seasons, respectively (Table 3). The spraying of Zn may compensate the lack of Zn and avoid deficiency of Zn in plants especially in poor microelements sandy soils. So, by increasing the level of Zn, the vegetative growth parameter will be improved. Marschner (1993) claimed that sandy soils in many semi-arid areas are known to limit mobility and availability of soil-Zn. El-Tohamy and El-Greadly (2007) observed in sandy soil conditions that Zn foliar spray was significantly improved vegetative growth and yield of bean plants compared to control especially at the higher Zn levels. The number of branches increased in anise (Pimpinella anisum) because of Zinc application (Pirzad et al., 2013). Wanyama et al., (2006) found that GA₃ application increases Cape gooseberry plants branching.

Chlorophyll a and b and total chlorophyll: were assayed in the commercial harvest stage. They were determined according to Wintemans and Mats (1965). The optical density of constant volume of filtrate was measured at a wave length of 622 nm. for chlorophyll a, 644 nm. and for chlorophyll b using spectrophotometer. The following equation was used: -

Flowering percentage and final fruit set %: The combination between 75ppm ZnSO₄ plus 0ppm GA₃ (Table 4) gave the maximum significant flowering percentage (57.56 and 59.74%), also this combination recorded the significant highest percentage of final fruit set percent (95.01 and 95.24%) compared with other treatments including control (85.02 and 86.11) in the first
Table 3: The mean of branch length (cm), secondary branches length (cm) and number of secondary branches per main branch of jojoba plants as affected with the GA_3 and ZnSO_4 combinations during two seasons of 2015 and 2016.

| Treatment                  | Branch Length(cm) | Secondary Branches length(cm) | No. Branches /Main Branch |
|----------------------------|-------------------|-------------------------------|---------------------------|
|                            | First season      | Second season                 | First season              | Second season             | First season | Second season |
| Zn 0ppm + 0ppm GA_3        | 66.22             | 73.58                         | 22.88                     | 24.55                     | 3.27         | 4.28          |
| Zn 0ppm + 50ppm GA_3       | 75.65             | 77.41                         | 34.68                     | 37.42                     | 3.21         | 3.26          |
| Zn 0ppm + 100ppm GA_3      | 83.65             | 87.58                         | 37.22                     | 40.25                     | 2.47         | 2.33          |
| Zn 0ppm + 150ppm GA_3      | 91.87             | 94.78                         | 45.42                     | 48.55                     | 2.15         | 2.16          |
| Zn 25ppm + 0ppm GA_3       | 70.14             | 74.54                         | 34.68                     | 29.54                     | 4.56         | 4.53          |
| Zn 25ppm + 50ppm GA_3      | 77.25             | 79.33                         | 37.74                     | 40.65                     | 4.28         | 4.47          |
| Zn 25ppm + 100ppm GA_3     | 85.41             | 88.26                         | 40.54                     | 46.35                     | 3.94         | 4.28          |
| Zn 25ppm + 150ppm GA_3     | 93.70             | 97.25                         | 48.25                     | 51.24                     | 3.21         | 3.54          |
| Zn 50ppm + 0ppm GA_3       | 74.58             | 76.25                         | 35.21                     | 43.68                     | 4.28         | 4.28          |
| Zn 50ppm + 50ppm GA_3      | 79.86             | 82.69                         | 39.41                     | 47.86                     | 4.16         | 4.28          |
| Zn 50ppm + 100ppm GA_3     | 88.26             | 92.64                         | 44.38                     | 53.24                     | 4.27         | 3.23          |
| Zn 50ppm + 150ppm GA_3     | 95.44             | 99.26                         | 48.22                     | 53.36                     | 4.35         | 4.69          |
| Zn 75ppm + 0ppm GA_3       | 77.54             | 79.32                         | 40.68                     | 42.85                     | 7.49         | 6.58          |
| Zn 75ppm + 50ppm GA_3      | 79.58             | 85.46                         | 43.21                     | 49.36                     | 5.68         | 5.35          |
| Zn 75ppm + 100ppm GA_3     | 92.69             | 98.46                         | 48.22                     | 52.36                     | 5.35         | 4.69          |
| Zn 75ppm + 150ppm GA_3     | 99.36             | 103.46                        | 55.82                     | 58.36                     | 5.35         | 5.35          |
| L.S.D.                     | 1.791             | 2.220                         | 1.136                     | 1.346                     | 0.394        | 0.442         |

