EFFECT OF SOME BIOREGULATORS ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF SESAME PLANT.

By

AbdEl-Dayem, H. M.; Mady, M.A.; El-Desouky, S.A. and Eid, Rania, S. M.

Dept. of Agric. Botany, Fac. of Agric. Moshtohor, Benha University.

Abstract

Two pot experiments were performed during 2007 and 2008 seasons to study the effect of foliar application with benzyladenine (BA) at 20,40 and 60 ppm, putrscine (Put) and salicylic acid (SA) at 25,50 and 100 ppm for each on growth, yield and its components as well as on some chemical composition of sesame plant (varity shandawel 3). The obtained results indicated that the foliar application of benzyladenine (40 ppm), putrscine (100 ppm) and Salicylic acid (50 ppm) significantly increased all vegetative growth characteristics, i.e. stem length, number and leaf area / plant, dry weight of stems, leaves and capsules/ plant, net assimilation rate, fruiting zone length, number of flower and capsules per plant at 75 days after sowing. In addition, foliar application of these treatments significantly increased yield and its components , i.e. number of capsules per plant, capsules weight and seeds weight (g) per plant, weight of 1000 seeds (g) and seeds yield (g) per pot as well as seed oil yield per plant. Also, foliar application of BA at 40 ppm, Put at 100 ppm and SA at 50 ppm induced an increase in photosynthetic pigments (chlorophyll a , b and carotenoids) in leaves and minerals (N, P, K, Ca, Mg, Fe and Zn), total sugars and carbohydrates, total free amino acids and crude protein concentration in sesame leaves and seeds. Also, seed oil percentage and percentage of fatty acids composition of sesame oil were increased. Beside that, foliar application with all used bioregulators decreased the percentage of total saturated fatty acids, while induced an obvious increase in the percentage of total unsaturated fatty acids and unsaturated : saturated ratios of sesame seeds oil. In this concern, the foliar applications of BA at 40 and put at 100 ppm were the most effective concentrations on seed and oil yield of sesame plant. Finally, this study strongly admit the use of BA, put and SA at 40, 100 and 50 ppm, respectively for increasing seasme growth and productivity.

Key words: Sesame, bioregulators: benzyladenine, puterscine, salicylic acid, net assimilation rate, photosynthetic pigments, fatty acids.

INTRODUCTION

Sesame (Sesamum indicum, L) plant is consider one of the most important oil crops in the world and Egypt because its seeds contain about 45-55% oil, 19-25% protein, 15-20% carbohydrates, 5% fiber and 4-6% ash (Weiss, 2000) as well as sesame oil contain about 45-50% oleic acid, 34-40% linoleic acid, 7-10% palmitic acid, 3-5%, stearic acid and 105-130 iodine value therefore, its an excellent edible semi-drying oil. This oil could be used as an edible oil for human consumption.

In Egypt, the local production of oil crops is insufficient for local consumption. Since, cropping composition dose not allow enough space for oil crops. Therefore, of interest is to increase its productivity by application of different factors including bioregulators or plant growth regulators (PGRs) to improve growth and development, flowering, fruit set, seed formation and yield of sesame seed oil. Many trails have been carried out for increasing or improvement growth, flowering, seed and oil yield of sesame or other crop plants by the use of plant growth regulators (bio-regulators) by (Zaghlool *et al*., 2001& 2006; Abo El-Saoud, 2005; Abd El-Dayem *et al*., 2005; and Ibrahim and Sharaf El-Deen, 2008).

Putrescine (Put) , benzyladenine and salicylic acid have been shown to be involved in several aspects of plant growth and development including cell division, somatic embryogenesis, rooting, floral initiation, development of flowers and fruits, fruit set, antisenescence, nucleic acids and protien synthesis and stabilization, ionic balance, chlorophyll content, reduce ethylene synthesis and leaf chlorophyll degradation (Smith, 1985;Evans and Malmberg, 1989; Davies, 1995; Shehata *et al*., 2000; Galston and Kaur-Sawhney, 1990&1995; Couee *et al.,* 2004; Lester, 2000; Jain *et al*.,2005 and Papadakis and Roubelakis-Angelakis, 2005). Also, these bio-regulators enhanced chlorophyll formation and carbohydrate content and induced changes in endogenous phytohormones in plants (Sharma and Ali (1998)Shehata *et al*., 2000 & 2001) and increase enzymes activities, ion uptake, inhibit ethylene biosynthesis, reversing of abscisic acid (ABA) induced stomatal closure and enhance disease resistance (Raskin, 1992).

