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Website: http://www.aun.edu.eg/faculty_agriculture *E-mail: ajas@aun.edu.eg*

Effect of Gibberellic Acid and Some Natural Compounds Application on Vegetative Growth, Yield and Fruit Characteristics of Jojoba Shrubs

Mostafa, F.M.A.[1]; M.G. Abd-El-Monem [2]; A.A. Badawy[1] and M.A. Amin[3]

[1] Pomology Dept., Faculty of Agric., Assiut University
[2]Soil and Water Dept., Faculty of Agric., Assiut University
[3]Agric. Engineer, Mout, El-Dakhla, New Valley

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Abstract

This study was carried out during 2014 and 2015 seasons in a private orchard of Jojoba located at Mout, El-Dakhla, New Valley Governorate to examine the effects of GA_3 (25, 50 and 100 ppm), camphor oil (1.5, 3.0 and 4.5 cm^3/L), effective microorganisms (EM1, 3, 6 and 9 cm^3/L), glauconite compound (250 and 500 g/shrub) and a mixture of GA_3 (50 ppm) with the afromentioned concentrations of camphor oil on vegetative growth, yield/shrub and Jojoba seed characteristics. The treatments were conducted at start of Jojoba blooming (the 1st application time), and the 2nd application was achieved 3 weeks after fruit set, except the glauconite was applied 3 weeks before Jojoba blooming. The experiment was conducted in randomized complete block design (RCBD) with 3 replicates, 2 shrubs each.

According to the obtained results of this study, it could be deduced that all treatments improved the vegetative growth, yield and seed quality.

Concerning oil weight/100 seeds and oil % in seeds treatment with mixture of GA_3 (50 ppm) and camphor oil (1.5 or 3.0 cm^3/L) gave the best results during the two studied seasons. Therefore, for improving yield and seed quality it could be recommended spray jojoba a mixture of GA_3 (50 ppm) plus camphor oil at 1.5 or 3.0 cm^3/L under the condition of this study.

Keywords: *GA_3, Camphor oil, EM1, Glauconite, Jojoba shrub, Yield, Seed quality.*

Introduction

Jojoba (*Simmondsia chinensis* L.) is economically important shrub. It is an extensively drought resistant, high atmospheric temperature, high soil salinity and low fertilize requirement (Rashmi *et al*., 2015).

The demand of environmentally friendly lubricating oil is growing rapidly due to the predicted depletion in petroleum supplies in the near future. Therefore, non-edible vegetable oils, jojobe, jatropha and castor oils were examined as lubricants. Jojoba oil gave the highest value of viscosity index than other vegetables and mineral oils (El-Kinawy *et al*., 2012).

Virender *et al*. (2005) studied six genotypes of jojoba for seed morphological traits, oil content and growth performance. They found significant variation in seed parameters vis. seed length, seed width and 100-seed weight among the different jojoba genotypes.

Applying different concentrations of yeast or effective microorganisms (EM1) on "Zaghloul" date palm improved bunch weight, the physical and chemical characteristics of fruits. Treated date palm with 20 g yeast/palm or EM1 (1.0 cm^3/L) gave the best results of bunch weight and fruit quality (Mostafa, 2006).

Spraying benzyl-adenine (150 ppm) and gibberelline (150 ppm as regulex) on 2 clones of jojoba induced significant differences vegetative growth among the clones but not between the treatments (Ravetta and Palzkill, 1992 and Prat *et al*., 2008). Moreover, spraying gibberelline (150 ppm as regulex on same jojoba clones showed a significant increase in flower bud No/shrub (Gonzalez, 1998 and Makwana and Robin, 2013).

El-Mallah and El-Shemi (2009) reported that Egyptian Jojoba seeds are rich in wax ester (55%) with fatty alcohols.

Al-Soqeer (2010) studied seven diverse female jojoba genotypes grown under Central Region of Saudi Arabia. He found highly significant differences for plant height, number of branches/plant among the jojoba clones as well as for leaf-area and seed yield/shrub.

Gohil *et al*. (2010) studied the effect of environmental factors on jojoba seed yield. They found that seed yield was influenced heavily by a maximum air temperature as compared to the other climatic factors.

Al-Hamamre (2013) showed that jojoba is a plant can grow in many semi-arid regions of the world requires little water and maintenance is free from diseases and yields a crop of seeds that have 40-50% oil.

Makwana and Robin (2013) reduced that spraying GA_3 (100 ppm) and ethrel (25 ppm) on Jatropha shrubs resulted in a significant increase in total flower No., female flowers No. and female/male flowers ratio.

Al-Anber *et al*. (2014) pointed out that maximum removal of ferric ion of Jojoba meal (defatted jojoba seeds) was approximately 96% by using high dosage amount of jojoba meal (60 g/L).

Furthermore, spraying camphor oil (1.0, 1.5 and 2.0%) on "White Banaty" grapevines induced a significant increase in yield weight/vine and improved the physical and chemical berry quality (Rizkalla, 2016).

Therefore, the objective of this study was to determine the effect of spraying the gibberellic acid (GA_3) and some natural compounds on growth, seed yield and fruit characteristics of jojoba shrubs grown under the New-Valley Governorate climatic conditions.

