J. Plant Production, Mansoura Univ., Vol. 2 (11): 1563 - 1577, 2011

EFFECT OF SOME GROWTH REGULATORS AND ANTIOXIDANTS ON GROWTH, YIELD AND SEED CHEMICAL COMPOSITION OF FABA BEAN PLANTS

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ABSTRACT

This study was carried out at Experimental Station of Agricultural Botany Department, Faculty of Agriculture, Moshtohor, Benha University during 2009 and 2010 seasons.

All applied growth substances significantly increased morphological characteristics, nodules number formation, pollen fertility, yield, content of N, P, K, crude protein and carbohydrates in seeds of faba bean plant.

The treatments of NAA at 200 or 100 ppm and salicylic acid at 100 or 50 ppm followed by pp333 at 10 or 5 ppm and Ascorbic acid at 100 or 50 ppm were more effective comparing in this respect. Also, the same treatments exhibited the lowest percentages of flowers and pods abscission.

In addition, NAA at 200 ppm and salicylic acid at 100 ppm gave the lowest percentage of abscission, pollen sterility while gave the highest seeds yield as well as significant differences in the anatomical characteristics.

Keywords: Faba bean, NAA, salicylic acid, Paclobutrazol, Ascorbic acid, anatomy and flower abscission.

INTRODUCTION

Faba bean is an important legume crop as a major source of protein and occupies large area of cultivated land in Egypt. Cultivation of faba bean leads to increase of soil nitrogenous compounds (Hungria and Vargas, 2000).

Field crop production in Egypt is concentrated mainly on the arable and around the banks of river Nile and the intensive agriculture system may leads to decrease the productivity of unit-area. Reclamation, cultivating new lands and adopting the most promising agronomic practices are the most important factors for increasing the productivity to close the gap between consumption and production of food crops.

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

Rhizobium plays a very important role in agriculture by inducing nitrogen-fixing nodules on the roots of legumes such as peas, beans, clover and alfalfa (Downie and Brewin, 2007). Therefore, this symbiosis can relieve the requirements for added nitrogenous fertilizer during the growth of leguminous crops.

Flower abscission occurs both 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).

Salicylic acid (SA) is an endogenous plant growth regulator. It is involved in various physiological processes of plant growth and development (Klessig and Malamy, 1994) such as induction of flowering and root growth stimulation (Gutiérrez-Coronado *et al*, 1998). SA also plays a major role during the early stages of Rhizobium-legume symbiosis (Rasmussen *et al*, 1991).

Paclobutrazol increased chlorophyll content, this may be partly due to the observed increase in mass of the root system which is the major site of cytokinin biosynthesis. The increase in cytokinin levels was associated with stimulated chlorophyll biosynthesis (Fletcher *et al.,* 2000).

Ascorbic acid, also named vitamin C or ascorbate, is an antioxidant and enzyme co-factor that has multiple functions in plants (Ishikawa *et al.,* 2006).

This present study was designed to investigate the effect of soaked and foliar spray of NAA, pp333, salicylic acid and ascorbic acid on enhancing the growth, nodules number, anatomical studies(stem & leaf), flower abscission, pollen fertility, yield and chemical composition in seeds of faba bean plant.

MATERIALS AND METHODS

This study was carried out at Experimental Station of Agricultural Botany Department, Faculty of Agriculture, Moshtohor, Benha University during 2009 and 2010 seasons.

This investigation aimed to study the response of faba bean plant (*Faba vulgaris* Mill.) Cv. Gridley to seed soaking and foliar spraying with some growth regulators and antioxidants. Seeds were soaked for 3 hours in the assigned concentrations as follow:-

1-The control (distilled water).
2-Naphthaline acetic acid (NAA) at 100 and 200 ppm.
3-Pacloputrazol (PP_{333}) at 5 and 10 ppm.
4- Salicylic acid(SA) at 50 and 100 ppm.
5- Ascorbic acid (AsA) at 50 and 100 ppm.

