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# Growth Behavior and Productivity of Faba Bean (*Faba vulgaris,* L.) as Affected by Various Promoting Foliar Applications

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## ABSTRACT

Experiments were designed and implemented to evaluate yield, its components and quality determinations of faba bean (*Faba vulgaris* L.) cv. Sakha 3 under nine growth promoting treatments (Control, Benzyl adenine at 50,100 mg/L, Putrescine at 50,100 mg/L, Zinc at 25, 50 mg/L and Boron at 25, 50 mg/L). Two field experiments were carried out at the Experimental Research Station, Faculty of Agriculture, Moshtohor, Benha University, Kalubia Governorate during two winter growing seasons (2012/13 and 2013/14). Results could be concluded as follows:

Generally, application of the different applied treatments induced significant increases growth characteristics, yield, its components and chemical constituents of faba bean (Sakha 3). Benzyl adenine at 50 or 100 mg/L produced the superior values of the obtained plant height, No. of branches / plant, chlorophyll content, yield, its components and P (%) in the respective two seasons with variable significant magnitudes. Boron at 25 or 50 mg/L concentrations had the highest values of stem diameter, No. of leaves / plant, leaf area/plant, leaf and stem dry weight, No. of pods / plant, N (%), K (%), Crude protein (%) and total carbohydrates (%) in each of the two seasons with different significant magnitudes.

***Key words:*** Faba bean, growth promoting, yield and quality, Foliar Applications

## Introduction

Faba bean is an important leguminous crop due to its major source of protein and its large area of cultivated land in Egypt. Cultivation of faba bean which in rich the soil with ambient nitrogen through its symbiotic rhizobium bacteria on its root nodules (Hungria and Vargas, 2000).

Field crop production in Egypt is mainly grown on the arable and around the river Nile banks. The intensive agriculture system leads to the decrease of production per unit-area of land. Reclamation of new lands and adopting the most promising agronomic practices are the most important factors for increasing productivity to fulfill the gap between consumption and production of food crops (Ismaeil and Abd El –All , 2011).

High demand of food in Egypt implies more production. Faba bean (*Vicia faba, L.*) is one of the major field crops grown in Egypt since, it is an important source of protein for human and animal consumption and it plays a major role in the crop rotation and fixing ambient nitrogen. However, the total production of this crop is still insufficient to cover the local consumption. (Khafaga *et al.,* 2009)

Flower abscission occurs before and after fertilization. In some species the mere lack of pollination, after a critical period, activates the abscission zones, and in other species the lack of fertilization, again after a critical period, does so. Unfertilized flowers often abscise due to competition for carbohydrates (Aloni *et al.,* 1996).

Also, the whole dried seeds of faba bean contain (per 100g) 344 calories, 10.1% moisture, 1.3g fat, 59.4g total carbohydrate, 6.8g fiber, 3.0 g ash, 104mg Ca, 301mg P, 6.7mg Fe, 8mg Na, 1123mg K, 130mg B-carotene equivalent, 0.38 mg thiamine, 0.24mg riboflavin, 2.1mg niacin, and 162mg tryptophan. Flour contains: 340 calories, 12.4, % moisture, 25.5g protein, 1.5g fat, 58.8g total carbohydrate, 1.5g fiber, 1.8g ash, 66mg Ca, 354mg P, 6.3mg Fe, 0.42mg thiamine, 0.28mg riboflavin, and 2.7mg niacin. The fatty acids composition of broad bean oil has been reported as 88.6% unsaturated" (Duke, 1981). The amino acids content except for methionine is reasonably well balanced (Bond *et al*., 1985).

Zinc is one of the most important essential micronutrients required for optimum crop growth. It plays an important role in many biochemical reactions within plants. Zinc is important in the formation of the plant growth hormone auxins. Auxins are produced by shoot tips, and control cell division, leaf and shoot growth and fruit development (Mansour, 2014). Zinc is also needed by leaf cells to form the green leaf pigment chlorophyll. Its regulates starch formation and proper root development (Wassel *et al*., 2007). Also, zinc plays an essential role in plant physiology where it actives some of enzymes such as dehydrogenises, pretenses, peptidases and

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phosphohydrolases. Zinc is a micronutrient needed in small amounts by crop plants, but its important in crop production has increased in recent years (Fageria, 2009).

