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RESPONSE OF FABA BEAN (*Vicia faba*, L.) PLANTS TO SEED-TREATING WITH GARLIC EXTRACT, SALICYLIC ACID AND PACLOBUTRAZOL

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ABSTRACT

Application of garlic extract (GE) at 100&200ml/l, salicylic acid (SA) at 100&200 ppm and paclobutrazol (PP_{333}) at 10&20 ppm as soaking treatments for faba bean seeds before sowing during 2004/05 and 2005/06 seasons, significantly enhanced many of the vegetative growth characters as plant height, No. of branches, No. of leaves, dry weight of both stems and leaves and total leaf area/plant. Yet, significant reduction in the plant height existed only with PP_{333} at its two applied concentrations. Besides, all applied treatments obviously increased photosynthetic pigments, NPK, crude protein and total sugars concentrations in the leaves of treated plants at 75 days after sowing. In addition, different applied treatments positively altered many anatomical features of stems and leaflet blade of treated plants. Since, all applied treatments caused an obvious increase in the thickness of stem wall and its comprising tissues as epidermis, cortex and parenchymatous pith as well as thickness of midrib, lamina, upper and lower epidermis, palisade and spongy tissues in leaves. Also, dimensions of vascular bundles, thickness of phloem and xylem tissues and number of xylem vessels/bundle were increased in both stems and leaves of treated plants. Moreover, with the onset of flowering, different applied seed-soaking treatments significantly increased number of formed flowers and setted pods/plants, whereas reduced the percentages of flowers and pods shedding, in turn significantly increased number of mature (yielded) pods and the final seed yield comparing with those of untreated plants. Furthermore, concentrations of NPK, crude protein, sugars and total carbohydrates in the seeds were also increased as affected by the applied treatments. Hence, it could be recommended the applying of GE, SA and PP_{333} as seed-soaking treatments for reducing the abscission of flowers and pods in faba bean plants which consequently reflect upon obvious increase in the final seed yield.

INTRODUCTION

The phenomena of buds, flowers and immature pod shedding of faba bean usually took place in serious values leading to great reduction in seed yield of this economical plant. Therefore, plant physiologists and breeders are studying intensively the problem of shedding, in order to find out a solution for reducing the high percentage of buds, flowers and immature pods that fail to develop into fully mature pods in this plant. In this respect, many trails have been carried out for increasing flower set, minimizing pre-harvest abscission of immature fruits of faba bean or other plants by the use of different factors including plant growth substances (Abd El-Dayem and El-Deeb, 2000 and Ahmed, 2002), mineral nutrients (Wanas, 2002a) and some natural plant extracts (Atawia and El-Desouky, 1997 and Wanas, 2002b).

Here, garlic extract, salicylic acid and paclobutrazol were used as soaking treatments for faba bean seeds to improve growth and reduce flowers and immature pods shedding of this economical plant.

Garlic extract (GE) was suggested to participate a beneficial role during vegetative and reproductive growth through improving flowers formation and their set of some plants due to its enhancement of endogenous auxin, gibberellin and cytokinin levels and carbohydrates accumulation (El-Desouky *et al.,* 1998). Also, it was reported about its stimulatory effects on cell division and enlargement and bio-synthesis of growth promotive hormones (Wanas *et al.,* 1998), protein synthesis and chlorophyll formation (El-Desouky *et al.,* 1998 and Seham, 2002), beside its contents of amino acids, antibiotics, sugars, vitamins (Watt and Merrill, 1963).

Salicylic acid (SA) is thought to be a new class of plant growth substances. It has an effect on many physiological process (Arteca, 1996). In this respect, Shehata *et al.* (2000) suggested that salicylic acid had a beneficial role on the vegetative and reproductive growths of cotton plants due to its enhancement of endogenous cytokinins, auxins and gibberellin levels, chlorophyll formation and carbohydrates accumulation. They added that SA increased number of fruiting organs and total bolls/plants, whereas reduced shedding of bolls and subsequently increased the final boll yield.