The seeds were sown in 25th of October during 2009-2010 seasons. Plants were sprayed with the same treatments (with 1ml/l of Tween 20 as a wetting and spreading agent) two times:(i.e., vegetative growth stage and the flowering stage).

the following measurements were recorded:-

Growth Parameters:

Root length(cm.), nodules number/ plant, plant height, number of leaves/ plant, total leaf area(cm^2)/ plant following the method described by Deriaux *et al*. (1973), dry weights (g / plant) of shoots and roots were

recorded (90 days after sowing). Shoots and roots were dried in an electrical oven at 75 °C till constant dry weight to determine dry weights.

Photosynthetic pigments:-

Chlorophyll a, b and carotenoids were Colorimetrically determined in leaves of faba bean plants at 60 and 85 days from sowing according to the methods described by Nornal(1982).

Anatomical studies

The samples of stem and leaf were taken from the 4th internode from top of the main stem from high concentration of all treatments at 85 days after sowing. The samples specimens were taken then killed and fixed in FAA (5ml. formalin, 5ml. glacial acetic acid and 90ml. ethyl alcohol 70%), washed in 50% ethyl alcohol, dehydrated in series of ethyl alcohols 70,90,95 and 100%, infiltrated in xylene, embedded in paraffin wax with a melting point of 60-63^{o}C, sectioned to 20 microns in thickness *(*Sass 1951), stained with the double stain method (fast green and safranin), cleared in xylene and mounted in Canada balsam (Johanson, 1940*).* Sections were read to detect histological manifestation of noticeable responses resulted from other treatments.

The prepared section were microscopically examined, counts and measurements (μ) were taken using a micrometer eye piece. Average of readings from 3 slides/treatment were calculated .

flowering characters:-

a)Total number of flowers / plant:

The total number of the opened flowers per plant through the season were recorded for each treatment of faba bean plants.

b) Abscission percentage: was calculated according to the equation:

$$\text{Abscission \%} = \frac{\text{No. of flowers/plant -No. of fruits/plant}}{\text{No. of flowers / plant}} \times 100$$

c) Pollen grains fertility:

Pollen fertility was estimated by the inspection and counting of fertile and non-fertile pollen grains mounted in dilute iodine solution and microscopically examined using the method described by Shahine (1961).

d) Pods setting percentage:

was calculated according to the following equation:

$$\text{\% of setted pods} = \frac{\text{No. of pods / plant}}{\text{No. of flowers / plant}} \times 100$$

yield and yield components:-

Number of setted pods/ plant , weight of pod(g), pods yield(g)/ plant, weight of seeds/ pod, seeds yield(g)/plant and seed index(weight of 100 seeds (g)) were recorded in the harvest sample(120 days after sowing).

Chemical analysis:

Seeds at the harvest (120 days after sowing) were used to determine the following chemical analysis during 2010 season.

-Total nitrogen percentage was determined in the dried seeds by 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., 1990), Phosphorus was determined colorimetrically according to the method of 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 described by Dubois *et al.*,(1956)

Statistical analysis:

All data obtained during both seasons of study were subjected to analysis of variance and significant differences among means were determined according to Snedecor and Corchran (1972). Significant differences among means were distinguished according to the Duncan`s multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth Parameters:

Data in Table (1) revealed that all applied treatments were significantly increased the root length, No. of nodules number/ plant, plant height, No. of branches/plant No. of leaves/plant, total leaf area/ plant and dry weight of root, stem and leaves compared the control. Maximum increments were obtained by applying 200 and 100 ppm of NAA followed by 100 and 50 ppm of salicylic acid and 100ppm of ascorbic acid treatments in 2009 and 2010 seasons.

Gutam *et al*.,(2009) stated that Naphthalene acetic acid(NAA) is a major factor has a stimulating effect on cell division and cell elongation, hence it could increase all vegetative growth and photosynthetic rates(Table, 2).

El-Shraiy and Hegazi(2009) showed that the maximum number of nodules per plant was achieved by the application of SA at 10^{-3} M. Whereas PP_{333} applications prevent nodule formation.

In this connection, Sakhabutdinova, *et al.,* (2003) mentioned that SA at 0.05 mM increased the level of cell division within the apical meristem of seedling roots which caused an increase in plant growth. SA treatment caused accumulation of both ABA and IAA in wheat seedlings.