Table 4: The mean of flowering percentage%, Final fruit set % as affected with gibberellic acid and zinc sulphate during two seasons of 2015 and 2016.

| Treatment                  | Flowering percentage % | Final fruit set % |
|----------------------------|------------------------|-------------------|
|                            | First season           | Second season     | First season | Second season |
| Zn 0ppm + 0ppm GA_3        | 39.21                  | 41.25             | 85.02        | 86.11         |
| Zn 0ppm + 50ppm GA_3       | 41.11                  | 43.23             | 85.55        | 86.87         |
| Zn 0ppm + 100ppm GA_3      | 42.16                  | 44.25             | 86.01        | 87.33         |
| Zn 0ppm + 150ppm GA_3      | 42.26                  | 45.33             | 86.66        | 87.92         |
| Zn 25ppm + 0ppm GA_3       | 41.65                  | 44.21             | 87.18        | 88.22         |
| Zn 25ppm + 50ppm GA_3      | 44.47                  | 46.23             | 88.31        | 89.51         |
| Zn 25ppm + 100ppm GA_3     | 47.94                  | 48.65             | 89.80        | 90.07         |
| Zn 25ppm + 150ppm GA_3     | 48.26                  | 50.36             | 90.33        | 90.12         |
| Zn 50ppm + 0ppm GA_3       | 44.71                  | 52.14             | 90.96        | 90.78         |
| Zn 50ppm + 50ppm GA_3      | 47.54                  | 49.62             | 91.39        | 91.83         |
| Zn 50ppm + 100ppm GA_3     | 51.55                  | 53.26             | 91.98        | 92.48         |
| Zn 50ppm + 150ppm GA_3     | 53.21                  | 54.74             | 92.42        | 92.56         |
| Zn 75ppm + 0ppm GA_3       | 54.23                  | 56.54             | 92.98        | 93.12         |
| Zn 75ppm + 50ppm GA_3      | 56.24                  | 58.21             | 94.81        | 94.35         |
| Zn 75ppm + 100ppm GA_3     | 55.44                  | 56.74             | 94.15        | 93.88         |
| Zn 75ppm + 150ppm GA_3     | 57.56                  | 59.74             | 95.01        | 95.24         |
| L.S.D.                     | 0.769                  | 0.167             | 0.289        | 0.159         |

and second seasons respectively. ZnSO_4 promotion effect on flowering and fruiting may be since the treatments enhanced the vegetative growth resulting in high amounts of assimilates which in turn acted meaningfully in improving flowering and fruiting. These results agree with (Cakmak, 2008), the flower biomass related with Zinc content. The Chlorophyll production, pollen function and fertilization require Zinc (Kaya et al., 2005). The application of GA_3 increased flower bud formation and fruiting of Cape gooseberry plants (Wanyama et al., 2006).

Seed yield: The interaction treatment of 75 ppm ZnSO_4 plus 150 ppm GA_3 caused more improvements for seed yield (2145 and 2200 Kg/Feed) compared with the other treatments and with control (1450 and 1512) kg/seed in the first and second seasons, respectively (Table 5). In seed yield effected with Zinc sprays might be due to its role for fruit growth and development which have been influenced via tryptophan (Sahota and Arora, 1981). The improvement occurred in seed yield may be due to its effects on promotion the formation, translocation of carbohydrates and activation of carbohydrate enzymes (Yogeratnam and Greenham, 1982). Increasing yield due to GA_3 or Zinc sprays may be related to their effects on increasing levels of IAA. Seed yield of Jojoba was positively correlated and was influenced heavily by maximum air temperature (Gohil et al., 2010). El-Habbasha,
Table 5: The mean of seed yield, minerals, lipids proteins and carbohydrates as affected with Gibberellic acid and Zinc sulphate during two seasons of 2015 and 2016.