Materials and Methods

This study was conducted in a private orchard located at El-Dakhla city, New Valley Governorate during two consecutive seasons 2014 and 2015 to assess the physiological effects of spraying camphor oil (1.5, 3.0 and 4.5 cm^3/L) and applying both of effective microorganisms (EM1) (3.0, 6.0 and 9.0 cm^3/L) and glauconite compound (250 g and 500 g/shrub) as soil drench on Jojoba shrubs. As well as, studying the effects of spraying GA_3 (25, 50 and 100 ppm) and spraying a mixture of GA_3 at 50 ppm and camphor oil at the three afromentioned on the vegetative growth, yield weight/shrub, the physical and chemical characteristics of Jojoba fruits.

This investigation included 15 treatments and was set up in a randomized complete block design (RCBD). Each treatment was replicated three times, 5 shrubs each, therefore 270 Jojoba shrubs at the same age (6 years old, 3x3 m apart)

and in a uniform vigour were selected for achieving the aims of this study.

The following measurements were determined during the two studied seasons.

Vegetative growth:

These vegetative growth parameters as shrub height (cm), trunk length (cm), and diameter (cm), shoots number per branch, shoot length (cm), shoot diameter (mm), branch number/shrub, branch length (cm), branch diameter (cm), shoot number/shrub, leaves number per shoot and leaves number per branch and leaves no/shrub were determined during the two studied seasons.

Fruiting characteristics of Jojoba shrub:

Fruiting characteristics of Jojoba shrubs were determined as yield weight (g)/shrub, 100 fruits weight (g), 100 seeds weight (g), oil weight (g) of 100 seeds, reg weight (seed weal, g) of 100 seeds and the oil % in Jojoba seeds were assessed throught the two studied seasons of this study.

Shrub height:

- **Shrub height (m)** was estimated as distance between the soil surface and the highest level of the shrub.

Trunk length:

- **Trunk length/shrub (cm)** was estimated as length of the main trunk of the shrub starting by the soil surface level until the beginning of the 1st branch on the trunk.

Trunk diameter:

- **Trunk diameter** (cm) was estimated at the position point, 20 cm lies under the 1st main branch/shrub.
- **Shoot number/branch** was recorded as number of all new shoots were found on 4 main branches at the harvest date of Jojoba fruits.
- **Shoot length (cm) and shoot diameter (mm)** were estimated for 3 shoots selected per the selected 4 main branch.
- **Branch number/shrub** was determined as number of all the main branches per a shrub.
- **Branch length (cm) and branch diameter** were estimated as aforementioned in shoot length and shoot diameter.
- **Shoot number/shrub** was recorded as a resulted number of multiplication of branch number/shrub by shoots no/branch.
- **Leaves number/shoot** was determined by the number of selected 5 shoots/ branch at the harvest date of fruits.
- **Leaves number/branch and leaves number per shrub** were calculated as a resulted number of the multiplication of leave No/shoot by shoots, No per branch and as well as leaves No/shrub by leaves No. per branch and branch No/shrub.
- **Yield weight (g)/shrub**: Ribe fruit were harvested at the optimum commercial harvesting time under the New Valley climatic conditions during the two studied seasons and yield weight per shrub was recorded in terms of grams.
- **Weight of 100 fruits**, **average weight of the fruits** was delivered (in grams) using a top pan. balance of 0.01 g sensitivity and then the weight of 100 seeds was recorded using the same tool used in determining 100 fruit weight.
- **Oil weight (g)/100 seeds:** to determine a weight of oil (g)/100 seeds weight, a known weight of seed

samples (10 g) was extracted with n-hexane for 6 hours in Soxhlet apparatus.

The solvent was evaporated and the residue was dried to constant weight and the total lipid percentage was calculated according to the following equation:

$$\text{Crude fat (oil weight)} \% = \frac{S - W}{S} \times 100$$

Whereas:

S= Sample weight of seeds (g).

W= Weight of dried residue of the sample (A.O.A.C., 2000).

Results and Discussion

Effect of camphor oil, gibberellic acid, effective microorganisms and glauconite on some vegetative growth of Jojoba shrubs:

1.1- Shrub height as well as trunk length and diameter:

As shown in Table (1) data indicated that all treatments with camphor oil, GA_3, EM1 and glauconite resulted in significant increases in shrub height (m), trunk length (cm) and diameter (cm) of Jojoba shrubs in comparison with untreated shrubs during 2014 and 2015 seasons.

Concerning the effects of treatments on shrub height (cm) of Jojoba, it could be noticed that treatment with 25 ppm of GA_3 gave the highest value of shrub height (m) (2.30 m), followed by both treatment of EM1 (9 cm^3/L) and mixed of GA_3 (50 ppm) and camphor oil (1.5 cm^3/L) (2.20 m, each) in season 2014, while treatment with EM1 (9 cm^3/L) gave the highest value of shrub height of Jojoba (2.56 m), followed by treatment with glauconite (250 g/shrub) (2.47 m), then GA_3 at 25 ppm (2.39 m) in season 2015, all results were compared with untreated shrubs.

Regarding the treatments effects on trunk length (cm) of Jojoba shrub, it could be observed that treatment with EM1 at 3 cm^3/L gave the highest trunk length (62.3 cm) followed by treatment with EM1 at 9 cm^3/L (60.0 cm), then treatment with glauconite at 250 g/shrub (59.7 cm) in season 2014 as well as in season 2015 treatment with EM1 at 3 cm^3/L gave the highest trunk length (81.0 cm) followed by treatment with GA_3 at 100 ppm (65.7 cm), then GA_3 at 25 ppm (63.3 cm), all in comparison with untreated shrubs.

