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(Original Article)

Effect of Foliar Application with Gibberellic Acid on Growth, Yield Components of Sesame and its Seed Oil Content

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Abstract

The present investigation was carried out at field Experimental Station, Agric. Faculty., Assiut Univ., during the two successive summer seasons, 2023 and 2024 to evaluate the effects of foliar application of gibberellic acid at three times; 25 or 45 days once and twice at 25 and 45 DAS during growing season with concentrations of 0, 50, 100, and 150 ppm GA_3 on the growth, yield, and seed oil characteristics of sesame (Giza 32).

Results showed that highly significant differences in mean vegetative growth, yield components and seed oil yield in both seasons. Application of 150 ppm of GA_3 significantly increased plant height by (18.23 & 18.18%) and fruiting zone length by (31.61 & 31.65%) as well as, No. of capsules plant $^{-1}$ by (28.86 & 28.90 %), capsule length by (5.86 & 11.22 %) and No. of seeds capsule^{-1} by (19.84 & 19.87 %) in comparison to the control treatment in both seasons, respectively.

Spraying GA3 twice at 25 and 45 DAS induced significant values of all vegetative and yield components and seed oil yield in both seasons.

The most effective treatment which gave the highest values of yield and its components in both studied seasons was that of spraying 150 ppm GA3 twice at 25 and 45 DAS which recorded (1036.1 & 1152.5kg fed) for Seed yield, (514.3 & 572.1kg fed) for Oil yield and (20.75 & 23.08) for HI in both seasons, respectively

Keywords: *Gibberellic acid, Growth, Oil content, Sesame, yield .*

Intoroduction

Sesame (*Sesamum indicum* L.) is one of the oldest oilseed crops worldwide and ranks among the most important edible oilseed species after groundnut and rapeseed–mustard. As a naturally drought-tolerant crop belonging to the Pedaliaceae family, sesame is highly valued for its rich chemical composition. Its seeds contain about 42–50% oil and around 25% protein, in addition to 16–18% carbohydrates and approximately 42% essential linoleic acid (Miah *et al.*, 2015). High-quality sesame oil is widely utilized in cooking, margarine production, and various pharmaceutical applications. It is also rich in essential vitamins and minerals (Malik *et al.*, 2003). The average area cultivated with sesame in Egypt during the period 2000–2018 was estimated at 73.73 thousand feddans, while the average production reached about 327.40 thousand ardebs (Fangary, 2021).

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Recently, plant growth regulators have emerged as a new generation of agrochemicals, valued not only for their capacity to modify plant architecture but also for their role in enhancing the source–sink relationship and promoting the translocation of photo-assimilates. These actions ultimately contribute to better flower retention, improved capsule formation, and enhanced seed development. (Hadiya *et al* 2021) Among these regulators, gibberellic acid (GA_3) is distinguished as a major factor influencing stem elongation in sesame. Plant growth hormones—organic molecules produced in very small amounts in specific organs or tissues—play a bivotal role in directing plant growth and productivity, acting either locally at their site of synthesis or after being transported to other parts of the plant. Gibberellins, including GA_3, are tetracyclic diterpenoid compounds essential for regulating various developmental processes. Gibberellic acid (GA_3), one of the most extensively studied phytohormones, exerts diverse physiological effects such as promoting seed germination, enhancing stem elongation, stimulating leaf expansion and photosynthesis, and supporting flowering and cell enlargement (Taiz and Zeiger, 2010). Moreover, GA_3 has been reported to promote rapid stem elongation and stimulate bud development (Kabar 1990). Moreover, gibberellic acid (GA_3) is an endogenous plant growth regulator that stimulates cell elongation and enhances overall plant growth (Zang *et al.*, 2016).

Gibberellic acid has been shown to enhance overall plant growth and increase the yield of many crops (Vekaria *et al.*, 2017). However, its effectiveness is strongly influenced by factors such as application concentration, timing, and prevailing environmental conditions (Roller *et al*., 1960). Reddi *et al.* (2021) reported that a spacing of 45 cm × 10 cm combined with foliar application of GA_3 at 10 ppm at 30 and 45 DAS resulted in significantly greater plant height (88.29 cm), number of branches (4.21), and plant dry weight (21.81 g) compared with all other treatment combinations. The same treatment also produced superior yield attributes, including a higher number of capsules per plant (43.96), seeds per capsule (54.52), seed yield (8.27 q/ha), and stover yield (27.84 q/ha), outperforming all other evaluated treatment Moreover, Hadiya *et al.* (2021) reported that foliar application of GA_3 at 200 ppm significantly enhanced sesame seed yield and its related attributes, including the number of capsules per plant, number of seeds per capsule, biological yield, harvest index, and oil content.