Also, Abo El-Saoud (2005) reported that foliar spray of snap bean plants with benzyladenine (40ppm) and Put (200ppm) significantly increased number of flowers and pods/ plant, fruit setting percentage and green pods yield/plant and fed. In addition, Abd El-Dayem et al., (2005) on soybean plants, observed that foliar application of BA (25 &50 &100 ppm) increased flowers number/plant and yield characteristics i.e., pod number, seed number, seed yield, seeds weight /plant and 100-seeds weight, oil percentage and the fatty acids composition meanwhile decreased shedding percentage. Abd El-Gawad (2006) showed that BA (5 & 25 ppm) treatments increased fruit setting, number of capsules/plant, weight of intact capsule, weight of seeds/capsule, seeds number/capsule, weight of 100-seeds and seed yield (economical yield) of Nigella sativa plants.

Therefore, the present investigation was carried out to study the effect of foliar application with benzyladenine (BA), putrescine (Put) and salicylic acid (SA) on the growth, seeds and oil yield and biochemical composition of sesame plant. Also the present study aimed to increase seeds yield and improve oil quality and content of sesame plant by using these plant bioregulators.

MATERIAL AND METHODS

Two pot experiments were carried out in the green house at The Experimental Station of Agricultural Botany Department Faculty of Agriculture Moshtohor, Benha University during two growing successive seasons of 2007 and 2008 to study the effect of foliar application with benzyladenine (BA), putrescine (Put) and salicylic acid (SA) on the growth, seed yield, oil content and chemical compositions of sesame (*Sesamum indicum* L.) var. Shandawel 3 plant. Their seeds of sesame plant were obtained from Agricultural Research Center, Giza, Egypt. The plastic pots of 30cm in diameter were filled with 7 kg of soil from mixture of clay and sand (2:1 w/w).

Phosphorus and potassium were added to the soil of each before sowing at the rate of 1.4 g/pot super phosphate and 1 g/pot potassium sulphate. Ten seeds were sown in each pot on 10th of may for 2007 and 2008 seasons. The plants were thinned to four uniformed seedlings per pot after three weeks from sowing. After thinning, plants were fertilized as recommended for this plant with (5gm) ammonium nitrate per pot as two equal doses, first after thinning (2.5gm) and the second one was added at the beginning of flowering stage (2.5gm)/pot. The pots were arranged in a complete randomized design with 12 replicates (12 pots for each treatment).

Bioregulators were used as foliar application at three concentrations as follows:

Control (distilled water) 0.0, Benzyladenine (BA) at 20, 40 and 60 ppm, Putrescine (Put) at 25, 50 and 100 ppm, Salicylic acid (SA) at 25, 50 and 100 ppm. The plants of each treatment were sprayed with different bioregulators three times after 30,55 and 80 days from sowing.

Sampling and collecting data:

Vegetative growth

Tow samples of sesame plant (i.e., 75 and 120 days after sowing) were taken from each treatment in 2007 and 2008 seasons. Twelve plants from each treatment were randomly taken for different measurements. Then the plants were separated into their organs (stems, leaves and capsules).The samples of these organs were dried in the oven at 70 c° for 48 hours till constant weight. The dried samples of different organs were weighted for dry weight estimation. The following growth characters estimated: Stem length (cm), number of leaves/plant, leaf area (cm^2)/plant, dry weight (g)/plant, dry weight of stems (g)/plant, dry weight of leaves (g)/plant, number of flowers/plant, number of capsules/plant, net assimilation rate (NAR) ($g/cm^2/day$).