Also, results showed that foliar application of paclobutrazol (10 ppm) recorded the highest values of number of branches/plant, No. of leaves/plant and dry leaves weight/plant. Meanwhile, paclobutrazol at 5 or 10ppm reduced plant height by inhibiting GA3 production which is responsible for cell elongation(Grossmann,1992)

Paclobutrazol (200 ppm) caused marked the highest values of fresh and dry weights/plant, leaf area, number of pods/plant, number of seed/pod, 100 seed weight and seed yield (Khafaga *et al.,* 2009).

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Photosynthetic pigments:-

Data in Table (2) showed that photosynthetic pigments content in leaves (i.e., chlorophyll a & b, Chl.(a+b) and Carotenoids) were increased with pp_{333} at 10 or 5ppm, NAA at 200 or 100ppm and salicylic acid at 100 or 50ppm in plants aged 60 and 85 days in two seasons of 2009 and 2010.

Also, it could be noticed that paclobutrazol gave the highest values in chlorophyll content, this may be partly due to the observed increase in mass of the root system which is the major site of cytokinin biosynthesis. The increase in cytokinin levels was associated with stimulated chlorophyll biosynthesis (Fletcher *et al.,* 2000).

This observation was supported by Sakhabutdinova, *et al*., (2003) who reported that, leaves treated with high concentrations of SA (5 mM) accumulated more Chl and carotene isomers. Leaves treated with SA enhanced SOD activities and accumulated H_2O_2 before the detection of the SA-mediated inactivation of H_2O_2-degrading enzymes.

Moreover, Ismaeil, (1995) and Fletcher *et al.*, (2000) found stimulating effects of paclobutrazol on the photosynthetic pigments in some other plants.

Table (2): Effect of some growth regulators and antioxidants on photosynthetic pigments concentration of faba bean leaves during 2010 season.

Characters / Treatments	Photosynthetic pigments mg/g fresh weight							
	Chl. A		Chl. B		Chl. A+ b		Carotenoids	
	60 days	85 days	60 days	85 days	60 days	85 days	60 days	85 days
Control(distilled water)	0.67	0.69	0.36	0.40	1.03	1.09	0.18	0.28
NAA at 100 ppm	1.39	1.44	0.85	0.82	2.24	2.26	0.46	0.51
200 ppm	1.44	1.48	0.87	0.88	2.31	2.36	0.48	0.58
PP_{333} at 5 ppm	1.50	1.53	0.93	0.96	2.43	2.49	0.56	0.64
10 ppm	1.57	1.56	0.95	0.99	2.52	2.55	0.59	0.66
Salicylic acid at 50 ppm	1.34	1.40	0.69	0.70	2.03	2.10	0.43	0.48
100 ppm	1.37	1.43	0.74	0.77	2.11	2.20	0.45	0.51
Ascorbic acid at 50 ppm	1.22	1.24	0.62	0.69	1.84	1.93	0.33	0.40
100 ppm	1.33	1.31	0.64	0.69	1.97	2.00	0.35	0.43

Anatomical studies:-

Stem anatomy:-

Table (3) and Fig. (1) show that the highest increase was existed with the application of pp_{333} at 10 ppm. These increase was 6552.32µ compared with the 3561.83µ that of the control.

The increase in the stem diameter was due to the increase in both hollow pith and stem wall(cuticle , epidermis, collenchyma, parenchyma, vascular bundle and parenchymatous pith thickness).

As for the total number of vascular bundles, all treatments increased them. The highest increase in this number was with the treatment of pp_{333} at 10 ppm. Also, the applied treatments increased phloem & xylem thickness and no. of xylem vessels.

Hence, of interest to note that different applied treatments increased stem diameter that reached to maximum with the treatment of NAA at

200ppm(6250.54µ) followed by salicylic acid at 100 ppm(5574.80µ) and ascorbic acid at 100 ppm(5574.80µ).