Sonia *et al.* (2024) concluded that the application of plant growth regulators (thiourea, ortho-silicic acid, and gibberellic acid) significantly improved the growth, physiological performance, yield, and quality of sesame under rainfed conditions. Among these, GA_3 at 20 ppm was found to be the most effective, enhancing not only optimal productivity but also key quality traits of sesame. Similarly, Sunaina *et al.* (2025) reported that the highest plant height (112.79 cm) and plant dry weight (12.79 g) were observed in treatment 6 (Sulphur 40 kg/ha + GA_3 200 ppm), moreover the maximum number of capsules per plant (38.60) and seeds per capsule (68.53) were recorded in treatment 5 (Sulphur 40 kg/ha + GA_3 150 ppm).

Furthermore, multiple applications of GA_3 can produce more pronounced effects compared to a single spray, although the optimal frequency and concentration depend on the specific growth stage and objectives (Thuc *et al.*, 2021). Reddi *et al.* (2021) reported that foliar application of GA_3 at 10 ppm with a spacing of 45 cm × 10 cm, applied twice at 30 and 45 DAS, resulted in 43.96 capsules per plant and a seed yield of 13.77 q/ha, outperforming a single spray at 30 DAS. Similarly, Thuc *et al.* (2021) found that spraying GA_3 at 100 ppm at 25 and 35 DAS produced the greatest plant height (123.1 cm) and the highest number of flowers on the main stalk (29.4), which subsequently increased the number of pods per plant, seeds per pod, and seed weight per plant. This treatment also enhanced sesame yield by 1.4 times compared to the control and resulted in the highest seed oil content (49.2%).

The aim of this study was to determine the optimum concentration and date of application of GA3 for improving sesame plant growth, yield components, seed yield and oil content.

Materials And Methods

A field experiment was carried out at the Field Experimental Station, Faculty of Agriculture, Assiut University, Assiut Governorate, Egypt, during the summer seasons of 2023 and 2024 to evaluate the effects of foliar application of gibberellic acid (GA_3) at different concentrations and application timings on the vegetative growth, yield components, and seed oil content of sesame (Sesamum indicum L. cv. Giza 32

The physical and chemical properties of the soil for both experimental seasons were determined according to Ryan *et al*. (1996) and are presented in Table 1. Sesame seeds were kindly provided by the Oil Crops Research Department, Giza, Egypt. The experiment was arranged in a split-plot design with three replicates. Foliar application of GA_3 at concentrations of 0, 50, and 100 ppm was assigned to the main plots, while foliar spraying dates (25 DAS, 45 DAS, and twice at 25 and 45 DAS) were allocated to the subplots. Each subplot covered an area of 21 m^2, consisting of seven ridges, each 5 m long and spaced 60 cm apart. Seeds were sown in hills 15 cm apart along one side of the ridges, with sowing carried out on 18 June in both seasons. Three weeks after sowing, seedlings were thinned to two per hill to achieve the recommended plant density. Phosphorus fertilizer was applied at a rate of 30 kg P_2O_5/fed before sowing in the form of calcium superphosphate (15.5% P_2O_5). Nitrogen fertilizer was applied at 22.5 kg N/fed (half of the recommended dose) in three equal split doses: before sowing, after thinning, and at floral bud initiation. Potassium fertilizer was added at 24 kg K_2O/fed in the form of potassium sulfate (48% K_2O) immediately after thinning. All other cultural practices were carried out according to recommended guidelines.

Table 1. Some physical and chemical properties of the soil in both seasons.