Moreover, it was observed that treatment with GA_3 at 100 ppm gave the highest value of trunk diameter (cm) (5.10 cm), followed by treatment with mixed of GA_3 (50 ppm) + camphor oil (1.5 cm^3/L) (4.77 cm), then treatment with EM1 at 6 cm^3/L (4.70 cm) in season 2014, on the other hand, treatment with EM1 at 3 cm^3/L gave the highest value of trunk diameter (5.60 cm), followed by glauconite at 250 g/shrub (5.50 cm), then treatment with EM1 of 6 cm^3/L (5.40 cm) in season 2015, all were compared with untreated shrubs.

Thee obtained effects of the treatments of this study could be attributed with the promotive effects of both GA_3, EM1 and glauconite on vegetative growth of Jojoba shrubs.

These obtained results are in agreements with those reported by Taha *et al*. (2015) who found that application of Moringa leaves extract (MLE) at 1% caused an increase in shrub height by 103.24%, meanwhile applied MLE at 7% led to 4.08% increament branches No. as compared to untreated plants (Ghulam *et al*., 2011).

Table 1. Effect of treatments with camphor oil, gibberellic acid (GA_3), effective microorganisms (EM1) and glauconite on shrub height (cm), trunk length (cm) and trunk diameter (cm) of Jojoba shrubs during 2014 and 2015 seasons

Treatments	Season 2014			Season 2015		
	Shrub height (m)	Trunk length (cm)	Trunk diameter (cm)	Shrub height (m)	Trunk length (cm)	Trunk diameter (cm)
Control	1.87	47.00	3.30	1.90	55.00	3.60
Camphor oil (1.5 cm^3/L)	1.95	46.00	3.60	2.18	58.70	4.00
Camphor oil (3 cm^3/L)	1.82	45.70	3.60	1.93	57.00	3.90
Camphor oil (4.5 cm^3/L)	2.00	56.00	3.60	2.35	59.00	4.00
GA_3 (25 ppm)	2.30	48.30	4.40	2.39	63.30	3.30
GA_3 (50 ppm)	1.98	44.00	4.20	2.20	62.70	4.30
GA_3 (100 ppm)	1.98	49.00	5.10	2.30	65.70	4.80
Glauconite (250 g/shrub)	2.07	59.70	3.80	2.47	59.30	5.50
Glauconite (500 g/shrub)	2.18	58.30	4.00	2.12	53.00	5.00
EM1 (3 cm^3/L)	2.15	62.30	4.50	2.14	50.30	5.60
EM1 (6 cm^3/L)	2.15	43.00	4.70	2.26	48.70	5.40
EM1 (9 cm^3/L)	2.20	60.00	3.60	2.56	81.00	4.10
Mixed of GA_3 50 ppm + Camphor oil (1.5 cm^3/L)	2.20	55.7	4.77	2.33	59.7	5.33
Mixed of GA_3 50 ppm + Camphor oil (3 cm^3/L)	1.98	50.7	4.53	2.13	54.3	4.83
Mixed of GA_3 50 ppm + Camphor oil (4.5 cm^3/L)	1.90	56.3	4.40	2.08	60.7	4.80
New LSD at 0.05	0.04	2.08	0.18	0.09	2.49	0.25

1.2- Shoot No/branch, shoot length and shoot diameter:

Data presented in Table (2) showed that all treatments with camphor oil, GA_3, glauconite, EM1 and mixture of GA_3 (50 ppm) + camphor oil (1.5 cm^3/L) induced significant increases in shoot No/branch, shoot length (cm) and shoot diameter (cm) of Jojoba shrubs in comparison with untreated shrubs during 2014 and 2015 seasons.

Regarding to effect of the treatments on shoot No/branch, it could be deduced that treatment with EM1 at 3 cm^3/L resulted in the highest number of shoots/branch (13.3), followed by treatment with camphor oil at 4.5 cm^3/L (13.0), then treatment with mixture of GA_3 50 ppm + camphor oil 3 cm^3/L (12.7), all in comparison with untreated shrubs in season 2014, while in season 2015, treatment with GA_3 a 100 ppm gave the highest shoot No/branch (13.3), followed by treatment with camphor oil at 4.5 cm^3/L; then treatment with EM1 at 3 cm^3/L or treatment with a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L gave value of 12.7 each, all data were compared with untreated shrub.

Concerning the effects of treatments on shoot length (cm) of Jojoba shrub, it was clear that all treatments significantly increased shoot length during the two studied seasons 2014 and 2015.

Noticlly that treatment with EM1 (6 cm^3/L) induced the highest length of shoot (16.5 cm), followed by spraying GA_3 at 100 ppm (15.8 cm), then treatments with GA_3 at 50 ppm (14.8 cm) during the 1st season, while in the 2nd season treatment with GA_3 at 100 ppm gave the highest length of shoot (15.5 cm), followed by treatment with a mixture of GA_3

50 ppm + camphor oil at 1.5 cm^3/L (15.3 cm), then treatment with a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L (15.2 cm), all data were compared to untreated shrubs.