In general, the stimulatory effects of applied treatments upon the anatomical features of treated plants could be attributed to the effect upon cambium activity. Increment of cambium activity could mainly attributed to the increase of endogenous hormones level especially auxins and cytokinins(Ismaeil, 1995 and Zewail, 2011) confirming the findings of the present study.

leaf anatomy:

Data in Table (4) revealed that all applied treatments significantly increased the anatomical features of faba bean leaf .

With regard to the blade thickness, it was increased with different used treatments to reach its maximum value (622.80µ) with PP333 at 10 ppm followed by Salicylic acid at 100 ppm (558.75 µ) and NAA at 200 ppm (541.13 µ) compared with the control(403.50 µ).

Table (3): Effect of some growth regulators and antioxidants on the mean counts and measurements of certain anatomical features of main stem of faba bean plants at 85 days after sowing during 2010 seasons.

Treatments / Histological Characteristics (µ)	Control (distilled water)	NAA at 200 ppm	PP_{333} at 10 ppm	Salicylic acid at 100 ppm	Ascorbic acid at 100 ppm
Stem diameter	3561.83	6250.54	6552.32	5574.80	4530.85
Cuticle layer thickness	11.25	13.28	17.10	12.60	11.70
Epidermal thickness	36.90	50.18	53.33	46.05	42.30
Thickness of collenchyma layers	62.10	90.00	97.65	86.40	85.50
Thickness of parenchyma layers	156.15	281.03	283.50	237.60	180.00
No. of vascular bundles	22	28	29	25	24
Thickness of fibers layers	126.90	258.30	319.95	252.40	150.30
Thickness of phloem layers	79.88	119.25	119.48	115.65	100.00
Cambium region thickness	37.35	88.43	90.90	72.15	60.45
Xylem thickness in vascular bundle	246.51	328.50	353.25	304.05	248.85
Length of vascular bundle.	490.64	794.48	880.58	744.25	559.60
No. of xylem vessels in vascular bundle	60	65	68	64	57
Diameter of the widest xylem vessel in Vascular bundle	45.00	63.00	67.05	60.25	56.25
Parenchymatous pith thickness	498.50	861.30	869.40	738.00	678.70
Hollow pith thickness	1050.75	2070.00	2149.20	1845.00	1415.25

For mesophyll tissue, the thickness of both palisade and spongy tissues were increased with different applied treatments. Here, palisade tissue thickness was 117.90µ in the control but was increased to reach 181.80, 163.35, 148.50 and 137.70µ with Salicylic acid at 100 ppm, PP333 at 10 ppm, NAA at 200 ppm and Ascorbic acid at 100 ppm, respectively. Also spongy tissues was 193.50µ in the control but was increased to reach 336.60, 284.18, 273.15 and 221.40µ with PP333 at 10 ppm, NAA at 200 ppm, Salicylic acid at 100 ppm and Ascorbic acid at 100 ppm, respectively.

Fig. (1): Transverse sections (X = 25) through 4 th internode of the main stem of faba bean plants at 60 days after sowing as affected by different applied treatments.

Where: (A): Control(distilled water) (B): NAA at 200 ppm (C): PP_{333} at 10 ppm
(D): Salicylic acid at 100 ppm (E): Ascorbic acid at 100 ppm
ep= Epidermis co= Cortex fi=fiber tissue
ph= phloem tissue cam=cambium region xy= Xylem tissue
cvb=cortical vascular bundle pi= pith hpi=hollow pith

Fig. (2): Transverse sections (X = 25) through 4 th leaflet of faba bean plants at 60 days after sowing as affected by different applied treatments.

