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Effect of Spraying with GA_3 on the Quality and Oil Content of Syrian Okra Seeds *Abelmoschus esculentus* (L.)

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Abstract

This study aimed to estimate the effect of spraying of okra plants, *Abelmoschus esculentus* (L.) with GA_3 on the quality and oil content of the seeds. For this, the local okra variety was selected and used, which was growing widespread in the coastal region of Syria. This study was carried out in Al-Haffa area, Lattakia governorate, Syria (with 105 MSL elevation) for two seasons 2019-2020. The results showed that the effect of spraying with GA_3 was more evident in the quality of the seeds as well as oil content at 75 ppm concentration with 68.7 g weight of 1000 seeds and 5.31% seed oil percentage. This study also showed that oil of local okra variety seed was rich in the essential fatty acids namely, linoleic, palmitic, oleic, stearic and linolenic, treatment with 75 ppm concentration of GA3 was more effective in the seed content of essential fatty acids with 42.30%, 32.55%, 9.20%, 6.73% and 5.72%, respectively. Finally, our results were indicated that treatment of okra plants at 75 ppm of GA3 enhanced the quality and oil content of seeds compared to the other concentrations.

Keywords

Oil Content, GA_3, Fatty Acids, Linoleic, Palmitic, Okra

1. Introduction

Okra, *Abelmoschus esculentus* (L.), (family Malvaceae), is one of the most popular summer vegetables for the Arab consumer and the most widely distributed locally, it is growing in the most tropical and subtropical regions of the world [1]. Okra pods can be used for consumption fresh, canned, frozen and dried [2]. These pods are an important food source because they contain many nutrients such as fiber, proteins and carbohydrates, in addition to a good percentage of vitamins and minerals [3]. In addition to the nutritional value, okra pods have medical and therapeutic benefits represented in their ability in regulating blood sugar levels, reducing of blood cholesterol and toxic substance levels in the liver, as well as treating digestive disorders because they contain many digestive enzymes and a large percent of fibers that facilitate the movement of intestines [4].

However, okra seeds are equally important to their pods. They may be roasted and mixed with coffee seeds or used as a substitute for it [5]. Okra seed has high oil content (11.2% - 20%) this oil is rich in unsaturated fatty acids, especially linoleic and palmitic acids, which are used for human consumption, or in the pharmaceutical and cosmetic industries.

Okra seeds are the richest plant parts in proteins, fibers and amino acids (essential and non-essential) especially tryptophan and lysine [6]. Studies show that the essential and non-essential amino acids found in okra seeds are similar to those found in soybean, which makes them of great importance in human nutrition [7]. In addition, the crushed seed may use as a feed for poultry because it is rich in protein and carbohydrate materials [8] and nutrients K, N, Mg, Ca in addition to the presence of Fe, Zn, Mn, Ni [9]. Mal [10] concluded that the combined application of bio-inoculants with organic manures and inorganic fertilizers enhanced the yield and yield attributing characters.

The discovery of plant growth regulators (PGRs) is considered a revolution in the agricultural field, as (PGRs) are organic compounds that are used in small quantities in many physiological processes of plants. The most dominant of these regulators is "gibberellic acid (GA_3)", which plays a great role in various stages of plant growth and development. In this context, [11] study showed that spraying okra plants with GA_3 led to an increase in height, leaf area, number of fruits, seed production and yield of plants. However, [12] study showed that spraying with a 100 ppm concentration of GA_3 achieved a significant increase in the wet and dry weight of the plant, increase in the number of pods/plant and an increase in seed yield per unit area. Some other studies showed that spraying okra plants with GA_3 led to an increase in the number of seeds in dry pods and an increase in the seed yield of okra plants [13] [14].

Due to the nutritional value, medicinal benefits, industrial importance of okra fruits and richness of its seeds in unsaturated fatty acids (linoleic and palmitic acids) which are necessary for human health, increased demand for vegetable oils due to the increase in population, search for new sources of vegetable oils production, and effectiveness of growth regulators, especially GA_3 in improving vegetative growth and seed indicators of okra, as shown by the other studies, this study aimed to evaluate the effectiveness of spraying with GA_3 in improving the quality of okra seeds and increasing their oil content.

2. Materials and Methods

2.1. Plant Material

Local okra cultivar used in this study was growing in widespread area of Coastal area of Syria, which was characterized by straight stems with little branching, purple in color and red pods with five edges.

2.2. Study Area

The research was conducted in the Al-Haffah area, Lattakia Governorate, Syria, which is 105 meters above sea level, during two seasons 2019, 2020.

2.3. Treatments

The experiment included five treatments, namely, the control and spraying with four concentrations of gibberellin (25, 50, 75 and 100 ppm). The sowing of seeds was carried out in single lines separated by a distance of 70 cm and a distance between the pits within the line was 50 cm. The plants were sprayed with GA_3 twice, the first spraying after the integration of germination and the second was a month after the first spray. The complete random block design was followed with three replications for each treatment. The okra pods were collected after ripping and before opening, then seed removed manually from the ripe capsules and dried at 40˚C away from sunlight.