| Treatment                          | Seed Yield kg/Fd* | Minerals% | Lipids% | Proteins% | Carbohydrates% |
|------------------------------------|-------------------|-----------|---------|-----------|----------------|
|                                    | first season      | second season | first season | second season | first season | second season | first season | second season | first season | second season |
| Zn 0ppm + 0ppm GA                  | 1450              | 1512       | 1.42    | 1.45      | 51.11         | 51.44         | 28.21        | 27.91        | 19.26        | 19.20          |
| Zn 0ppm + 50ppm GA                 | 1490              | 1598       | 1.26    | 1.36      | 52.14         | 52.14         | 27.33        | 26.94        | 19.27        | 19.56          |
| Zn 0ppm + 100ppm GA                | 1650              | 1674       | 1.15    | 1.23      | 52.87         | 52.87         | 26.01        | 26.22        | 19.97        | 19.68          |
| Zn 0ppm + 150ppm GA                | 1700              | 1750       | 1.22    | 1.22      | 53.24         | 53.24         | 25.61        | 25.74        | 19.92        | 19.80          |
| Zn 25ppm + 0ppm GA                 | 1548              | 1650       | 1.48    | 1.51      | 51.64         | 52.31         | 27.85        | 26.77        | 17.96        | 19.41          |
| Zn 25ppm + 50ppm GA                | 1610              | 1650       | 1.46    | 1.51      | 52.77         | 53.21         | 26.88        | 26.33        | 18.88        | 18.95          |
| Zn 25ppm + 100ppm GA               | 1688              | 1701       | 1.39    | 1.41      | 53.66         | 54.41         | 25.44        | 25.37        | 19.51        | 18.81          |
| Zn 25ppm + 150ppm GA               | 1741              | 1787       | 1.36    | 1.39      | 54.55         | 55.12         | 24.21        | 24.01        | 19.87        | 19.47          |
| Zn 50ppm + 0ppm GA                 | 1601              | 1811       | 1.52    | 1.56      | 52.33         | 53.11         | 27.11        | 26.21        | 19.04        | 19.12          |
| Zn 50ppm + 50ppm GA                | 1811              | 1854       | 1.48    | 1.51      | 53.88         | 54.12         | 25.65        | 25.25        | 18.98        | 19.12          |
| Zn 50ppm + 100ppm GA               | 1887              | 1904       | 1.43    | 1.48      | 54.94         | 55.24         | 24.23        | 24.11        | 19.40        | 17.44          |
| Zn 50ppm + 150ppm GA               | 1985              | 1988       | 1.41    | 1.46      | 55.11         | 56.88         | 23.22        | 22.89        | 20.26        | 18.77          |
| Zn 75ppm + 0ppm GA                 | 1874              | 1894       | 1.64    | 1.68      | 53.23         | 53.88         | 26.22        | 25.88        | 18.91        | 18.56          |
| Zn 75ppm + 50ppm GA                | 1920              | 2000       | 1.61a   | 1.62      | 54.11         | 55.21         | 24.31        | 24.10        | 19.97        | 19.06          |
| Zn 75ppm + 100ppm GA               | 1987              | 2100       | 1.51    | 1.59      | 55.70         | 57.54         | 24.11        | 23.74        | 18.78        | 17.13          |
| Zn 75ppm + 150ppm GA               | 2145              | 2200       | 1.45    | 1.55      | 57.65         | 58.55         | 22.94        | 22.45        | 19.03        | 19.10          |
| L.S.D.                             | 100.6             | 90.21      | 0.05    | 0.005     | 0.776         | 0.450         | 0.842        | 0.874        | 0.019        | 0.108          |

*Feed (Fd) = 4100 m²

(2015) found that the Zinc foliar spray significantly increased the yield of groundnut and its components under sandy soil conditions. The role of GAs in improving fruit quantity reflected on seed yield may be to its role in increasing cell elongation (Eman et al., 2007). The GA₃ may be act as simulative influence of this bioregulator on cell extension and/or cell division. GAs increase sink demand by the enhancement of phloem unloading and/or metabolism of carbon assimilates in fruit which correlated with changes in activities of sugar metabolizing enzymes induced by GA₃ application. Hagagg et al., (2014) found that the combination between zinc sulfate and gibberellic acid increased fruit yield and oil content of olive trees cv. Kallamata.