According to data pointed out in Table (2), it was clear that only treatment with different concentrations used of GA_3 induced a significant increase in shoot diameter, while the other treatments resulted in a significant decrease in shoot diameter during 2014 season. On the other side all the treatments caused significant increase in shoot diameter in 2015 season, all date were compared to untreated shrubs.

Moreover, it could be deduced that treatment with GA_3 at 50 ppm gave the highest value of shoot diameter (3.87 mm), followed by treatment with GA_3 100 ppm (3.57 mm), thereafter treatment with GA_3 at 25 ppm (3.50 mm), in season 2014, while treatment with camphor oil at 4.5 cm^3/L gave the greatest shoot diameter (1.83 mm) followed by treatment with GA_3 25 ppm (1.73 mm), then treatment with GA_3 50 ppm (1.63 mm), and the other treatments resulted in an enhancement of shoot diameter varied from treatment to another during season 2015, all date were compared with untreated shrubs.

These positive effects of the tested compounds could be due to their enhancement effects on vegetative growth attributed to GA_3 function, EM1 and the mixture of GA_3 with camphor oil, whereas the later (camphor oil) might be induced their effects by modification of leave transpirant, as well as throughout reducing respiration rates of shrub leaves, thus in turn to were nutrient and organic compound to enhance vegetative growth of Jojoba shrubs.

These obtained results are in considence with those found by El-Mallah and El-Shami (2009) and Al-Soqeer (2010).

Table 2. Effect of treatments with camphor oil, gibberellic acid (GA_3), effective microorganisms (EM1) and glauconite on shoot No/branch, shoot length (cm) and shoot diameter (mm) of Jojoba shrubs during 2014 and 2015 seasons.

Treatments	Season 2014			Season 2015		
	Shoot No/ branch	Shoot length (cm)	Shoot diameter (mm)	Shoot No/ branch	Shoot length (cm)	Shoot diameter (mm)
Control	10.3	12.7	2.43	10.3	11.7	1.30
Camphor oil (1.5 cm^3/L)	11.3	12.6	2.07	12.7	13.6	1.58
Camphor oil (3 cm^3/L)	11.0	13.9	1.57	11.7	13.7	1.38
Camphor oil (4.5 cm^3/L)	13.0	13.9	1.47	13.0	15.5	1.83
GA_3 (25 ppm)	11.0	14.6	3.50	11.7	13.3	1.73
GA_3 (50 ppm)	11.0	14.8	3.87	12.3	14.1	1.63
GA_3 (100 ppm)	11.7	15.8	3.57	13.3	15.5	1.53
Glauconite (250 g/shrub)	12.7	13.1	1.23	11.0	14.0	1.57
Glauconite (500 g/shrub)	12.3	13.3	2.00	11.0	15.1	1.57
EM1 (3 cm^3/L)	13.3	13.8	1.23	12.7	14.6	1.60
EM1 (6 cm^3/L)	11.3	16.5	1.23	11.3	14.8	1.53
EM1 (9 cm^3/L)	10.7	14.1	1.17	10.7	15.0	1.37
Mixed of GA_3 50 ppm + Camphor oil (1.5 cm^3/L)	12.4	14.1	1.23	12.4	15.3	1.63
Mixed of GA_3 50 ppm + Camphor oil (3 cm^3/L)	12.7	14.7	1.33	12.7	15.2	1.67
Mixed of GA_3 50 ppm + Camphor oil (4.5 cm^3/L)	11.00	13.9	1.17	11.0	15.0	1.33
New LSD at 0.05	0.73	0.42	0.35	0.77	0.43	0.04

1.3- Branch No/shrub, length and diameter of branch:

Data recorded in Table (3) showed that all treatments with camphor oil (1.5, 3 and 4.5 cm^3/L), GA_3 (25, 50, 100 ppm), glauconite (250 and 500 g/shrub), EM1 (3, 6 and 9 cm^3/L) and mixtures of GA_3 at 50 ppm with camphor oil at 1.5, 3 and 4.5 cm^3/L resulted in significant increase in branch No/shrub, branch length (cm) and branch diameter (cm) of Jojoba shrub in comparison with untreated shrubs during 2014 and 2015 seasons.

Concerning treatment effects on branch No/shrub, it was obviously that treatment with glauconite at 500 g/shrub gave the highest branch No/shrub (13.3), followed by treatment with a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L (13.1), thereafter treatment with camphor oil at 4.5 cm^3/L (13.0), then treatment with EM1 at 9 cm^3/L (12.7) in comparison with untreated shrubs in season 2014, while in season 2015 treatment with camphor oil at 3 cm^3/L gave the highest branch No/shrub (13.7), followed by treatment with GA_3 at 50 ppm (13.3), then treatment with a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L (13.1), all results were compared with untreated shrubs.

Regarding to treatments effects on branch length (cm) of Jojoba shrubs, it could be observed that treatment with camphor oil at 1.5 cm^3/L gave the highest branch length (45.0 cm), followed by treatment with GA_3 at 50 ppm or treatment with a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L (41.7 cm each), thereafter treatment with a mixture of GA_3 50 ppm + camphor oil at 1.5 cm^3/L) (39.7 cm) during 2014 season, while in season 2015, treatment with glauconite at 250 g/shrub gave the highest branch length (47.7 cm), followed by treatment with glauconite at 500 g/shrub (46.7 cm), thereafter treatment with a mixture of GA_3 50 ppm + camphor oil 1.5 cm^3/L or a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L (45.7 cm, each), all data were compared to untreated shrubs.