2.4. Oil Extraction

Oil was extracted from seeds with solvents after grinding the seeds and adding hexane (20:1 w/v) in a water bath for 6 hours in an extraction flask and solvent was then evaporated at 45˚C using a rotary evaporator and stored at a temperature of 20˚C in the dark for fatty acid analysis [15].

2.5. Estimation of Fatty Acid

Determination of fatty acids was carried out using gas chromatography (GC) after preparing the methyl ester of fatty acids (FAMEs) according to the method [16], the fatty acids were saponified using 1 mL of oil and 10 mL of methanolic sodium hydroxide solution (0.1M) were added. And was placed for 15 minutes in a water bath at 65˚C, then 10 mL of methanol solution was added.

2.6. Studied Parameters

- ✓ Estimating the weight of 1000 seeds by taking the mean of two random samples, each containing 1000 seeds of pure seeds.
- ✓ Estimating of the seed oil contains (%) using solvents.
- ✓ Estimating of unsaturated fatty acids (%) using a gas chromatography device (GC).

3. Results and Discussion

3.1. Effect of GA_3 on the Weight of 1000 Seeds and the Percentage of Oil in the Seeds

3.1.1. Weight of 1000 Seeds

The results showed that average weight of 1000 seeds in treated plants was 61.8 -

68.7 g compared to 57.4 g in control plants (**Table 1**).

The efficiency of GA_3 was at 75 ppm with the highest recorded weight 68.7 g then it was decreased to 61.8 g at 100 ppm and this indicates that the use of GA_3 at a dilute concentration leads to improve the quality of the seeds and thus increasing their size compared with the higher concentration.

This increase in the weight of 1000 seeds in the treated plants was due to the effective role of GA_3 in stimulating the growth of the shoot and giving it more leaf area by encouraging cell division and increasing its size [17], as well as the effect of GA_3 on the overall physiological processes in the plant-like increasing the leaves content from total chlorophyll and co-enzymes, which enhancing efficiency of plants in production of organic compounds such as carbohydrate and protein, in addition to its effectiveness in assisting the transfer and store these substances in the seeds, which eventually leads to an increase in the size of the seeds [18].

3.1.2. Oil Percentage % in the Seeds

The percentage of seed oil in the treated plants was ranged between 4.55% - 5.31% *versus* 4.31% in control. The effectiveness was more obvious at 75 ppm concentration, in which the oil percent was the highest 5.31% to decrease in treated plant at 100 ppm concentration of GA_3 with 4.93% of seed oil (**Table 1**). Eventhough, the decreasing in the seed oil of Syrian local okra variety but was approximate or exceed the percentage in the Egyptian varieties cultivated in different geographical areas, which was ranged between 4.34% - 4.52% [19], but it was less than the seed oil percentage of the Greek varieties in which was 15.9% - 20.7% [20].

It was noticed that the carbohydrate content of the seeds declined in treated plant seeds from 8.20% to 6.69% corresponding to a rising in the fatty substances from 17.45% to 18.96%, thus, the accumulation of fats in the seeds was associated with decreasing in their content of carbohydrate materials as shown in **Table 2**. Accordingly, increasing in the percentage of fatty substances in the seeds of the treated plants is a result of decrease in carbohydrates [21].

3.2. Effect of GA_3 on the Fatty Acids of the Seeds

The results showed that despite the low percentage of oil in the local okra seeds compared to other varieties, however, it was rich in essential fatty acids, especially linoleic, palmitic, oleic, stearic, and linolenic. The effect of GA_3 was perfect for improving the presence of these acids in okra seed oil. The ratio of linoleic acid was 38.43% - 42.30% compared to untreated plant seeds, 37.50%, and palmitic acid 27.20% - 32.55% *versus* 25.62%, oleic acid 7.30% - 9.20% *versus* 7.10, stearic acid 6.43% - 6.73% *versus* 6.40%, and linolenic acid 4.70% - 5.72% *versus* 4.60%. The effect of GA3 was more evident and effective at a concentration of 75 ppm, where the fatty acids reached the highest values in linoleic, palmitic, oleic, stearic, and linolenic acid 42.30%, 32.55%, 9.20%, 6.73, and 5.72%, respectively (**Table 3**).

Table 1. Effect of spraying with GA_3 on the weight of 1000 seeds and the percentage of oil in okra *Abelmoschus esculentus* (L.) seeds.

	Weight of 1000 seeds (g)	Oil percent %
T0: control	57.4^{e}	4.31^{d}
T1: GA_3 (25 ppm)	63.6^{c}	4.55^{c}
T2: GA_3 (50 ppm)	66.6^{b}	4.84^{b}
T3: GA_3 (75 ppm)	68.7^{a}	5.31^{a}
T4: GA_3 (100 ppm)	61.8^{d}	4.93^{b}
L.S.D. 5%	1.7	0.21

*Values that have the same letters within the same column have no significant difference between them at LSD 5%.