Boron is an essential micronutrient which plays a major role for plant growth and development (Pilbeam and Kirkby, 1983; Marschner, 1995). In commercial plant production, providing a sufficient B supply is particularly important for yield formation (pollination) (Khayyat *et al.*, 2007; Wojcik *et al.,* 1999) and fruit quality (Wojcik *et al.,* 1999; Dordas, 2006; Dordas *et al.,* 2007). Boron deficiency in crops is more widespread than the deficiency of any other micronutrients (Gupta, 1993).

Also, foliar application with micro nutrients especially boron not only have major effects upon flower formation, carbohydrate and protein metabolism, pollen germination and pollen tube growth and increase yield (Gerendas and Sattelmatcher, 1990), but also required for chloroplast formation and sink limitations (Tersahima and Evans, 1988). Also, boron plays a key role in higher plants by facilitating the short- and long- distance transport of sugar *via* the formation of borate-sugar complexes (Dugger, 1983). However, such a proposal is unacceptable because, the prevalent sugar transport in the phloem forms only weak complexes with boron and in the mechanisms of phloem loading of ucrose boron is not involved (Marschner, 1995).

Furthermore, foliar spray of boron represents the more quick and efficient treatments in many cases which lead to vigorous vegetative growth and plenty of chemical constituents (El-Sherbeny *et al*., 2007).

Abou EL-Yazied and Mady (2012) revealed that foliar application with boron not only significantly stimulate many growth parameters of faba bean plants but also increased photosynthetic pigments, NPK, B, total sugars, crude protein, auxins, cytokinins and decreased abscisic acid content. Boron treatments increased number of formed flowers, setted pods per plant, green pod and dry seed yields, as well as satisfactory effect upon shedding percentage.

Benzyl adenine is an important plant hormone that regulates various processes of plant growth and development including cell division and differentiation, enhancement of leaf expansion and nutrient mobilization in high value field crops to increase yield, improve crop quality and management Davies, (1995). In this respect, Evidence suggests that Benzyl adenine (BA) belongs to a group of plant hormones called cytokinines and its role is connected with the growth and development of plants. It is also implicated in the vascular development and synthesis of secondary metabolites like indols, alkaloids and anthocyanins. It influences chloroplast differentiation and chlorophyll (Chl) biosynthesis by stimulation of 5-aminolevulinc acid synthesis Duszka *et al.,* (2009). When exogenously applied, BA has been shown to result in increasing plant height Letham, (1969), leaf area Abdullah *et al.,* (1986), branching Hrotko *et al.,* (1996 b).

Liu *et al.,* (2007) reported that Polyamines, mainly diamine putrescine (Put) is polycationic compounds of low molecular weight that are present in all living organisms. It has been proposed as a new category of plant growth regulators that are purported to be involved in a large spectrum of physiological processes, such as embryogenesis, cell division, morphogenesis, and development (Bais and Ravishankar 2002; Liu *et al.*, 2006a).

Polyamines (Putrescine) play an important role in protecting plant against various a biotic stress, they are potent ROS scavengers and inhibitors of lipid peroxidation. The diamine Putrescine (Put) can alleviate harmful stress effects in plants by many ways including: polyamines (PAs) may be involved in free radical scavenging (Drolet *et al.,* 1986). Its modulators of stress - regulated gene expression and exhibit antioxidant properties (Kuznetsov and Shevyakova, 2007). High accumulation of polyamines (Putrescine) in plants during a biotic stress has been well documented and is correlated with increased tolerance to a biotic stress (Kuznetsov and Shevyakova, 2007 and Ahmad *et al.,* 2012).

The main target of this investigation is to evaluate the specific properties of growth characteristics, yield, its components and quality of faba bean seeds cv.Sakha 3 as affected by foliar application of some growth regulators and microelements i.e., Benzyl adenine, Poly amine (Putrescine), Zn and B.

## Materials and Methods

Two field experiments were carried out during two successive growth seasons (20012/13and 2013/14) at the Experimental Research Station, Faculty of Agriculture, Moshtohor, Benha University, Kalubia Governorate. This study was designed and implemented to evaluate the specific properties of growth behavior, yield, its components and quality of faba bean seeds (Sakha 3) as affected by foliar application of Benzyl adenine, Poly amine (Paterceen), Zn and B. Experiments were designed and layed out in a complete randomized block design (CRBD), where the applied treatments were randomly distributed. The applied treatments were as follows:

1- Control (distilled water).
2-Boron (B) at 25 and 50 mg/L.
3-Zinc (Zn) at 25 and 50 mg/L.
4- Benzyl adenine (BA) at 50 and 100 mg/L.
5- Poly amine (Putrescine) at 50 and 100 mg/L.