Seed composition: The maximum mineral content in seed (1.64 and 1.68%) was observed with the application of combination treatment of Zn 75ppm plus 0ppm GA3, while, the highest protein (28.21 and 27.91%) was found in the first combination (control) in both seasons, respectively (Table 5). The combination treatment of 0 ppm ZnSO₄ plus 100 ppm GA₃ recorded the maximum carbohydrates content (19.97 %) in the first season. While in the second one, the combination treatment of 0 ppm ZnSO₄ plus 150 ppm GA₃ had the maximum value of carbohydrates content (19.80%) (Table 5). The maximum seed oil content (55.17and 56.29%) and minimum proteins content (22.94 and 22.45%) were produced in the combination Zn 75 ppm plus 150 ppm GA₃.Jordão and Lietão (1990) reported that there was a positive correlation between the fruit Zn content and the weight of oil content of olive fruit. The certain plant hormones can increase mobilization of assimilates to fruit and modulate many of the rate-limiting components in carbon partitioning (Ozga and Dennis, 2003). These hormones may promote the transportation of nutrients through the phloem, modify the strength of the sink by stimulating its growth and increase the sugar unloading ability from the phloem or they may act on compartmentalization and metabolism of sugar and its metabolites (Brenner and Cheikh, 1995).

Nitrogen, phosphorus and potassium content (%): As shown in Table 6, the highest contents of nitrogen (3.010 and 3.050 %), phosphorus (0.470 and 0.480%) and potassium (2.860 and 2.850%) in the leaves of jojoba plants were found in the treated plants with 150ppm GA₃ plus 75ppm ZnSO₄ compared with the other combination treatments and control plants in the first and second seasons, respectively. This increase in the level of macro-nutrients with Zn application may be due to some synergetic relationship between N, P, K with Zn. Effect of foliar spray of Zn was reported to have positive effect on the leaf mineral contents of ‘Balady’ mandarin (Samra, 1985). Also, El-Tohamy et al., (2012) observed that spraying Zn and GA₃ has no significant effects on N, P and K contents of Cape gooseberry leaves but they have higher values compared to the control.

Chlorophyll a, b and total chlorophyll: In Table 7, the combination of GA₃ and ZnSO₄ improved a, b and total chlorophyll content of jojoba plants and the best combination was 150ppm GA₃ plus 100ppm ZnSO₄ gave the maximum chlorophyll a (0.930 and 0.910mg/gm), chlorophyll b (0.630 and 0.640 mg/gm) and total chlorophyll content (1.590 and 1.580 mg/gm) in both seasons, respectively compared with the other combination treatments and the control.
Table 6: The mean of N, P and K content in jojoba leaves as affected with Gibberellic acid and Zinc sulphate during two seasons of 2015 and 2016.

| Treatment           | N first season | N second season | P first season | P second season | K first season | K second season |
|---------------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|
| Zn 0ppm + 0ppm GA   | 2.80           | 2.79            | 0.350          | 0.33            | 2.70           | 2.65            |
| Zn 0ppm + 50ppm GA  | 2.83           | 2.82            | 0.380          | 0.34            | 2.71           | 2.69            |
| Zn 0ppm + 100ppm GA | 2.87           | 2.86            | 0.390          | 0.38            | 2.72           | 2.72            |
| Zn 0ppm + 150ppm GA | 2.93           | 2.90            | 0.420          | 0.41            | 2.73           | 2.74            |
| Zn 25ppm + 0ppm GA  | 2.84           | 2.88            | 0.380          | 0.35            | 2.72           | 2.71            |
| Zn 25ppm + 50ppm GA | 2.91           | 2.94            | 0.41           | 0.36            | 2.74           | 2.72            |
| Zn 25ppm + 100ppm GA| 2.92           | 2.95            | 0.42           | 0.39            | 2.74           | 2.74            |
| Zn 25ppm + 150ppm GA| 2.94           | 2.97            | 0.44           | 0.42            | 2.75           | 2.75            |
| Zn 50ppm + 0ppm GA  | 2.91           | 2.94            | 0.39           | 0.37            | 2.75           | 2.73            |
| Zn 50ppm + 50ppm GA | 2.94           | 2.97            | 0.42           | 0.39            | 2.78           | 2.74            |
| Zn 50ppm + 100ppm GA| 2.97           | 2.99            | 0.42           | 0.41            | 2.79           | 2.77            |
| Zn 50ppm + 150ppm GA| 2.97           | 2.99            | 0.45           | 0.44            | 2.81           | 2.81            |
| Zn 75ppm + 0ppm GA  | 2.95           | 2.96            | 0.43           | 0.41            | 2.77           | 2.75            |
| Zn 75ppm + 50ppm GA | 2.97           | 2.97            | 0.46           | 0.44            | 2.80           | 2.81            |
| Zn 75ppm + 100ppm GA| 3.00           | 3.01            | 0.47           | 0.45            | 2.83           | 2.83            |
| Zn 75ppm + 150ppm GA| 3.01           | 3.05            | 0.47           | 0.48            | 2.86           | 2.85            |
| L.S.D.              | 0.118          | 0.091           | 0.053          | 0.053           | 0.002          | 0.002           |