Net assimilation rate was calculated between successive samples (45 and 75 days) as described by Hunt (1978) using the following equation:

$$NAR\ (g/cm^2/day) = \frac{(W2 - W1)}{(T2 - T1)} \times \frac{(LnLA2 - LnLA1)}{(LA2 - LA1)}$$

W: whole plant dry weight, LA: leaf area, T: time.

Yield and its component :

At harvest, 120 days after sowing in 2007 and 2008 seasons, 12 randomly chosen plants from each treatment were taken for estimating the following yield characters: Fruiting zone length (cm)/plant, number of capsules/plant, weight of intact capsules (g)/plant, weight of seeds (g)/plant, weight of seeds (g)/pot, weight of empty capsules (g)/plant, weight of 1000 seeds (g), seed oil percentage, seed oil yield/plant, fatty acids composition in sesame seed oil.

Chemical analysis:

Chemical analysis was carried out on the samples of leaves at 75 days from sowing and seeds during the second season (2008) only to determine chlorophyll a, b and carotenoids were calorimetrically determined in the fresh leaves according to the method described by Wettstein (1957), total nitrogen (Horneck and Miller, 1998), Phosphorus (Sandell, 1950), potassium (Horneck and Hanson ,1998). Calcium and magnesium were determined according to Jackson (1967). Also, Fe and Zn were determined according to (Black, *et al.* 1965). Total soluble sugars and total carbohydrates were determined according to the method described by (Dubois et al., 1956).Total free amino acid was determined in the ethanolic extract with ninhydrine, buffer, solvent and boiling time colourimetrically according to Muting and Kaiser (1963). Crude portein was calculated according to the following equation: Crude protein in seeds = Total nitrogen x 5.26 (A.O.A.C. 1990).

Determination of oil content of sesame seed oil:

a- Crude Fat: Oil percentage was determined by using soxlet apparatus using petrolium ether as a solvent according to A.O.A.C. (1990).

b- Fatty Acids: Fractionation, identification and quantification of different fatty acids were carried out. The fatty acids were converted to methyl esters according to Sink et al., (1964).

The fatty acids methyl esters were analyzed using Gas Liquid Chromatography (GLC)/HP (6890) GC capillary equipped with flame ionization detectors and coiled glass column each (DB-23 capillary column), Dimension:60 m × 0.32 mm × 0.25 µm.

Statistical analysis:

Data of growth and yield characteristics were subjected to statistical analysis according to Snedecor and Cochran (1989).

RESULTS AND DESSICUSION

Growth characteristics

The growth characteristics of sesame plants as stem length, number and leaf area per plant, dry weights of stems, leaves, capsules and net assimilation rate as well as fruiting zone length, number of flowers and number of capsules were significantly increase by foliar application with bioregulators as benzyladenine (20, 40 and 60ppm), putrescine (25, 50 and 100ppm) and salicylic acid (25, 50 and 100ppm) at 75 and 120 days after sowing in both seasons are presented in Tables (1). As for stem length, number and leaf area per plant foliar application with Put 100 ppm, BA 40 ppm and SA 50 ppm gave the highest values respectively, at 75 days after sowing mean of two seasons. Regarding, the total leaf area per plant it nearly behaved as the same as leaves number. Since, all foliar application treatments showed its significant increase but its maximum was also, obtained with BA 40 ppm and Put 100 ppm treatments.

Increment in leaf area is of great interest because it could be reflected up the efficiency of photosynthesis by accumulating more assimilates and high rates of their translocation specially toward formed capsules. The increment in leaf characters in response to foliar spray with bioregulators (BA, Put, SA) may be attributed to the stimulating effect of these bioregulator on cells division and enlargement in the meristems and organ primordia, increasing endogenous promoters substances (CYK, GA, IAA) levels which in turn increased leaves expansion.