Seeds of *Faba vulgaris* L.*cv. Sakha 3* were obtained from the Legumes Crops Research Centre, Ministry of Agriculture at Giza, Egypt. The area of each experimental plot was 10.5 $m^2$, including five rows of 3.5 meters long and 60 cm apart. Seeds were sown on 1st and 11th of November in the two seasons respectively in hills of 20 cm apart on one side of the ridge. Seeding rate was 60 kg/fed.

Phosphorus fertilizer was applied in form of calcium super phosphate (15.5% $P_2O_5$) at a rate of 150 kg/feddan during the appropriate soil preparation and before sowing. Twenty five days-later after sowing, plants were thinned to two plants / hill, with approximate 70000 plant/fed. The preceding crop was maize in each of the two seasons. Nitrogen fertilizer (in the form of urea 46.5 %) was applied at the rate of 15 kg N / fed before the first irrigation.

Plants were sprayed twice at 40 and 70 days from sowing with freshly prepared solutions of the previous treatments using 1.0 and 1.5 litter of solution for each experimental plot.

**Sampling and data collecting:**

*I- Vegetative growth characteristics:*

Five plants were randomly chosen from the central row of each plot at 90 days after sowing in the respective two seasons to estimate plant height (cm), stem diameter (cm), stem dry weight (g)/ plant, number of leaves /plant, number of branches /plant, leaves dry weight (g) /plant and total leaf area ($cm^2$) using the disc method as described by Derieux *et al.* (1973).

*II-Photosynthetic pigment:*

Total chlorophyll content measured by chlorophyll meter (SPDS) Model SPAD 402 according to Mielke and Schaffer (2010).

*III- Yield and its Components:*

For each experimental plot at harvest stage from each of the three inner rows, the following characters were recorded: Biological yield /fed (kg), Seed yield /fed (kg), Seed yield / plant (g), Weight of plant (g), Number of pods / plant, Number of seeds / plant, Weight of pods / plant, Weight of seeds / pod (g) and Seed index (weight of 100 seeds (g)).

*IV-Chemical analysis:*

Seeds at harvest (120 days after sowing) were used to determine the following chemical constituents during 2012/13 and 2013/14 seasons.

Total nitrogen percentage was determined in the dried seeds using wet digestion according to Piper (1950), using microkjeldahl method as described by Horneck and Miller (1998). Crude protein = total nitrogen x 6.25 (A. O. A. C., 1995), Phosphorus was determined colorimetrically according to Sandell (1950), Potassium content was determined by flame photometer according to Horneck and Hanson (1998), Total carbohydrates content was determined by using phenol-sulphoric acid method as described by Dubois *et al.* (1956).
Statistical analysis: The analysis of variance for data of each of the two growing seasons were carried out according to Steel and Torrie (1981). The L.S.D. test at the 5% level was used in means comparison.

## Results and Discussion

**I- Vegetative Growth characteristics:**

Data in Table (1, 2) revealed that all of the applied treatments significantly increased all vegetative growth characteristics of faba bean plants i.e., the plant height, No. of branches/plant, No. of leaves/plant, stem diameter /plant, total leaf area/ plant and dry weight of stem and leaves as compared with the control. Boron foliar application produced maximum increments for the increase of its applying (25 and 50 mg/L) for No. of leaves/plant, stem diameter /plant, total leaf area/ plant and dry weight of stem and leaves in both growing seasons. On the other hand, benzyl adenine at 50 and 100 mg/L gave the highest values of plant height, No. of branches/plant in the respective two seasons (Table 1).

These results are of great interest, because at this early stage of growth great simulative effects existed with various applied treatments. Hence, that could be prolonged to the advanced growth stages including each of flowering and the final fruit yield as well as quality of yielded seeds. Also, of interest to note that increase of stem diameter may be accompanied with basic anatomical modification in different stem tissues especially phloem and xylem . Therefore, that could be accompanied with great variations in the nature of broad bean branching. Besides, increasing of stem diameter accompanied with increasing of plant height means that applied treatments lead to vigorous growth and more healthy plant Abd El-Aal, (2012).

In this respect, Mady (2009) reported that foliar application of zinc significantly increased many growth parameters as number of leaves per plant, dry weights of both stems and leaves per plant and total leaf area as well.