Where: (A): Control(distilled water) (B): NAA at 200 ppm (C): PP_{333} at 10 ppm
(D): Salicylic acid at 100 ppm (E): Ascorbic acid at 100 ppm
uep= upper epidermis lep= lower epidermis pl=palisade tissue
spo=spongy tissue co= collenchyma tissue
ph= phloem tissue oft=outer fiber tissue ift=inner fiber tissue

The applied treatments increased in most of the midrib anatomical features such as thickness of both uppermost and lowermost collenchyma tissue and dimensions of main vascular bundle as well as thickness of phloem tissue, xylem tissue, number and diameter of xylem vessels in main vascular bundle. These increases were more obvious with the pp_{333} and NAA treatment. The results specially increment of the conductive tissues (xylem and phloem) are great importance because they could be involved in the interpretation about why vigorous growth and high yielded pods were existed with different applied treatments specially with pp_{333} at 10 ppm.

flowering characters:-

Data in Table(5) clearly demonstrate that all applied treatments significantly enhanced total number of flowers/ plant, Pollen grains fertility and Pods setting percentage as compared with the untreated plants. On the other hand, the all applied treatments were decreased abscission percentage

Data in Table (5) show fertility and sterility of pollen grains. The treatments especially NAA at 200 or 100 ppm and salicylic acid at 100 or 50ppm increased pollen fertility over the control plant and other treatments. These results could illustrate the increase or decrease of yield as the fertility of pollen grains could be an indication for egg fertility. Meanwhile, the antioxidant treatments might decreased flower abscission percentage by the protection of flower to abscise through increase those substances responsible for scavngening of free radicals and exchange
these radicals to beneficial substances to cause protection of membranes and all cell organelles in plant cell. The above mentioned increase flower number and flower setting as well Eaid (2010) and Zewail (2011)

Maximum values of growth parameter, Total number of flowers, Pollen grains fertility and Pods setting percentage were recorded by NAA and salicylic acid. So, these increments led to increase yield and yield components. These results were in agreement with those of Ismaeil (1995), Fletcher *et al*.(2000), Ishikawa *et al.*(2006), Riad *et al* (2008) and Zewail (2011).

yield and yield components:-

Higher yield and yield components (No. of pods, weight of pod(g), Pods yield(g)\ plant, Weight of seeds\ pod, Seed yield (g)\ plant and Seed index(g))of faba bean as affected by NAA and salicylic acid followed by pp_{333} and ascorbic acid treatments in Table(5) may be attributed to the indirect effect of most materials in many biochemical processes SA applied on basil stimulated the growth and yield by enhancing photosynthesis and nutrient uptake (Gharib, 2006).

The obtained increase of the final seed yield could be attributed to that increase firstly in growth characteristics such as branches number, bacterial nodules number, total leaf area and dry weight (Table, 1) and secondly may be due to that increase in photosynthetic pigments content (Table, 2).

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Thereby, increase of all substances and bioconstituents synthesis and their translocation from leaf and different plant organs to seeds Zewail (2011). NAA increased flower number and flower setting (Table, 5) and increased of 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 2009 and 2010 seasons Qbal *et al.*,(2009)

Chemical analysis:

Data presented in Table (6) indicate that the NAA at 200 or 100 ppm and salicylic acid at 100 or 50ppm followed by pp_{333}at 10 or 5ppm and ascorbic acid at 100 or 50 ppm treatments increased nitrogen , phosphorus, potassium and crude protein contents in seeds. On the other hand, High increase in total carbohydrates was obtained from NAA at 200 or 100 ppm and pp_{333}at 10 or 5ppm followed by salicylic acid at 100 or 50ppm.

Table (6): Effect of some growth regulators and antioxidants on some minerals (mg/g D.W.), total carbohydrates, crude protein of faba bean seeds during 2009 and 2010 seasons.

Characters / Treatments	Minerals (mg/g dry weight)			Crude protein (mg/g dry weight)	Total carbohydrates %
	N	P	K		
Control(distilled water)	3.85	0.38	0.18	24.06	50.82
NAA at 100 ppm	5.25	0.45	0.42	32.81	60.58
200 ppm	5.60	0.52	0.30	35.00	60.86
PP_{333} at 5 ppm	4.06	0.53	0.22	25.38	61.47
10 ppm	4.20	0.43	0.25	26.25	64.93
Salicylic acid at 50 ppm	4.90	0.45	0.25	30.63	59.29
100 ppm	4.90	0.58	0.28	30.63	60.22
Ascorbic acid at 50 ppm	4.48	0.44	0.29	28.00	52.93
100 ppm	4.55	0.57	0.34	28.44	55.58

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

The positive effect existed with pp_{333} on total carbohydrates could be attributed to that increase of chlorophylls content and its reversion on improvement or enhancement of photosynthetic processes (Ismaeil,1995).