In this connection, Shehata *et al*., (2000&2001), Ibraheem (2007), Zaghlool *et al*., (2001 and 2006), Abo El-Saoud (2005), Wanas (2007 a & b), Ibraheem (2007) and Zaghlool *et al*. (2001 and 2006) stated that, bioregulators (BA, Put and SA) increased leaves growth by (via) increasing cytokinins levels in wheat and other plants..

With regard to leaves dry weight per plants of interest to note that all foliar application with bioregulators increased it, to reach the level of significance. Also, it could be noticed that BA 40 ppm and Put 100 ppm gave the highest value when compared with control plants of mean of tow seasons.

As for net assimilation rate at 75 days after sowing, it increased in most treatments with different used bioregulators. The exception was that SA at 100 ppm caused a reduction in this respect two seasons. Also, it could be noticed that each of Put 100 ppm and BA 40ppm gave the highest values in this respect compared with the control.

With regard to fruiting zone length per plant, all used bioregulators were significantly increased fruiting zone length of seasame plants at 75 and 120 days after sowing of mean of two seasons. The most effective, bioregulator in this respect was the putrescine (Put) at 100ppm followed by benzyladenine (BA)at 40ppm and salicylic acid (SA) at 50ppm when compared with the control plants.

The positive favourable effects of bioregulators (BA, Put and SA) on all previous growth characters (stems length, leaf area and dry weights of sesame organs) may be attributed to their improvement on the physiological processes such as:1) Enhance cells division and differentiation activity, 2) Increasing endogenous growth promoters (IAA, GA and CYKs) and decreasing ABA and ethylene, Ibraheem (2007), 3) Photosynthesis efficiency and mobilizing, 4) Enhance the uptake of mineral nutrients assimilates translocation from source to sink, 5) Increasing leaves growth and photosynthesis capacity by increasing endogenous cytokinins. Arigita *et al*., (2005) mentioned that cytokinins promote shoot development through increased cell division. Regulation of the cell cycle and the number of cycles that cells under go in the meristems and organ primordial are the primary regulatory targets cytokinins.

The stimulating effect of BA, Put and SA on number of flowers and capsules/plant may be due to the critical role of these bioregulators in enhance various processes of reproductive growth such as: a) Increasing flowers bud formation (flower bud initiation differentiation and development), b) Delaying flower abscission (decrease shedding %), c) Enhancing pollination, fertilization and development of fruit, d) Increasing fruit set which in turn increasing capsules/plant, e) Enhancing transport of photoassimilates and nutrients from leaf towards fruits (sinks) there by, which reflect on the fruits formation.

Chemical composition of leaves :

Photosynthetic pigments

Data in Table (2) indicate that different photosynthetic pigments, i.e., chlorophyll a, b and carotenoids were positively responded to the different foliar application with BA, Put and SA treatment 75 days after sowing during the two assigned seasons. Also, BA and Put at 100ppm gave the highest values in this respect comparing with the control plants. Moreover, the stimulation of photosynthetic pigments formation could be attributed to the vigorous obtained in Table (1) increasing of chlorophylls and carotenoids content, enhanced photosynthesis efficiency and increase dry matter production Table (1). The promoting effect of bioregulators (BA, Put and SA) on chlorophyll synthesis was supported by Sudria et al. (2001) who found that cytokinins application accelerated the development and photosynthesis such as co_2 assimilation activity of photosynthetic enzymes and consequently promoted the photosynthetic activity. The present results agreed with those obtained by Patil et al., (2002), Senthil et al., (2003) and Talaat et al., (2005). Also, Abo El-Saoud (2005) observed that foliar application of snap bean plants with BA (40 ppm) and Put (200 ppm) increased the content of photosynthetic pigments i.e., chlorophyll a, b and carotenoids in leaves. Also, Shehata *et al*., (2001) and Zaghlool *et al*.,(2006) stated that , SA increased photosynthetic pigments i.e., chlorophyll a, b and carotenoids on some plants.

Minerals and some bioconstituents

Data in Table (2) clearly indicate that all foliar application treatments increased N, P, K, Ca and Mg at 75 days after sowing in sesame leaves during 2008 season. Also, Put at 100 ppm showed the highest content of N, P, K, Ca, Fe and Zn at 75 days after sowing compared with control plants and other treatmeants.