Season	Sand %	Silt %	Clay %	Texture	pH 1:1	ECe dS/m	Total CaCO3 %
2023	19.3	31.0	49.7	Clay	7.59	1.44	3.10
2024	21	29.4	49.6	Clay	8.06	1.32	3.75
Season		**Total N %**	**Available nutrients ppm**				
			P	**K**	**Fe**	**Mn**	**Zn**
2023		1.85	16.7	354	10.7	9.3	1.0
2024		1.80	14.8	325	8.6	8.0	1.1

At harvest, sampling of ten guarded plants was done across one middle ridge of each plot for measuring.

Data recorded

1- Growth traits: Including plant height (cm), Fruiting zone length (cm) and No. of fruiting nodes plant^{-1} .

2- Capsule properties: At harvest (150 days after sowing) a random sample of ten plants was taken from the three central ridges in each subplot to estimate No. of capsules plant $^{-1}$, capsule length (cm) and No. of seeds capule^{-1}.

3- Seed properties: At harvest time, sample of mature seed 1000-seed weight (g), Seed weight plant $^{-1}$ (g) and Seed oil (%).

4- Seed Oil yield: Seed yield (kg fed), Oil yield (kg fed) and harvest index HI (%). Seed yield ha−1 was calculated based on 9% moisture content. Seed oil content was determined according to A.O.A.C. (1995) then oil yield ha−1 were computed.

5- Statistical analysis: Data were statistically analyzed according to Steel and Torrie (1980). “Means with the same letter are not significantly different according to Tukey’s HSD test (Steel & Torrie, 1980).

Results And Discusion

Vegetative Growth parameters

Data presented in Table 2 indicate the effect of different Gibberellic Acid concentrations (GA_3) and time of application on the examined parameters of plant height, fruiting zone length (cm) and No. of fruiting nodes plant^{-1} had significant effects during the both growing seasons of 2023 and 2024.

Results in Table 2 showed that significant differences in mean plant height between the four studied concentrations of (GA_3). Foliar application at 150 ppm recorded the maximum mean values of all the examined parameters under the study than the control and even than the other concentrations of GA_3 in both seasons, respectively. Also, the increase percentages due to the application of 150 ppm of GA_3 surpassed the control treatment by (18.23 & 18.18%) for plant height , by (31.61 & 31.65%) for fruiting zone length and by (36.57 & 36.59%) for No. of fruiting nodes plant^{-1} in comparison to the control treatment in the 1st and 2nd season, respectively. Application of different levels of GA_3 had significant impact on all the growth and yield characters. Similar result was revealed by Thuc *et al.,* (2021) found that at 100 ppm GA_3, greatest plant height was recorded (123.1 cm) and this was significantly higher than the control. Also, foliar application by GA_3 may be enhanced metabolic activities and photosynthetic rate resulting in improvement in plant height and ultimately the accumulation of dry matter at the successive growth stages The similar results Sunaina *et al* (2025) revealed that significantly higher plant height (112.79) was recorded application of sulphur at a rate of 40 kg/ha + GA_3 at 200 ppm. Similar results were obtained by Murmu *et al.,* (2015) and Kumar *et al.,* (2017). The increase of plant height supports the earlier investigators findings of Behera *et al.* (2017), Sarkar *et al*. (2002) and Vekaria *et al.* (2017) in sesame.

Regarding time of applications Table 2, results revealed that GA_3 foliar application of twice (at 25 and 45 DAS) increased all studied parameters in comparison to foliar application once at 25 or 45 DAS in both seasons. Obtained results revealed that spraying the plants either once at 25 or 45 DAS had insignificant effect on all studied parameters except No. of fruiting nodes plant^{-1} which represents highest response of spraying at 45 DAS compared to spraying at 25 DAS in both seasons, respectively. It's known that spraying sesame with GA_3 double times is generally better than a single application for improving growth indicators like the number of branches and overall yield. Multiple applications of GA_3 can lead to more significant results compared to a single spray, but the optimal frequency and concentration depend on the specific growth stage and goals (Thuc *et al.*, 2021). Reddi *et al.,* (2021) indicated that spraying with gibberellic acid at a rate of 10 ppm twice with spacing 45cm ×10 cm (after 30 and 45 DAS) led to an increase in plant height to (88.29 cm), compared to spraying once (at 30 DAS) to (84.07 cm).Moreover, Lakhnotra *et al.,* (2023) revealed that the application of IAA 100 ppm at flowering and capsule formation stage in sesame had significant effect on days to maturity and gave early maturity than other treatments of plant growth regulators. Late maturity observed under Control. This might be due to the favorable growth and more number of capsules which promotes earliness as compare to Control.