These results are in agreement with those of El – Desouky *et al.,* (2001), El – Shraiy and Hegazi (2009) Sharaf El-Deen and Manaf (2009), Eaid (2010) and Zewail (2011)

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تـأثير بعض منظمـات النمـو و مضـادات الأكسـدة علـى النمـو، المحصـول و التركيـب الكيمـاوي للبذور في نباتات الفول

فاتن حسن محمود إسماعيل و محمد محمد محمود عبد العال
قسم النبات- كلية الزراعة- جامعة بنـها

تمت هذه الدراسة فى مزرعة كلية الزراعة بمشتهر – جامعة بنها فى موسمى النمو ٢٠٠٩-٢٠١٠م.
تهدف هذه الدراسة الى دراسة تـأثير بعض منظمات النمو و مضادات الأكسدة على الصفات المورفولوجية، التشـريحية، عـدد العقـد البكتيريـة، الإزهـار، تسـاقط الأزهار،خصـوبة حبـوب اللقـاح، المحصـول و التركيـب الكيماوي للبذور في نباتات الفول صنف جريدلى. حيث نقعت البذور فى التركيزات الآتية:
١-الكنترول، ٢-نفثالين حمض الخليك بتركيز ١٠٠ و ٢٠٠ جزء فى المليون، ٣-الباكلوبيوترازول بتركيز ٥ و ١٠ جزء فى المليون، ٤-حمض الساليسيلك بتركيز ٥٠ و ١٠٠ جزء فى المليون و ٥-حمض الإسكوربيك بتركيز ٥٠ و ١٠٠ جزء فى المليون و بعد ذلك تم رش النباتات بنفس المعاملات عند ٤٠ و ٧٠ يوم من الزراعة.
أعطت كل المعاملات زيادة معنوية للصفات المورفولوجية، عدد العقد البكتيرية، خصوبة حبوب اللقاح، المحصول ، محتوى البذرة من النيتروجين، القوسفور، البوتاسيوم، البروتين و الكربوهيدرات.
أعطت المعاملات نفثالين حمض الخليك بتركيز ١٠٠ و ٢٠٠ جزء فى المليون و حمض الساليسيلك بتركيز ٥٠ و ١٠٠ جزء فى المليون يتبعها الباكلوبيوترازول بتركيز ٥ و ١٠ جزء في المليون و حمض الإسكوربيك بتركيز ٥٠ و ١٠٠ جزء فى المليون أعلى تأثير مقارنةً بالكنترول. و أيضاً نفس المعاملات أدت الى تقليل النسبة المئوية للتساقط.
بالإضافة الى أن نفثالين حمض الخليك بتركيز ٢٠٠ جزء فى المليون و حمض الساليسيلك بتركيز ١٠٠ جزء فى المليون أعطيا أقل نسبة مئوية للتساقط و عقم حبوب اللقاح و أعلى محصول من البذور و أدت الى اختلافات معنوية فى الصفات التشريحية.

قام بتحكيم البحث

أ.د / محب طه صقر	**كلية الزراعة – جامعة المنصورة**
أ.د / سعيد على الدسوفى	**كلية الزراعة – جامعة بنـها**

Table (1): Effect of some growth regulators and antioxidants on morphological characters, bacterial nodules number and dry weight of faba bean plants during 2009 and 2010 seasons.