As shown in Table (2) it could be clearly noticed that total carbohydrates, sugars and free amino acids and protein content were increased with different foliar application of bioregulators in 2008 season at 75 days after sowing. Also, Put at 100 ppm and BA at 40ppm gave the highest content of total carbohydrates, sugars and free amino acids at 75 days after sowing, respectively when compared with the control.

This increase in total sugars, carbohydrates, proteins and amino acids of leaves in response to BA, Put and SA applications is supported by stimulation in photosynthetic pigments (Table, 2) and the accumulation of dry matter in leaves at 75 days (Table, 1). Also, the increase in protein and total free amino acids in leaves was accompanied by increase in total N (Table, 2) parellel to growth rate, stimulation of amino acids into protein and to the translocation of sugars and free amino acids to young leaves and developing fruits. Many investigators suggested that bioregulators BA, Put and SA not only promote photosynthetic activity, but also increased RNA and protein synthesis by Senthil et al., (2003); Sood and Nagar (2003); Abo El-Saoud (2005); Papadakis and Roubelakis-Angelakis, (2005); Ibraheem (2007).

Yield and its component

Data in Tables (3) indicate that foliar application with different bioregulators significantly increased yield and its components expressed as number of capsules/plant, weight of seeds (g)/plant and weight of 1000-seeds (seed index) at 120 days after sowing in mean of tow seasons.

These increases in capsules number/plant were accompanied by increasing flowers numbers and decreased shedding of flowers and fruits. The promotive effect of bioregulators BA at 40 ppm and Put at 100 ppm treatments on capsules numbers may be attributed to its effect on floral bud formation, multiple number of flowers on node and opposite leaf arrangement encourages multiple flowering in the leaf axils of lower and middle nods on the main stem. The leaf arrangement is important as it controls the number of flowers formed in the axils and the number of capsules in sesame plants (Weiss, 2000). It is clear from results in mean of tow seasons that the heighest capsules number/plant (102.05/plant) in response to 40 ppm BA followed by 100 ppm(68.42). In this respect, Kamal *et al.*, (1995) observed that application of kinetin with 5 ppm at flowering stage of soybean plants increased yield by an average of 9.3 % over the control. The yield increased was primarily due to the increase in pods number through the increased of fertile node number and number of pods per fertile node. Also, Awasthi *et al.*, (1997) on faba bean plants, showed that salicylic acid treatments resulted was increase in number of flowers, pod number/plant, number of seeds/pod, pod weight and seed yield/plant. Sharma and Ali (1998) working on soybean, found that foliar application of putrescine and spermine at 10-3M significantly increased number of pods per plant, 100 seed weight, seed biological and oil yield. Also, the seeds weight (g) per plant and seeds yield (g) per pot at 120 days after sowing in most cases were significantly increased.Weight of 1000-seeds (seed index) was significant increase in most treatments with different used bioregulators.

The increase in yield and its component in sesame plants treatment with BA, Put and SA may be attributed to an increase in the vigorous growth (Tables, 1), photosynthetic pigments content (Table,2), the amount of metabolites synthesis (carbohydrates, protein and free amino acid in leaves (Table, 2), absorption and translocation of nutrient elements (Table, 2) and enhance sink activity by increasing the rate of net amount of photoassimilates transport from sites of synthesis in leaf tissue source to sites of accumulation in developing seeds or storage organs (sink) and decrease shedding of reproductive organs, which reflected upon yield and its components. These results are agreed with those reported by Ibrahim et al. (2001), Abd El-Dayem et al. (2005), Abo El-Saoud (2005), Zaghlool et al. (2006), Wanas (2007a&b) and Ibraheem (2007) and El-Moawafy (2008).

Chemical composition of seeds (seeds quality)

Minerals and some bioconstituents

Data in Table (4) and clearly show that different foliar application with bioregulators increased mineral contents N, P, K, Ca, Mg, Fe and Zn in seeds of sesame plants during 2008 season. Also, it could be noticed that BA at 40ppm ranked the first followed by Put at 100ppm when compared with the control plants and other treatments.