Table 7: The mean of chlorophyll a, b and total chlorophyll content in jojoba leaves as affected with gibberellic acid and zinc sulphate during two seasons of 2015 and 2016.

| Treatment           | Chlorophyll a first season | Chlorophyll a second season | Chlorophyll b first season | Chlorophyll b second season | Total Chlorophyll first season | Total Chlorophyll second season |
|---------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|-------------------------------|-------------------------------|
| Zn 0ppm + 0ppm GA   | 0.81                      | 0.79                        | 0.40                      | 0.41                        | 1.23                          | 1.24                          |
| Zn 0ppm + 50ppm GA  | 0.84                      | 0.83                        | 0.44                      | 0.45                        | 1.320                         | 1.33                          |
| Zn 0ppm + 100ppm GA | 0.85                      | 0.85                        | 0.47                      | 0.48                        | 1.35                          | 1.36                          |
| Zn 0ppm + 150ppm GA | 0.87                      | 0.86                        | 0.51                      | 0.53                        | 1.40                          | 1.43                          |
| Zn 25ppm + 0ppm GA  | 0.83                      | 0.82                        | 0.41                      | 0.43                        | 1.27                          | 1.28                          |
| Zn 25ppm + 50ppm GA | 0.85                      | 0.85                        | 0.50                      | 0.51                        | 1.39                          | 1.39                          |
| Zn 25ppm + 100ppm GA| 0.87                      | 0.87                        | 0.52                      | 0.54                        | 1.42                          | 1.45                          |
| Zn 25ppm +150ppm GA | 0.88                      | 0.87                        | 0.53                      | 0.56                        | 1.44                          | 1.48                          |
| Zn 50ppm + 0ppm GA  | 0.84                      | 0.83                        | 0.44                      | 0.45                        | 1.330                         | 1.32                          |
| Zn 50ppm + 50ppm GA | 0.86                      | 0.87                        | 0.51                      | 0.50                        | 1.41                          | 1.41                          |
| Zn 50ppm + 100ppm GA| 0.89                      | 0.88                        | 0.56                      | 0.57                        | 1.47                          | 1.49                          |
| Zn 50ppm + 150ppm GA| 0.90                      | 0.89                        | 0.58                      | 0.60                        | 1.51                          | 1.52                          |
| Zn 75ppm + 0ppm GA  | 0.86                      | 0.85                        | 0.45                      | 0.47                        | 1.35                          | 1.35                          |
| Zn 75ppm + 50ppm GA | 0.88                      | 0.89                        | 0.55                      | 0.58                        | 1.46                          | 1.50                          |
| Zn 75ppm +100ppm GA | 0.89                      | 0.91                        | 0.61                      | 0.62                        | 1.53                          | 1.55                          |
| Zn 75ppm+ 100ppm GA | 0.93                      | 0.91                        | 0.63                      | 0.64                        | 1.59                          | 1.58                          |
| L.S.D.              | 0.001                     | 0.053                       | 0.005                     | 0.053                       | 0.005                         | 0.053                         |

results agreed with El-Tohamy et al., (2012) who observed that spraying Zn and GA increased total chlorophyll content of Cape gooseberry leaves compared to control.

CONCLUSION

By comparing means of treatments, it is concluded that there were significant effects of spraying Zn and GA treatments on all jojoba studied parameters. Furthermore, jojoba vegetative and productive parameters enhanced with increasing the level of their combination. So, the treatments of 150ppm GA plus 75ppm ZnSO$_4$ treatment gave the best results to increase seed yield, seed lipid content in both seasons which lead to raise the economic value of jojoba as a promising tree which potentially useful as a biofuel with multi chemical and pharmaceuticals industries uses.

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