Characters / Treatments	Root length (cm)	Nodules number/ plant	Plant height (cm)	No. of Branches /plant	No. of leaves /plant	Total leaf area (cm^2)/ plant	Root dry weight (g)/plant	Stem dry weight (g)/plant	Leaf dry weight (g)/plant
	2009 season								
Control(distilled water)	13.17C	20.00D	38.33E	3.33C	46.00C	3657.00D	4.15B	8.47E	8.53D
NAA at 100 ppm	18.67AB	33.33AB	48.00B	5.33AB	48.33C	6699.00A	6.77A	11.49AB	11.16BC
200 ppm	20.00A	35.00A	51.17A	5.33AB	54.33B	6888.00A	7.04A	12.42A	1181AB
PP_{333} at 5 ppm	15.67BC	26.67ABCD	43.67CD	6.00AB	59.67A	5628.00ABC	5.21AB	9.54CDE	12.56AB
10 ppm	17.00AB	26.67ABCD	41.00DE	6.67A	61.67A	5974.00ABC	5.61AB	9.79BCDE	13.40A
Salicylic acid at 50 ppm	17.33AB	28.33ABCD	46.50BC	5.67AB	55.67B	6407.00AB	5.84AB	11.11ABCD	12.13AB
100 ppm	18.00AB	30.00ABC	46.67B	5.67AB	59.33A	6680.00A	6.65A	11.29ABC	12.53AB
Ascorbic acid at 50 ppm	13.33C	23.33CD	44.00CD	4.33BC	47.00C	5110.00C	4.15B	8.90E	9.18D
100ppm	13.33C	25.00BCD	46.50BC	5.00ABC	48.33C	5288.00BC	5.14AB	9.39DE	9.84CD
	2010 season								
Control(distilled water)	13.67E	23.33D	39.67F	3.67C	48.33C	5563.00D	5.59C	8.75E	8.79E
NAA at 100 ppm	20.67AB	40.67AB	52.50B	6.33AB	55.67B	8427.00A	7.59A	13.08B	12.24BC
200 ppm	21.67A	45.00A	57.67A	6.33AB	56.00B	8462.00A	8.47A	15.55A	12.29BC
PP_{333} at 5 ppm	16.33CDE	30.00CD	45.00DE	7.67AB	62.67A	7396.00ABC	5.86BC	11.03CD	15.85A
10 ppm	15.67DE	33.33BC	42.33EF	8.33A	63.33A	7637.00AB	6.01BC	11.25BCD	15.96A
Salicylic acid at 50 ppm	18.67BC	35.00BC	48.50CD	6.67AB	62.00B	8137.00A	6.03BC	12.06BCD	13.81B
100 ppm	20.00AB	36.67BC	49.83BC	7.00AB	62.33A	8237.00A	7.27AB	12.63BC	15.69A
Ascorbic acid at 50 ppm	14.33E	28.33CD	45.50DE	5.67BC	50.33C	6499.00CD	5.75BC	10.22DE	10.19DE
100 ppm	15.67DE	30.00CD	48.00CD	6.33AB	51.33C	6661.00BC	5.76BC	10.88CD	10.67CD

Table (4): Effect of some growth regulators and antioxidants on the mean counts and measurements of certain anatomical features of faba bean leaf at 85 days after sowing during 2010 seasons.

Treatments / Histological Characteristics (µ)	Control (distilled water)	NAA at 200 ppm	PP_{333} at 10 ppm	Salicylic acid at 100 ppm	Ascorbic acid at 100 ppm
Thickness of upper epidermis cuticle layer	16.50	14.40	18.00	15.30	10.80
Thickness of Lower epidermis cuticle layer	12.60	10.80	15.30	12.90	9.00
Upper epidermis thickness	36.90	49.50	55.35	43.20	41.40
Lower epidermis thickness	26.10	33.75	34.20	32.40	33.30
Palisade tissue thickness	117.90	148.50	163.35	181.80	137.70
Spongy tissue thickness	193.50	284.18	336.60	273.15	221.40
Thickness of blade	403.50	541.13	622.80	558.75	453.60
Thickness of collenchyma layers below the upper epidermis at midrib	45.90	105.30	98.10	77.40	63.90
Thickness of collenchyma layers above the lower epidermis at midrib	36.90	51.30	64.80	64.35	46.80
Thickness of upper fibers layers in the vascular bundle	112.50	153.90	150.30	156.60	231.30
Thickness of xylem tissue	201.60	244.80	225.10	211.80	215.20
Number of xylem vessels in the vascular bundle	36	52	59	47	37
Thickness of widest xylem vessel in the vascular bundle	31.50	47.70	39.15	37.80	41.85
Thickness of phloem in the vascular bundle	61.20	86.40	95.40	94.50	85.95
Thickness of lower fibers layers in the vascular bundle	100.35	109.80	120.60	108.00	117.10
Length of midrib vascular bundle	556.20	649.80	621.90	563.40	558.00
No. of vascular bundle in midrib	1	1	1	1	2
Thickness of leaf midrib	1058.40	1275.30	1374.60	1291.70	1251.10