Also, Abou EL-Yazied and Mady (2012) reported that foliar application with boron significantly stimulate many growth traits as number of leaves per plant, dry weights of both stems and leaves per plant, total leaf area and absolute growth rate as compared with the control treatment.

**Table 1:** Growth behavior of Faba bean (*Faba vulgaris, L.*) as affected by foliar application of the growth stimulators of plants.

| Character / Treatments | Concentration (mg/L) | Plant height (cm) | Stem diameter (cm) | No. of leaves /plant | No. of branches /plant |
|---|---|---|---|---|---|
| **First season 2012/13** | | | | | |
| Control | (distilled water) | 101.67 | 1.60 | 106.00 | 3.97 |
| Zinc | 25 | 109.33 | 1.80 | 135.67 | 4.53 |
| | 50 | 111.67 | 1.80 | 186.67 | 4.73 |
| Boron | 25 | 110.67 | 1.70 | 233.33 | 4.20 |
| | 50 | 116.67 | 2.20 | 285.00 | 4.87 |
| Benzyl adenine | 50 | 110.00 | 1.60 | 128.33 | 4.10 |
| | 100 | 120.00 | 1.80 | 137.33 | 4.90 |
| Putrescine | 50 | 109.67 | 1.80 | 129.33 | 4.87 |
| | 100 | 111.33 | 1.80 | 183.33 | 4.57 |
| L.S.D at 5% for: | | T= 6.65 | T= 0.22 | T= 15.96 | N.S |
| **Second season 2013/14** | | | | | |
| Control | (distilled water) | 84.67 | 1.44 | 124.33 | 3.53 |
| Zinc | 25 | 87.67 | 1.52 | 156.67 | 3.87 |
| | 50 | 90.33 | 1.62 | 200.00 | 4.37 |
| Boron | 25 | 92.33 | 1.48 | 240.67 | 3.90 |
| | 50 | 94.67 | 1.81 | 265.00 | 4.53 |
| Benzyl adenine | 50 | 90.00 | 1.62 | 145.00 | 4.00 |
| | 100 | 97.67 | 1.60 | 158.33 | 4.60 |
| Putrescine | 50 | 82.33 | 1.51 | 148.33 | 4.23 |
| | 100 | 93.67 | 1.57 | 188.67 | 3.83 |
| L.S.D at 5% for: | | N.S | T= 0.13 | T= 16.89 | T= 0.36 |

**Table 2:** Growth behavior of Faba bean (*Faba vulgaris, L.*) as affected by foliar application of the growth stimulators of plants.

| Character / Treatments | Concentration (mg/L) | Leaf area($cm^2$) /plant | Leaves dry weight (g)/plant | Stems dry weight (g)/plant | Total Chlorophyll |
|---|---|---|---|---|---|
| **First season 2012/13** | | | | | |
| Control | (distilled water) | 1574.14 | 7.33 | 21.67 | 34.83 |
| Zinc | 25 | 2861.83 | 13.33 | 35.67 | 39.47 |
| | 50 | 4506.73 | 17.67 | 45.67 | 41.03 |
| Boron | 25 | 3585.35 | 15.67 | 47.67 | 42.53 |
| | 50 | 4125.53 | 16.33 | 57.33 | 42.07 |
| Benzyl adenine | 50 | 1782.49 | 7.67 | 25.33 | 43.93 |
| | 100 | 2040.15 | 10.00 | 28.00 | 44.47 |
| Putrescine | 50 | 1838.49 | 7.67 | 24.33 | 39.50 |
| | 100 | 2239.07 | 8.67 | 30.67 | 43.73 |
| L.S.D at 5% for: | | T= 345.60 | T= 1.60 | T= 5.85 | N.S |
| **Second season 2013/14** | | | | | |
| Control | (distilled water) | 1934.31 | 8.67 | 25.67 | 41.03 |
| Zinc | 25 | 2525.46 | 13.00 | 32.00 | 43.03 |
| | 50 | 4471.11 | 19.67 | 45.00 | 46.30 |
| Boron | 25 | 4086.75 | 15.00 | 43.33 | 43.33 |
| | 50 | 4607.41 | 19.67 | 45.00 | 46.20 |
| Benzyl adenine | 50 | 2217.00 | 11.33 | 28.67 | 46.50 |
| | 100 | 2783.54 | 12.00 | 32.00 | 47.87 |
| Putrescine | 50 | 2131.72 | 8.67 | 27.00 | 43.13 |
| | 100 | 2807.22 | 11.33 | 27.00 | 47.27 |
| L.S.D at 5% for: | | T= 725.16 | T= 2.84 | T= 4.28 | N.S |