Concerning the interaction between GA_3 concentrations and time of application found that maximum values of plant height, fruiting zone length (cm) and No. of fruiting nodes plant^{-1} recorded due to foliar application of GA_3 at a concentration of 150 ppm twice at 25 and 45 DAS in both seasons, respectively with values of (109.1 & 121.4 cm) for plant height, (77.21 & 85.88 cm) for fruiting zone length, (21.10 & 23.47) for No. of fruiting nodes plant^{-1} in both seasons, respectively.

جدول 2 بالعرض

Capsule properties

Average of No. of capsules plant $^{-1}$, Capsule length (cm) and No. of seeds capule^{-1} of sesame as affected by different GA_3 concentrations, time of applications and their interaction in 2023 and 2024 seasons are presented in Table 3.

Obtained results in the same Table indicated that maximum mean values of No. of capsules plant $^{-1}$, Capsule length (cm) and No. of seeds capule^{-1} were significantly recorded by 150 ppm foliar application of GA_3 in both seasons. The increase percentages were (28.86 & 28.90 %) for No. of capsules plant $^{-1}$, (5.86 & 11.22 %), for Capsule length (cm) and (19.84 & 19.87 %) for No. of seeds capule^{-1} in comparison to the control treatment in both seasons, respectively. Its might be attributed that GA_3 treatment promotes early and synchronized flowering, increases the number of capsules per plant, and improves seed filling. The optimal GA_3 concentration for sesame is usually reported between 50–150 ppm**,** depending on genotype and environmental conditions. Excessive doses, however, may lead to excessive vegetative growth at the expense of reproductive development (Thuc *et al.*, 2021). Similar results was in agreement with Sunaina *et al.*, (2025) who revealed that treatment sulphur application at a rate of 40 kg/ha and foliar application of GA_3 150 ppm recorded significant highest No. of capsules/plant (38.60) as well as highest No. of seeds/capsule (68.53). These findings are in conformity with those reported by Behera *et al.*, (2017) .

Concerning the main effect of time of application in Table 3, results revealed that, yield components under the study were significantly increased with increasing time of applications in both seasons. Application of GA_3 twice (at 25 and 45 DAS) increased the values of No. of capsules plant $^{-1}$, Capsule length (cm) and No. of seeds capule^{-1} in both seasons, respectively. The values were recorded (34.83 & 38.74) for No. of capsules plant $^{-1,}$ (2.819 & 3.136) for Capsule length (cm) and (52.83 & 58.76) for No. of seeds capule^{-1}. It's known that foliar application can be better than a single application when it's done twice, especially for growth hormones or during critical growth stages, because it increases the supply of hormones to the plant at a time it needs them most. Double foliar application can lead to significantly better yield attributes and growth compared to a single spray or even a soil application alone. in this respect, Reddi *et al.*, (2021) stated that spacing 45cm×10cm + GA3 10 ppm + Foliar spray twice at 30 and 45 DAS recorded (43.96) capsules/plant, (13.77 (q/ha)) seed yield compared to foliar spray once at 30 DAS. Similar result was obtained by Sarkar *et al.*, (2002) who recorded that GA_3 had a regulatory effect to increase the number of flowers, number of pods, percentage of fruit set, number of seed plant^{-1}, seed yield plant^{-1}, 1000-seeds weight and seed yield and Stover yield. Moreover, Hadiya *et al.*, (2021) revealed that highest value of capsules per plant, Number of seed per capsule recorded with GA_3 200 ppm followed by NAA 50 ppm as compared to rest of all other treatments. These results were evident by the finding of Behera *et al.*, (2017).

جدول 3 بالعرض

In relation to the interaction effects between GA concentrations and time of application in the same Table, results indicated that spraying sesame plants by 150 ppm GA_3 twice (at 25 and 45 DAS) recorded the highest value of No. of capsules plant $^{-1}$, Capsule length (cm) and No. of seeds capule^{-1} which reached (40.76 & 45.34%), (2.906 & 3.232%) and (58.33 & 64.88%) in the 1st and 2nd seasons, respectively.