Table 2. Effect of spraying with GA_3 on the chemical composition of okra seeds *Abelmoschus esculentus* (L.).

	Moister %	Ash %	Protein substances %	Fatty substances %	Carbohydrates substances %	Fiber %
T0: control	12.20^{a}	4.12^{c}	20.25^{c}	16.34^{c}	8.20^{a}	35.70^{a}
T1: GA_3 (25 ppm)	14.02^{ab}	4.30^{bc}	20.93^{bc}	17.45^{b}	7.55^{b}	33.91^{b}
T2: GA_3 (50 ppm)	13.63^{bc}	4.70^{b}	22.43^{b}	18.25^{ab}	7.01^{c}	31.39^{c}
T3: GA_3 (75 ppm)	12.75^{d}	4.90^{a}	23.73^{a}	18.96^{a}	6.69^{d}	30.17^{c}
T4: GA_3 (100 ppm)	13.56^{c}	4.60^{b}	21.30^{ab}	17.84^{b}	7.32^{bc}	33.30^{b}
L.S.D. 5%	0.42	0.36	1.25	0.81	0.28	1.63

*Values that have the same letters within the same column have no significant difference between them at LSD 5%.

Table 3. Effect of spraying with GA_3 on the percentage of unsaturated fatty acids in okra seed oil *Abelmoschus esculentus* (L.).

Fatty acids Treatments	Linoleic %	Palmitic %	Oleic %	Stearic %	Linolenic %	Margaric %	Palmitoleic %	Myristic %
T0: control	37.50^{d}	25.62^{d}	7.10^{c}	6.40^{d}	4.60^{d}	1.76^{e}	0.51^{e}	0.21^{e}
T1: GA_3 (25 ppm)	38.43^{c}	27.20^{c}	7.30^{c}	6.43^{d}	4.70^{cd}	1.80^{d}	0.56^{c}	0.26^{c}
T2: GA_3 (50 ppm)	40.40^{b}	29.40^{b}	8.50^{b}	6.53^{c}	4.80^{c}	1.86^{c}	0.60^{b}	0.30^{b}
T3: GA_3 (75 ppm)	42.30^{a}	32.55^{a}	9.20^{a}	6.73^{a}	5.72^{a}	2.20^{a}	0.67^{a}	0.33^{a}
T4: GA_3 (100 ppm)	38.39^{c}	29.92^{d}	8.80^{b}	6.64^{b}	5.36^{b}	1.97^{b}	0.54^{d}	0.24^{d}
L.S.D. 5%	0.72	0.91	0.31	0.05	0.10	0.03	0.02	0.02

*Values that have the same letters within the same column have no significant difference between them at LSD 5%.

However, Okra seed oil contained a small amount of margaric acid 1.80% - 2.20% in treated plants *versus* 1.76% in control plants, palmitoleic acid 0.56% - 0.67% compared to 0.51% in untreated plants, and myristic acid 0.26% - 0.33% compared to 0.21%, with a strong effect of treatment with GA_3 at a concentration of 75 ppm, where the highest values recorded 2.20%, 0.67%, and 0.33%, for three above acids, respectively (Table 3).

The dominance of GA_3 treatment with the concentration of 75 ppm was due to its role in increasing the osmotic pressure inside the plant cells, which leads to an increase in the absorption of water and nutrients by the plant [22] and GA_3 also stimulates the production of RNA, which increases proteins synthesis [23] as well as its role in encouraging the activity of the lipase, which contributes to the breakdown of fats into fatty acids [24].

This study showed that okra seeds were the source of many fatty acids. Those fatty acids are essential for human health, especially linoleic, palmitic. Linoleic and oleic acid are the most important sources of omega 6, which is a necessary compound in the cosmetics industry, because of their assistance in maintaining the freshness and moisture of the skin, as well as its use in the manufacture of dyes, resins, and plastics [25].

In addition, the local okra seed oil represents an essential source of palmitic acid, which is also crucial for the cosmetics industry [5]. Palmitic acid occupied the second rank after linoleic acid in the local okra seed oil (**Table 3**). Linolenic acid is equal to other fatty acids because it is one of the sources of omega 3, which is necessary to maintain the health of the cardiovascular system. It also reduces the risk of cardiovascular diseases due to its richness in prostaglandins, which are essential in lowering blood pressure and inhibiting aggregation of platelets [19].

4. Conclusion

Treating of plants by GA_3 at a concentration of 75 ppm enhanced the weight of 1000 seeds and seed oil content of okra as well as improved the oil content of unsaturated fatty acids which was rich in linoleic and palmitic acid. Thus, okra seeds are a promising source of fats with medicinal and cosmetic usage. Therefore, we propose to expand the study of the effect of some plant extracts, organic compounds, and growth regulators on local okra varieties planted in different geographical areas of Syria to increase the percentage of oil and improve its quality.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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