## II-Photosynthetic pigment:

Data in Table (2) showed that photosynthetic pigments content in leaves as total chlorophyll were increased with different applied treatments i.e., Benzyl adenine at 50 or 100 mg/L, Boron at 25 or 50 mg/L, Putrescine at 50 or 100 mg/L and Zinc at 25 or 50 mg/L in plants of 90 days aged in each season of 2013 and 2014.

In this respect, Benzyl adenine at 50 or 100 mg/L produced the highest content of total chlorophyll in leaves of plants (43.93, 44.47) in the first season, being (46.50, 47.87) in the second season in the previously respective season compared with control.

In addition, increment of shoots (stems & leaves) fresh weight due to increases of number of both branches and leaves and the total leaf area as mentioned previously. Increment of leaf characteristics (number and area) as well as their content of photosynthetic could be a basic for increasing the photosynthetic efficiency. These results are of great interest, because they are lightly considered direct reason for the more dry matter production and distribution in shoots of broad bean plants as affected by different applied treatments (El-Desouky *et al.,* 2011; Abd El-Aal 2012; El-Badawy and Abd El-Aal, 2013 and Youssef and Abd El-Aal 2014).

The obtained results are in agreement with those reported by Fletcher *et al.* (2000) reported that the increase in cytokinin levels was associated with stimulated chlorophyll biosynthesis Mady (2009) reported that foliar application with zinc significantly increased photosynthetic pigments. Abou EL-Yazied and Mady (2012) reported that foliar spraying with boron at 50 mg/L increased photosynthetic pigments.

Polyamines retard chlorophyll loss and prevent the rise of RNase and protease activity (Altman, 1982; Cohen *et al.,* 1979; Kaur- Sawhney and Galston, 1979).

**III-Yield and its Components:**

Data in Table (3) clarified that all of the applied treatments significantly increased yield and its components of faba bean plants i.e., biological yield /fed, seed yield /fed, seed yield / plant, weight of plant , number of pods / plant, number of seeds / plant, weight of pods / plant, weight of seeds / pod, seed index as compared to the control. The superior enhancement was obtained for the application of the higher concentration of B, Zn, benzyl adenine and Putrescine compared with the relevant previous substances.

Results indicated significant differences among the applied treatments, where benzyl adenine was the superior for biological yield (3533.33, 3466.67kg/fed), seed yield (1216.46, 1647.32 kg/fed), seed yield / plant (34.5, 26.3 g), weight of plant (118.17, 72.53 g), number of seeds / plant (36.67, 30.7), number of pods / plant (15.00, 12.70 ), weight of pods / plant (47.07, 42.77 g), seed index (96.67, 96.33) in the respective two seasons. Such result may be attributed to the indirect effect of most materials in many biochemical processes.

In this connection, the obtained increase of the seed yield production could be attributed to that increase in growth characteristics of branches number, total leaf area and dry weight (Table, 1 and 2) and also may be due to the increase in photosynthetic pigments content (Table, 2). Thereby, increase in all substances and bioconstituents synthesis and their translocation from leaf and different organs of plants up to seed production Zewail (2011). Benzyl adenine increased all physiological substances to bring plant growth and development and highest production in from of seeds and all different part of plant production of this plant during two growing seasons.

These results might be explained according to the role of Benzyl adenine on promoting proteins synthesis, soluble and non-soluble sugars synthesis, or may be due to the ability of Benzyl adenine for making the treated area to act as a sink into which nutrients from other parts of the plant are drawn. Additionally, these results may explain the role of cytokinins in promoting proteins and pigments synthesis and their ability to delay senescence and withdraw sugars and other solutes from older parts of a plant to the new organs Salisbury and Ross, (1974). In the same line, Leopol and Kawase (1964) stated that cytokinins stimulate the movement of sugars, starch, amino acids and many other solutes from mature organs to primary tissues of other ones. Furthermore, may be due to the role of kinetin on increasing the promoters in the plant tissues at the expense of the inhibitors to increase roots growth. Moreover, it is well established that cytokinins stimulate lateral roots initiation, absorption and thus increasing the size (number, thickness, fresh and dry weights) Devlin and Witham, (1983). The abovementioned results of are in harmony with those attained by Youssef and Abd El-Aal, (2014).