Seed properties

Data demonstrated in Table 4 stated that main values of yield parameters highly significantly affected by GA_3 time of applications and their interactions in both seasons. The obtained results in Table, 4 showed that GA at a concentration of 150 ppm recoded the maximum values of 1000-Seed weight (g) (4.834 & 5.3774), Seed weight plant $^{-1}$ (g) (29.38 & 32.68) and Seed oil (%) (50.04 & 55.66) While, foliar application with the control recorded the minimum values of all the parameters under the study in the 1st and 2nd season, respectively. Also, foliar application of GA_3 at 150 ppm was superior in increasing yield parameters in comparison to the other concentrations of GA in both seasons. In this respect, Hadiya *et al.,* (2021) revealed that 1000-seed weight (g) save the maximum 1000-seed weight (g) with foliar application of GA_3 200 ppm as compared to all other treatments.

Also, data in the same Table, 4, showed that main value of yield parameters highly significantly affected by the time of applications in both seasons. 1000-seed weight (g), seed weight plant $^{-1}$ (g) and seed oil (%) significantly increased with increasing no of application of GR. Foliar application of GA twice (25 and 45 DAS) recorded the maximum values of 1000-seed weight (g), seed weight plant $^{\mathbf{-1}}$ (g) and seed oil (%) in both seasons, respectively. While, the minimum values of these traits was recorded due to foliar application once (at 25 or 45 DAS) during the season. Results concluded that, two applications of GA3 were more effective in increasing sesame yield attributer than a single one. The optimal number of applications and concentration depends on the specific plant and growth stage.

Regarding the interaction between GA_3 concentration and time of application, results recorded in Table, 4 found that the maximum values of 1000-seed weight (g) (4.871 & 5.418), seed weight plant $^{-1}$ (g) (31.16 & 34.66) and seed oil (50.30 & 55.95) due to the applied 150 ppm of GA_3 twice in both seasons, respectively.

جدول 4 بالعرض

Seed and Oil yield/fed and HI%

Data demonstrated in Table, 5 indicated that main values of Seed yield, oil yield and HI (%) had highly significantly affected by GA_3 concentrations, time of applications and their interaction in both seasons. The obtained results in the same Table showed that 150 ppm of GA recoded the maximum values of seed yield (1013.1 & 1126.9), oil yield (490.5 & 545.6) and HI (20.57 & 22.88). Meanwhile, control treatment recorded the minimum values of seed yield (790.7 & 879.3), oil yield (235.4 & 261.8) and HI (15.55 & 17.29) in the 1^{st} and 2^{nd} season, respectively. Also, foliar application of 150 ppm of GA_3 significantly increased by (28.12% & 28.15%), (108.36% & 108.40%) and (32.28% & 32.33%) over the control treatment in both seasons, respectively. In this respect, Thuc *et al* (2021) found that foliar application of GA3 at 100pppm increased sesame yield by 1.4% times with compared to the control and significantly oil content in sesame seeds (13.4). Moreover, Behera *et al* (2017) reported that foliar applications of GA_3 improve the oil content in sesame seeds. Hadiya *et al.*, (2021) concluded the same trend.

Data the same Table showed that main values of seed yield, oil yield and HI (%) highly significantly affected by the time of applications in both seasons.

Results revealed that foliar application of GA_3 twice at 25 and 45 DAS gave the maximum values of seed yield, oil yield and HI (%). The values recorded (947.3 & 1053.6) for seed yield, (421.9 & 469.2) for oil yield and (18.47 & 20.54) for HI in both seasons, respectively. These results could be explained that spraying with gibberellic acid twice, 25 and 45 days after planting, helps plants respond fully to the spraying process, which occurs between the flowering and fruit set stages. The response is highest at the beginning of flowering and continues until the end of fruit set.

Mishra *et al.*, (2018) indicated that three times application of GA_3 at 100 ppm of China aster (*Callistephus chinensis* (L.) Nees) recorded maximum plant height, number of primary branches, number of leaves, and number of flowers and duration of flowering. Days to bud initiation, bud showing colour and flowering were earliest when sprayed trible with 100 ppm GA3.