Table (5): Effect of some growth regulators and antioxidants on flowering, fruit setting, flower abscission, pollen grains fertility, yield and yield components of faba bean plants during 2009 and 2010 seasons.

Characters / Treatments	No. of flowers / plant	% of Abscission	pollen grains fertility(%)		No. of setted pods/ plant	% of setted pods	Weight of pod(g)	Pods yield(g)/ plant	Weight of seeds/ pod	Seed yield (g)\ plant	Seed index(g)
			Fertility	Sterility							
	2009 season										
Control(distilled water)	58.00C	58.59A	49.46D	50.54A	22.74B	39.38B	2.13C	56.80F	1.647D	54.61D	82.33D
NAA at 100 ppm	70.00AB	43.58B	94.12A	5.88FG	32.88AB	53.56A	3.75A	139.20A	3.253AB	131.10A	162.7AB
200 ppm	72.23A	46.44B	94.97A	5.03FGH	40.67A	56.42A	3.76A	144.00A	3.303A	142.20A	165.2A
PP_{333} at 5 ppm	60.33C	49.96B	77.26C	22.74C	26.65B	50.04A	3.56A	90.38DE	2.803BC	86.77C	140.2BC
10 ppm	61.67C	47.59B	81.82AB	18.18D	31.23AB	52.41A	3.62A	101.60CD	3.003AB	90.56C	150.2AB
Salicylic acid at 50 ppm	62.33C	47.09B	87.79AB	12.21E	31.24AB	52.91A	3.56A	111.50BC	3.130AB	98.15BC	162.5AB
100 ppm	63.67BC	46.50B	92.74A	7.26F	31.61AB	53.50A	3.62A	118.90B	3.259AB	102.90B	156.5AB
Ascorbic acid at 50ppm	58.33C	58.57A	72.89C	27.11B	24.98B	41.43B	2.28C	66.35F	1.797D	61.84C	89.33D
100 ppm	58.33C	58.50A	74.70C	25.30BC	25.56B	41.50B	3.08B	82.90E	2.450C	81.84C	122.5C
	2010 season										
Control(distilled water)	60.33C	56.63A	56.90D	49.10A	26.15D	43.37C	2.26C	81.59D	1.767C	64.84D	88.33C
NAA at 100 ppm	80.00A	42.43BC	94.38A	5.62 EF	44.08A	57.57AB	3.85A	169.40A	3.343A	147.30A	167.2A
200 ppm	81.33A	40.63C	94.06A	5.94EF	46.72A	59.37A	3.91A	175.30A	3.410A	156.40A	170.5A
PP_{333} at 5 ppm	67.67B	49.15ABC	77.12C	22.88BC	35.67BC	50.85ABC	3.74A	112.30BC	3.237A	94.80BC	161.8A
10 ppm	69.67B	46.82ABC	84.21AB	15.79CD	35.75BC	53.18ABC	3.75A	112.90BC	3.250A	105.70B	162.5A
Salicylic acid at 50 ppm	70.33B	46.68ABC	85.37AB	14.63CD	36.65BC	53.32ABC	3.77A	134,10B	3.270A	139.40A	163.5A
100 ppm	78.67A	45.78ABC	90.91A	9.09E	42.55AB	54.22ABC	3.84A	166.30A	3.343A	145.00A	167.2A
Ascorbic acid at 50ppm	63.67BC	52.70AB	74.54C	25.46B	32.56CD	47.30BC	2.46C	82.87D	1.967C	65.12D	98.33C
100 ppm	65.33BC	49.47ABC	81.08AB	18.92C	33.07C	50.53ABC	3.18B	97.68CD	2.673B	84.46C	133.7B