Also, zinc play an essential role in plant physiology where it activate some enzymes as dehydrogenises, pretenses, peptidases and phosphohydrolases. Zinc is a micronutrient needed in small amounts by crop plants, but its important in crop production was noticed in the recent years (Fageria, 2009).

Abou EL-Yazied and Mady (2012) cleared that foliar application with boron application not only increased auxins and cytokinins but also decreased abscisic acid. Also, increased number of the intiation flowers, setted pods per plant, green pod and dry seed yields, as well as the satisfactory effect upon shedding percentage.

**IV-Chemical analysis:**

Data presented in Table (4) indicated that the Zn at 25 or 50 mg/L and B at 25 or 50 mg/L followed by Benzyl adenine at 50 or 100 mg/L and Putrescine at 50 or 100 mg/L treatments increased nitrogen, phosphorus, potassium crude protein and total carbohydrates contents in seeds. On the other hand, High increases in total carbohydrates having the descending order: B at 25 or 50 mg/L followed by Benzyl adenine at 50 or 100 mg/L then Putrescine at 50 or 100 mg/L followed by Zn at 25 or 50 mg/L for the respective two seasons.

In this respect, the increase in nitrogen and phosphorus due to applying the growth substances (BA) may be the result of its role on regulating ions and may be modifying the uptake movement and metabolism of nutrients within plant tissues. The increase in total carbohydrate in response to the applied treatment is supported by stimulating of photosynthetic pigments and the accumulated dry matter in shoots of BA treated plants (Zewail, 2011).

In this connection, Mady (2009) mentioned that foliar application of zinc significantly increased NPK, Zn, total sugars, total free amino acids and crude protein content of faba bean seeds.

Along the same line, Abou EL-Yazied and Mady (2012) reported that foliar spraying with boron at 50 mg/L increased NPK, B, total sugars and crude protein content in leaves at 70 and 85 days after sowing.

**Table 3:** Growth behavior and productivity of Faba bean (*Faba vulgaris, L.*) as affected by foliar application of the growth stimulators of plants.

| Treatments \ Character | Concentration (mg/L) | Yield (kg/fed) | | Plant weight (g) | Pods weight /plant | No. of pods /plant | Seed yield /plant | No. of seeds /plant | Seed index |
|---|---|---|---|---|---|---|---|---|---|
| | | Biology | seeds | | | | | | |
| **First season 2012/13** | | | | | | | | | |
| Control | (distilled water) | 3066.67 | 889.59 | 65.50 | 28.67 | 10.00 | 20.40 | 23.00 | 76.33 |
| Zinc | 25 | 3133.33 | 908.91 | 74.00 | 32.23 | 14.33 | 30.27 | 29.00 | 92.67 |
| | 50 | 3466.67 | 1147.67 | 82.00 | 48.93 | 16.67 | 30.23 | 29.67 | 93.00 |
| Boron | 25 | 3133.33 | 935.84 | 95.00 | 32.93 | 10.67 | 22.27 | 26.00 | 87.00 |
| | 50 | 3466.67 | 1108.47 | 100.73 | 39.90 | 12.00 | 29.63 | 34.33 | 90.00 |
| Benzyl adenine | 50 | 3266.67 | 1011.77 | 102.00 | 36.03 | 12.67 | 26.13 | 27.67 | 94.67 |
| | 100 | 3533.33 | 1216.46 | 118.17 | 47.07 | 15.00 | 34.50 | 36.67 | 96.67 |
| Putrescine | 50 | 3066.67 | 1020.46 | 79.17 | 30.77 | 10.67 | 27.73 | 27.33 | 82.67 |
| | 100 | 3200.00 | 1156.74 | 81.00 | 40.83 | 15.00 | 29.40 | 33.33 | 94.67 |
| L.S.D at 5% for: | | N.S | N.S | T= 14.50 | T= 8.23 | T= 2.55 | T= 4.01 | T= 4.14 | N.S |
| **Second season 2013/14** | | | | | | | | | |
| Control | (distilled water) | 2866.67 | 958.37 | 44.90 | 22.47 | 7.53 | 18.50 | 20.60 | 78.33 |
| Zinc | 25 | 3000.00 | 1240.96 | 51.97 | 27.10 | 7.53 | 20.83 | 26.33 | 91.33 |
| | 50 | 3333.33 | 1280.26 | 59.17 | 34.57 | 8.97 | 24.67 | 27.87 | 96.00 |
| Boron | 25 | 2866.67 | 1334.19 | 58.37 | 29.83 | 9.07 | 24.27 | 28.77 | 82.67 |
| | 50 | 3000.00 | 1553.68 | 55.00 | 27.50 | 10.03 | 25.17 | 28.87 | 88.00 |
| Benzyl adenine | 50 | 3066.67 | 1090.78 | 45.13 | 25.33 | 10.03 | 19.50 | 21.93 | 90.33 |
| | 100 | 3466.67 | 1647.32 | 72.53 | 42.77 | 12.70 | 26.30 | 30.70 | 96.33 |
| Putrescine | 50 | 3200.00 | 1243.09 | 48.70 | 26.30 | 9.10 | 18.57 | 22.47 | 86.00 |
| | 100 | 3400.00 | 1301.38 | 50.67 | 33.57 | 11.77 | 19.60 | 23.67 | 86.33 |
| L.S.D at 5% for: | | N.S | T= 244.57 | T= 3.11 | T= 3.04 | T= 0.99 | T= 2.50 | T= 2.17 | T= 5.47 |