As well as, it was clear that all treatments induced significant increase in branch diameter of Jojoba shrubs during the two studied seasons, whereas treatment with both of camphor oil at 4.5 cm^3/L, GA_3 at 50 ppm and GA_3 at 100 ppm gave the greatest branch diameter (cm) (3.70 cm, each), followed by treatments with a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L, or a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L (3.67 cm, each), thereafter treatment with a mixture of GA_3 50 ppm + camphor oil at 1.5 cm^3/L (3.33 cm) during season 2014, while in season 2015, treatment with glauconite at 250 g/shrub or treatment with EM1 at 9 cm^3/L and a mixture of GA_3 50 ppm + camphor oil t 1.5 cm^3/L gave the greatest branch diameter (4.00 cm, each) followed by treatment with camphor oil at 3 cm^3/L or treatment with camphor oil at 5.4 cm^3/L and treatment with GA_3 at 50 ppm (3.70 cm), thereafter treatment with a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L, or treatment with a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L (3.67 cm, each), all results were compared to untreated shrubs.

These obtained results are in agreement with those found by Yousaf *et al.* (2007) and Ahmed (2007).

Table 3. Effect of treatments with camphor oil, gibberellic acid (GA_3), effective microorganisms (EM1) and glauconite on branch No/shrub, branch length (cm) and branch diameter (mm) of Jojoba shrubs during 2014 and 2015 seasons.

Treatments	Season 2014			Season 2015		
	Branch No/shrub	Branch length (cm)	branch diameter (mm)	Branch No/shrub	Branch Length (cm)	Branch Diameter (mm)
Control	10.7	35.7	2.70	10.3	33.3	3.00
Camphor oil (1.5 cm^3/L)	11.7	45.0	3.00	13.0	41.7	3.10
Camphor oil (3 cm^3/L)	11.7	38.3	3.30	13.7	35.3	3.70
Camphor oil (4.5 cm^3/L)	13.0	31.7	3.70	13.0	35.0	3.70
GA_3 (25 ppm)	8.7	37.3	3.00	11.7	38.3	3.30
GA_3 (50 ppm)	9.0	41.7	3.70	13.3	35.7	3.70
GA_3 (100 ppm)	12.3	34.0	3.70	12.3	33.7	3.30
Glauconite (250 g/shrub)	11.3	35.3	3.00	8.3	47.7	4.00
Glauconite (500 g/shrub)	13.3	33.7	3.30	9.0	46.7	3.30
EM1 (3 cm^3/L)	12.3	31.7	3.30	12.3	36.3	3.70
EM1 (6 cm^3/L)	12.0	33.7	3.30	12.0	35.7	3.30
EM1 (9 cm^3/L)	12.7	37.7	3.00	12.7	43.3	4.00
Mixed of GA_3 50 ppm + Camphor oil (1.5 cm^3/L)	11.3	39.7	3.33	11.3	45.7	4.00
Mixed of GA_3 50 ppm + Camphor oil (3 cm^3/L)	11.3	41.7	3.67	11.3	45.7	3.67
Mixed of GA_3 50 ppm + Camphor oil (4.5 cm^3/L)	13.1	34.3	3.67	13.1	37.3	3.67
New LSD at 0.05	0.71	1.37	0.11	0.81	1.77	0.10

1.4- Shoot No/shrub, leave No/branch and leave No/shrub:

As shown in Table (4), data indicated that most of treatments with camphor oil (1.5, 3.0 and 4.5 cm^3/L), GA_3 (25, 50 and 100 ppm), glauconite (250 and 500 g/shrub), EM1 (3, 6 and 9 cm^3/L), a mixture of GA_3 50 ppm + camphor oil 1.5 cm^3/L, a mixture of GA_3 50 ppm + camphor oil at 3.0 cm^3/L and a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L resulted a significant increase of shoot No/shrub, leave No/branch and leave No/shrub of Jojoba shrubs during 2014 and 2015 seasons.

Concerning the effect of treatments on shoot No/shrub, it could be observed that all treatments induced significant increase in shoot No/shrub of Jojoba during the two studied seasons, except treatment with GA_3 at 25 ppm or 50 ppm resulted in slight decrease in this parameter during season 2014, and treatment with glauconite at 250 g/shrub or 500 g/shrub during season 2015 in comparison with untreated shrub. Moreover, treatment with camphor oil at 4.5 cm^3/L gave the highest shoot No/shrub (169.0), followed by treatment with both of glauconite at 500 g/shrub or with EM1 at 3 cm^3/L (163.6, each), then treatment with a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L (144.1), in season 2014, while in season 2015, treatment with camphor oil gave the highest shoot No/shrub (169.0), followed by treatment with camphor oil at 1.5 cm^3/L (165.1), then treatment with GA_3 at 50 ppm or with GA_3 at 100 ppm (163.9, each), all results were compared with untreated shrubs.

Regarding to effect of the treatments on leave No/branch, it was clear that all treatments caused significant increase in leave No/branch

of Jojoba during the two studied seasons, except treatment with camphor oil at 1.5 cm^3/L in season 2014 (215) and treatment with camphor oil either at 1.5 cm^3/L or at 3.0 cm^3/L caused also a slight decrease in this parameter (225, 236, each, respectively) in season 2015, all data were compared with untreated shrubs.