As for crude protein content, it increased with different foliar application treatment. Also, SA at 50ppm treatment gave the highest content of crude protein in seed yield followed by BA at

40ppm and Put at 100ppm respectively,. Also, all foliar application treatments increased total carbohydrates content in seed yield of sesame plants during 2008 season. In addition, total carbohydrates increased to reach its maximum with Put at 50ppm followed by Put at 100 ppm during 2008 season. These stimulatory effects of BA, Put and SA on mineral contents in sesame seeds may be attributed to their enhancing effects on membrane permeability, ions uptake and increase the rate of ion entry through the membrane, which reflected on translocation of mineral nutrients to shoot and consequently to fruits. As well as these bioregulators treatment improved photosynthetic activity and efficiency and consequently more synthesis of sugars and increases the mobilization, translocation and partitioning of biosynthesized material (sugars) to seeds in fruits of sesame plants. Similar results were obtained by Abd El-Dayem et al., (2005) who found that foliar application of soybean plants with benzyladenine at 50 ppm significantly increased total soluble sugars, polysaccharides and consequently total carbohydrates, total protein, N, P, K, Ca and Mg contents in the yielded seeds.

Similar responses were obtained by several investigators, among them, Abo El Saoud (2005) on snap bean plants, Ibraheem (2007) on wheat plants, Ibrahim and Sharaf El-Deen (2008) and El-Mowafy (2008) on wheat plant, Zaghlool et al., (2001) on Phaseolus vulgaris, Zaghlool et al., (2006) on wheat plants, Wanas, (2007a&b) on faba bean plants and El-Mowafy, (2008) on wheat plants.

Oil percentage and oil yield / plant

Data in Table (4) show that foliar application with different bioregulators increased oil percentage and yield/plant of sesame plants during 2008 season. In addition, Put at 100ppm and BA at 40ppm gave the highest The maximum values in oil yield (g)/plant BA at 40 ppm followed by Put at 100 ppm and SA at 50ppm during 2008 season. Values were 28.07 & 20.88 and 13.50 during 2008 season, respectively, but was 4.40 with control plants. It could be concluded that the foliar application of bioregulators (BA, Put and SA) caused an increase in fatty acids biosynthesis and other metabolites which reflected an increase in the oil percentage of sesame seeds.

Fatty acids percentage

Data also in Table (4) showed the effect of foliar application with BA, Put and SA on saturated and unsaturated fatty acids of sesame seed oil in 2008 season. Percentage of saturated fatty acids were decreased by foliar application with bioregulators on the contrary all used bioregulator treatments increased unsaturated fatty acids as well as a marked increase in unsaturated fatty acids: unsaturated fatty acids ratio of sesame seed oil when compared with the control plants and other treatments.

These results are in harmony with those obtained by Sharma and Ali (1998) who showed that the soybean seeds and oil yield were increased by about 12.46 and 20.94% respectively with the application of 10-3 M spermine at 50% flowering stage. In addition, Abd El-Rehim et al., (2000) found that kinetin treatments (5,10and 20 ppm) increased the percentage of lauric, myristic, streic palmitic and oleic acids. Also, the saturated fatty acids were increased while unsaturated fatty acids were decreased in oil of datura seeds. Also, Ibrahim et al., (2001) indicated that kinetin treatment (50ppm) increased crude fat and unsaturated fatty acids (C18:1, C18:2 and C20:1) meanwhile saturated fatty acids were decreased in oil of sunflower seeds. Also, Abd El-Dayem et al., (2005) showed that foliar application of benzyladenine (50ppm) increased the oil percentage and the fatty acids composition of soybean seeds oil. Amarked increase in the levels of unsaturated fatty acids (C18:1, C18:3 and C20:1), while linoleic was decreased. In the meantime, there was an increase in the detectable saturated fatty acids in seeds oil of treated plants.

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