**Table 4:** Chemical constituents of Faba bean (*Faba vulgaris, L.*) seeds as affected by foliar application of the growth stimulators of plants.

| Treatments \ Character | Concentration (mg/L) | Minerals (%) | | | | | Crude protein (%) | Total carbohydrates (%) |
|---|---|---|---|---|---|---|---|---|
| | | N | P | K | B | Zn | | |
| **First season 2012/13** | | | | | | | | |
| Control | (distilled water) | 4.10 | 0.073 | 1.08 | 0.06 | 0.25 | 25.62 | 53.25 |
| Zinc | 25 | 4.30 | 0.088 | 1.41 | 0.06 | 0.30 | 26.87 | 57.29 |
| | 50 | 4.50 | 0.125 | 1.40 | 0.08 | 0.34 | 28.12 | 58.78 |
| Boron | 25 | 5.10 | 0.084 | 1.54 | 0.10 | 0.26 | 31.87 | 60.65 |
| | 50 | 5.87 | 0.095 | 1.44 | 0.11 | 0.33 | 36.68 | 60.98 |
| Benzyl adenine | 50 | 4.50 | 0.369 | 1.21 | 0.08 | 0.27 | 28.12 | 57.30 |
| | 100 | 4.93 | 0.419 | 1.44 | 0.09 | 0.28 | 30.83 | 61.84 |
| Putrescine | 50 | 4.97 | 0.161 | 1.33 | 0.07 | 0.28 | 31.06 | 56.18 |
| | 100 | 5.73 | 0.241 | 1.53 | 0.07 | 0.30 | 35.81 | 61.26 |
| L.S.D at 5% for: | | T= 0.22 | T= 0.15 | T= 0.03 | T= 0.003 | T= 0.03 | T=1.42 | T= 1.83 |
| **Second season 2013/14** | | | | | | | | |
| Control | (distilled water) | 4.03 | 0.060 | 1.35 | 0.06 | 0.22 | 25.19 | 52.27 |
| Zinc | 25 | 4.43 | 0.122 | 1.49 | 0.07 | 0.27 | 27.69 | 56.17 |
| | 50 | 5.40 | 0.137 | 1.49 | 0.08 | 0.32 | 33.75 | 58.70 |
| Boron | 25 | 4.73 | 0.065 | 1.49 | 0.09 | 0.27 | 29.56 | 58.97 |
| | 50 | 5.50 | 0.076 | 1.64 | 0.12 | 0.31 | 34.37 | 61.47 |
| Benzyl adenine | 50 | 4.50 | 0.216 | 1.52 | 0.07 | 0.26 | 28.12 | 57.43 |
| | 100 | 4.90 | 0.240 | 1.59 | 0.08 | 0.26 | 30.62 | 58.67 |
| Putrescine | 50 | 4.77 | 0.149 | 1.52 | 0.07 | 0.24 | 29.81 | 55.37 |
| | 100 | 5.00 | 0.166 | 1.52 | 0.08 | 0.26 | 31.25 | 59.90 |
| L.S.D at 5% for: | | T= 0.19 | T= 0.06 | T= 0.009 | T= 0.001 | T= 0.02 | T= 1.21 | T= 1.35 |

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