Furthermore, in season 2014, treatment with EM1 at 5.0 cm^3/L gave the highest leave No/branch (338), followed by treatment with glauconite at 500 g/shrub (338), then treatment with GA_3 at 50 ppm (332), as well as in season 2015 treatment, with EM1 at 6 cm^3/L gave the greatest leave No/branch (338), followed by treatment with GA_3 at 100 ppm or with glauconite at 500 g/shrub (328, each), then treatment with GA_3 at 25 ppm (303), all results were compared with untreated shrubs.

Examining effects of the treatment on leave No/shrubs it could be noticed that all treatment induced significant increase in leave No/shrub in comparison to untreated shrub of Jojoba during the two studied seasons.

The obtained results exhibited that treatment with glauconite at 500 g/shrub induced the greatest leave No/shrub (55234.3), followed by treatment with GA_3 at 100 ppm (46191.9), thereafter treatment with EM1 (6 cm^3/L) (45968.0) during season 2014, while in season 2015 treatment with GA_3 at 100 ppm (53821.1), camphor oil 4.5 cm^3/L (48672.0) then treatment with GA_3 at 50 ppm (47113.9), all data were compared with untreated shrubs.

These positive or negative effects of treatment could be attributed with the growth regulators that the used compound contains.

The obtained results of this study are in harmony with these reported by Ghulam *et al*. (2011), Al-Soqeer *et al*. (2012), and El-Kinawy *et al*. (2012).

Table 4. Effect of treatments with camphor oil, gibberellic acid (GA_3), effective microorganisms (EM1) and glauconite on Shoot No/Shrub, leave No/branch and leave No/ Shrub of Jojoba shrubs during 2014 and 2015 seasons.

Treatments	Season 2014			Season 2015		
	Shoot No/Shrub	Leave No/Branch	Leave No/Shrub	Shoot No/Shrub	Leave No/Branch	Leave No/Shrub
Control	110.21	234	25789.1	106.09	259	27477.3
Camphor oil (1.5 cm^3/L)	132.21	215	28425.2	165.1	225	37147.5
Camphor oil (3 cm^3/L)	128.7	236	30373.2	160.29	236	37828.4
Camphor oil (4.5 cm^3/L)	169.00	288	48672.0	169.00	288	48672.0
GA_3 (25 ppm)	95.7	321	30719.7	136.89	303	41477.7
GA_3 (50 ppm)	99	332	32868.0	163.59	288	47113.9
GA_3 (100 ppm)	143.9	321	46191.9	163.59	329	53821.1
Glauconite (250 g/shrub)	143.9	304	43745.6	91.3	296	27024.8
Glauconite (500 g/shrub)	163.9	337	55234.3	99	329	32571.0
EM1 (3 cm^3/L)	163.6	276	45153.6	156.21	268	41864.3
EM1 (6 cm^3/L)	136	338	45968.0	135.6	338	45832.8
EM1 (9 cm^3/L)	135.9	297	40362.3	135.89	297	40359.3
Mixed of GA_3 50 ppm + Camphor oil (1.5 cm^3/L)	140.12	311	43577.3	140.12	295	41335.4
Mixed of GA_3 50 ppm + Camphor oil (3 cm^3/L)	143.51	303	43483.5	143.51	296	42479.0
Mixed of GA_3 50 ppm + Camphor oil (4.5 cm^3/L)	144.1	255	36745.5	144.1	248	35736.8
New LSD at 0.05	10.7	13.9	1992.0	7.5	13.3	1794.0

1.5- Yield weight (g)/shrub, weight of 100 fruits and weight of 100 seeds:

Data presented in Table (5) exhibited that all treatments with camphor oil (1.5, 3 and 4.5 cm^3/L), GA_3 (25, 50, 100 ppm), glauconite (250 and 500 g/shrub), EM1 (3, 6 and 9 cm^3/L) and mixtures of GA_3 (50 ppm) + camphor oil at (1.5 cm^3/L), mixture of GA_3 (50 ppm) + camphor oil (3.0 cm^3/L) and mixture of GA_3 (50 ppm) + camphor oil (4.5 cm^3/L) resulted in significant increase in yield weight (g)/shrub, weight of 100 fruits (g) and weight of 100 seeds (g) during 2014 and 2015 seasons in comparison with untreated shrubs.

Concerning effects of the treatments on yield weight (g) per shrub, it could be observed that treatment with GA_3 at 50 ppm gave the heaviest weight of yield (g)/shrub (859 (g)/shrub), followed by treatment with a mixture of GA_3 50 ppm + camphor oil (4.5 cm^3/L) (487 (g)/shrub), thereafter treatment with GA_3 at 25 ppm (780 (g)/shrub) during season 2014, while throughout season 2015, treatment with GA_3 at 100 ppm gave the heaviest yield weight (g)/shrub (1455 (g)/shrub), followed by treatment with GA_3 at 50 ppm (1397 (g)/shrub), then treatment with GA_3 at 25 ppm (1380 (g)/shrub), all date were compared to untreated shrubs. These obtained results could be due to the enhancement effects of the treatments specially treatments with GA_3 on improving the vegetative growth of Jojoba shrubs during the two studied seasons.