Regarding the interaction between GR_3 concentrations and time of application, results recorded in Table, 5 that the maximum values of (1036.1 & 1152.5) for seed yield, (514.3 & 572.1) for oil yield and (2075 & 23.08) for HI due to foliar application by GA3 twice at 25 and 45 DAS in both seasons, respectively.

جدول 5 بالعرض

The Interrelationships among Sesame Traits

The correlation coefficients between seed yield and most traits were significant and positive (Table, 6). Highly significant and positive correlations was observed between seed yield and Seed weight plant (0.959**), No. of fruiting nodes plant (0.956**), Fruiting zone length (0.951**), HI (0.949**), 1000-seed weight (0.940**), Oil yield (0.937**), No. of capsules plant (0.884**), Seed oil (0.879**), Seed yield (0.835**), No. of seeds capsule (0.766**) and Capsule length (0.698**). These strong positive relationships indicate that improving these specific components will lead to higher seed yields. In this respect, Rao *et al.*, (2021) reported that all the yield components of sesame showed significantly positive linear relationship with seed yield

In this connection positive and significant relationships were found between seed yield and all parameters under the study. In this respect, Hamza and Abd El-Salam (2015) in Egypt showed significant and positive association between seed yield and most studied characters especially oil yield, seed yield plant ^{1}, number of capsules plant, 1000-seed weight and number of seeds capsule.

جدول 6 بالعرض

Conclusions

Results of this research under clay soil conditions in Upper Egypt refer that among all the studied characters related to seed yield production and their distribution in component parts of plant and it was observed that the GA_3 150 ppm sprayed twice after 25 and 45 DAS was found superior under Assiut conditions. Therefore on the basis of these observations, foliar application of GA_3 150 ppm twice after 25 and 45 DAS was most promising treatment due to the highest seed yield under Assiut condition.

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تأثير الرش الورقي بحمض الجبريليك على نمو ومكونات المحصول في السمسم ومحتوى بذوره من الزيت

هويدا عز الدين عبد القادر

قسم المحاصيل ، كلية الزراعة ، جامعة أسيوط

الملخص

أُجريت هذه الدراسة في محطة التجارب الحقلية التابعة لكلية الزراعة، جامعة أسيوط، خلال موسمي الصيف المتتاليين (2023 ، 2024)، من أجل دراسة تأثير الرش الورقي مفردا عند 25 ، 45 ومرتين عند 25 ، 45 (DAS) بتركيزات حمض الجبريليك (0، 50، 100 ، 150 جزء في المليون) على النمو والإنتاجية وكذلك محتوى بعض الزيوت في بذور السمسم (جيزة 32).

أظهرت النتائج وجود فروق معنوية عالية في متوسط النمو الخضري ومكونات المحصول ومحتوى بذوره من الزيت في كلا الموسمين. أدى رش GA3 بتركيز 150 جزء في المليون إلى زيادة معنوية في ارتفاع النبات بنسبة (18.23 ، 18.18%) وطول منطقة الإثمار بنسبة (31.61 ، 31.65%)، بالإضافة إلى عدد الكبسولات النباتية بنسبة (28.86 ، 28.90%)، وطول الكبسولة بنسبة (5.86 ، 11.22%)، وعدد البذور / للكبسوله بنسبة (19.84 ، 19.87%)، وذلك مقارنةً بمعاملة الكنترول في كلا الموسمين على التوالي.

أدى رش GA3 مرتين بمعدل 25 ، 45 يومًا بعد الزراعة إلى زيادة معنوية في جميع مكونات المجموع الخضري ومكونات المحصول، بالإضافة إلى إنتاج زيت البذور في كلا الموسمين على التوالي. كانت المعاملة الأكثر فعالية والتي أعطت أعلى قيم للمحصول ومكوناته في كلا الموسمين هي رش 150 جزء في المليون من حمض الجبرليك مرتين عند 25 و45 يومًا بعد الزراعة، حيث سجلت (1036.1 ، 1152.5 كجم فدان) لمحصول البذور، ،(514.3 ، 572.1 كجم فدان) لمحصول الزيت، (20.75 ، 23.08) لمعامل الحصاد في كلا الموسمين على التوالي.

الكلمات المفتاحية :