Regarding the effects of treatments on weight of 100 fruits (g), it was noticed that treatment with a mixture of GA_3 50 ppm + camphor oil (3 cm^3/L) gave the greatest weight of 100 fruits (g) in season 2014 (217 (g)), followed by treatment with GA_3 at 50 ppm (200 (g)), then treatment with a mixture of GA_3 50 ppm + camphor oil (4.5 cm^3/L (187 (g)), while in season 2015 treatment with GA_3 at 100 ppm gave the heaviest weight 100 fruits (g) (205 (g)), followed by treatment with GA_3 at 50 ppm (190 (g)), then treatment with GA_3 at 25 ppm (185 (g)), all data were compared to untreated shrubs.

In addition to that all treatments induced significant increase in weight of 100 seeds (g), during the two studied seasons in comparison with untreated Jojoba shrubs. Furthermore, treatment with a mixture of GA_3 50 ppm + camphor oil at 3 cm^3/L gave the heaviest weight of 100 seeds (g) (159 (g)), followed by treatment with a mixture of GA_3 50 ppm + camphor oil at 4.5 cm^3/L (138 g), then treatment with a mixture of GA_3 50 ppm + camphor oil at 1.5 cm^3/L (130 g) in season 2014, while in season 2015, treatment with GA_3 at 100 ppm gave the greatest weight of 100 seeds (g) (205 g), followed by treatment with GA_3 at 50 ppm (190 g), thereafter treatment with GA_3 at 25 ppm (185 g) all date were compared with untreated shrubs. These positive effects of the treatments with mixture with GA_3 and camphor oils or with GA_3 spraying could be due to the enhancement effects of these compounds on leave no/shrubs, as well as the reduction of respiration rate of Jojoba shrub specially fruits, therefore were reserved carbohydrates and other nutrients, whereas spraying thee comp9ound induced a thin film.

Meanwhile makes a modification of micro-climate conditions around the fruits.

These obtained results are in harmony with those reported by El-Mallah and El-Shami (2009), Al-Soqeer (2010) and Gohil *et al*. (2010) who reported that seed yield of Jojoba as influenced heavily by maximum air temperature and are rich in wax esters with fatty alcohols.

Table 5. Effect of treatments with camphor oil, gibberellic acid (GA_3), effective microorganisms (EM1) and glauconite on yield weight (g)/ shrub, weight of 100 fruits (g) and weight of 100 seeds of Jojoba shrubs during 2014 and 2015 seasons

Treatments	Season 2014			Season 2015		
	Yield(g)/ Shrub	Weight of 100 fruits (g)	Weight of 100 seeds (g)	Yield(g)/ Shrub	Weight of 100 fruits (g)	Weight of 100 seeds (g)
Control	696	145	100	1137	150	105
Camphor oil (1.5 cm^3/L)	723	152	105	1145	160	125
Camphor oil (3 cm^3/L)	717	150	102	1140	155	105
Camphor oil (4.5 cm^3/L)	750	150	105	1150	165	120
GA_3 (25 ppm)	780	155	115	1380	185	140
GA_3 (50 ppm)	754	165	120	1397	190	145
GA_3 (100 ppm)	859	200	110	1455	205	155
Glauconite (250 g/shrub)	702	150	105	1280	180	130
Glauconite (500 g/shrub)	775	150	110	1144	180	135
EM1 (3 cm^3/L)	616	155	112	1286	155	115
EM1 (6 cm^3/L)	744	175	126	1342	150	110
EM1 (9 cm^3/L)	718	165	120	1355	186	135
Mixed of GA_3 50 ppm + Camphor oil (1.5 cm^3/L)	777	177	130	1377	180	135
Mixed of GA_3 50 ppm + Camphor oil (3 cm^3/L)	687	217	159	1360	175	125
Mixed of GA_3 50 ppm + Camphor oil (4.5 cm^3/L)	787	187	138	1357	170	120
New LSD at 0.05	22.0	7.10	6.90	55.8	10.5	8.20

1.6. Rag weight of 100 seeds, oil weight of 100 seeds and oil percentage:

According to date recorded in Table (6), it could be deduced that all treatments with camphor oil (1.5, 3.0 and 4.5 cm^3/L), GA_3 (25, 50 and 100 ppm), glauconite (250, 500 g/shrub), EM1 (3, 6 and 9 cm^3/L), mixture of GA_3 50 ppm + camphor oil (1.5 cm^3/L), mixture of GA_3 50 ppm + camphor oil (3.0 cm^3/L) and mixture of GA_3 50 ppm + camphor oil (4.5 cm^3/L) produced significant increase in rag weight of 100 seeds (g), oil weight of 100 seeds (g) and oil % during the two studied seasons, except treatment with the used compounds induced a reduction in oil % during the second season 2015, all data were compared with untreated Jojoba shrubs.

These negative effects of some treatments on oil % of 100 seeds of Jojoba shrubs could be due to the increase of rag weight of 100 seeds in

response to the effects of this treatments.

Thee obtained results of this study are in agreement with those found by Virender *et al*. (2005) who found a significant variation in seed parameters and showed that oil content ranged from 44.33 to 53.54% and varied among Jojoba clones.

Table 6. Effect of treatments with camphor oil, gibberellic acid (GA_3), effective microorganisms (EM1) and glauconite on rag weight of 100 seed (g), oil weight of 100 seed (g) and oil percentage/100 seed of Jojoba shrubs during2014 and 2015 seasons

Treatments	Season 2014			Season 2015		
	Rag weight of 100 seeds (g)	Oil weight of 100 seeds (g)	Seed Oil %	Rag weight of 100 seeds (g)	Oil weight of 100 seeds (g)	Seed Oil %
Control	47.7	52.3	52.30	46.4	58.6	55.83
Camphor oil (1.5 cm^3/L)	52.3	52.7	55.47	60.0	65.0	52.00
Camphor oil (3 cm^3/L)	47.8	54.2	57.05	51.4	53.6	51.04
Camphor oil (4.5 cm^3/L)	44.4	60.6	57.91	58.0	62.0	51.68
GA_3 (25 ppm)	48.7	66.3	57.65	64.0	76.0	54.20
GA_3 (50 ppm)	54.5	65.5	54.58	67.6	77.9	53.30
GA_3 (100 ppm)	41.7	68.3	57.88	75.0	70.0	51.60
Glauconite (250 g/shrub)	46.3	58.7	53.36	63.1	66.9	51.43
Glauconite (500 g/shrub)	49.7	60.3	55.83	70.8	64.2	47.50
EM1 (3 cm^3/L)	47.0	65.0	58.04	59.9	55.1	47.90
EM1 (6 cm^3/L)	57.0	69.0	57.50	53.2	56.8	51.67
EM1 (9 cm^3/L)	49.6	70.4	58.67	70.1	64.9	48.07
Mixed of GA_3 50 ppm + Camphor oil (1.5 cm^3/L)	61.7	68.3	52.54	58.4	76.6	56.71
Mixed of GA_3 50 ppm + Camphor oil (3 cm^3/L)	77.8	81.2	52.39	64.7	60.3	48.20
Mixed of GA_3 50 ppm + Camphor oil (4.5 cm^3/L)	62.5	75.5	55.93	59.1	60.9	50.75
New LSD at 0.05	3.33	3.20	2.23	2.68	3.43	2.53

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Website: http://www.aun.edu.eg/faculty_agriculture *E-mail: ajas@aun.edu.eg*

تأثير إضافة حمض الجبريليك (GA_3) وبعض المركبات الطبيعية علي النمو الخضري والمحصول وخصائص ثمار شجيرات الجوجوبا

فاروق محمد أحمد مصطفي[١]، محسن عبد المنعم جامع[٢]، علاء عبد الجابر بدوي[١]، محمد عبدالمنعم أمين[٣]

[١] قسم الفاكهة – كلية الزراعة – جامعة أسيوط.
[٢] قسم الأراضي والمياه – كلية الزراعة – جامعة أسيوط.
[٣] مهندس زراعي بالإدارة الزراعية بالداخلة (موط).

الملخص

أجريت هذه الدراسة خلال موسمي ٢٠١٤، ٢٠١٥ علي شجيرات الجوجوبا المنزرعة في مدينة موط بالداخلة بالوادي الجديد لدراسه تأثير إضافة حمض الجبريليك (GA_3) بتركيز ٢٥ ، ٥٠ ، ١٠٠ جزء في المليون ، وزين الكافور (١,٥ ، ٣,٠ ، ٤,٥ سم٣/لتر). ومحلول الكائنات الدقيقة الفعالة (EM1 ، ٣ ، ٦ ، ٩ سم٣/لتر) ومركب الجلوكونايت (٢٥٠ ، ٥٠٠ جم/الشجيرة) وذلك في موعدي : بداية التزهير وبعد العقد بثلاثة أسابيع. بينما تم إضافة الجلوكونايت مرة واحدة قبل بداية التزهير بثلاثة أسابيع وقد صممت التجربة بنظام القطاعات كاملة العشوائية (CBR) مع تكرار كل معاملة ثلاثة مرات وشجيرتان لكل مكررة. وقد أتضح من هذه الدراسة أن:

- أدت جميع المعاملات إلي تحسين خصائص النمو الخضري لشجيرات الجوجوبا وأفضلها محتوي الكائنات الدقيقة الفعالة EM1 ثم حمض الجبريليك GA3 في زيادة إرتفاع الشجيرات وطول وقطر جذعها.
- بينما سجلت معاملات رش زيت الكافور او خليط من الجبريليك مع زيت الكافور افضل النتائج تحسين لعدد الأفرع/ الشجيرة وطول وقطر الفرع.
- في حين كانت معاملات الـ EM1 أفضلها في تحسين عدد الأوراق/الفرع وعدد الأوراق/ الشجيرة ثم مركب الجلوكونايت.
- كانت معاملات الجبريليك ثم معاملات خليط من الجبريليك مع زيت الكافور أفضل المعاملات في إنتاج أعلي محصول/الشجيرة وكذلك أحسن خصائص جودة ثمار وبذور الجوجوبا.

وعليه فإنه للحصول علي أعلي محصول وخصائص جودة للثمار للجوجوبا يمكن التوصية باستعمال خليط من حمض الجبريليك ٥٠ جزء في المليون مع زيت الكافور ٣ سم^3/لتر للحصول علي أعلي وزن ونسبة زيت في بذور الجوجوبا. أو التوصية برش حمض الجبريليك (١٠٠ جزء في المليون) للحصول علي أعلي محصول/ الشجيرة تحت ظروف هذه الدراسة.