Paclobutrazol (PP_{333}) is relatively one of the new growth retardants. It has been reported that PP_{333} enhanced branching, flowers setting, earlier maturity and yield of some plants (Wanas, 1996; Ahmed, 2002 and Hyam, 2006). The main effect of PP_{333} takes place through the alteration of hormonal balance. Since, it promotes treated plants to create more cytokinins, whereas inhibits biosynthesis of gibberellins (Wanas, 1996; Abd El-Dayem and El-Deeb, 2000 and Hyam, 2006).

Therefore, it was thought advisable to use natural garlic extract, salicylic acid and paclobutrazol as soaking treatments for faba bean seeds to improve growth, flower setting and reduce shedding of immature pods as well as increasing the final seed yield of this economical plant.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of the Faculty of Agriculture at Moshtohor, Benha University during two successive growing seasons (2004/05 and 2005/06) to investigate the effects of applying the natural garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) as seed-soaking treatments on some growth aspects, chemical components, anatomical features, flowering, shedding as well as yield and its components of faba bean (*Vicia fabe*, L.) cultivar Giza 461. Seeds of faba bean were secured from Agricultural Research Center, Ministry of Agriculture, Giza, Egypt.

Garlic extract preparation:

Fresh mature garlic cloves were blended in distilled water (½ kg cloves/1 liter H_2o), frozen and thawed two times, then filtered. The filtrate was used for preparation of different garlic extract concentrations, i.e. ,100 & 200 ml/l. Such technique for garlic preparation modified after El-Desouky *et al.*, (1998).

Experimental design of treatments:

Each experiment included seven treatments, i.e. the control (distilled water), 100 & 200 ml/l of garlic extract, 100&200 ppm of salicylic acid and 10&20 ppm of paclobutrazol. The experiment was arranged in a complete randomized block design system with five replicates. The plot area was 10.5m^2 (3.5 x 3m) with 5 rows. Faba bean (cv. Giza 461) seeds were soaked in the solutions of the assigned concentrations of either GE, SA or PP_{333} as well as in distilled water (as control) for 6 hours, then sown in hills spaced 15 cm on one side of ridges at the 16th of November in the two growing seasons. At 21 days from sowing, seedlings were thinned to one seedling per hill. Calcium superphosphate (15.50% P_2O_5) and potassium sulphate (48% K) were added before sowing in both seasons at the rates of 100 and 50 kg/fed., respectively. Also, nitrogen fertilizer at rate of 20 kg/fed. was applied before the first irrigation in from of urea (46% N). The other cultural practices for growing faba bean plants were carried out as recommended.

Sampling date and collecting data:

I- Growth characters:

Ten plants were randomly chosen from each treatment at two stages of growth, i.e. at 75 and 105 days from sowing in both seasons to estimate plant height (cm), number of branches/plant, stem dry weight (g)/ plant, number of leaves/plant, leaf dry weight (g) /plant and total leaf area (cm^2) /plant using the disk method as described by Derieux *et al.,* (1973). Also, assimilation rate (A.R.) was calculated according to Wareing and Phillips (1981) using the following equation:

$$\text{A.R.} = \frac{\text{Total leaf area } (cm^2)/\text{plant}}{\text{Total dry weight of leaves (g)/plant}}$$

II - Photosynthetic pigments:

Chlorophyll a, b and carotenoids were colorimetrically in the leaves only determined at 75 days from sowing in both seasons according to the method described by Inskeep and Bloom (1985).

III- Chemical constituents in the leaves:

Samples from faba bean leaves at 75 days from sowing were taken to determine total nitrogen (Horneck and Miller. 1998), phosphorus (Sandell, 1950) potassium (Horneck and Hanson, 1998), and total and reducing sugars (Dubois *et al*., 1956). Also, crude protein was calculated according to A.O.A.C (1990) using the following equation :

Crude protein = Total nitrogen X 6.25

IV - Anatomical study:

According to the wide differences in the morphological characters of faba bean plants due to treatments in the first season a comparative anatomical studies on stems and leaf blades of treated plants compared with those of the control were examined during the second season.

At 75 days from sowing specimens of stems (1cm long) were taken

from the middle part of the 4th apical internode, while those of leaves (1cm^2) were taken from the middle part of certain leaflet blade of the 4th apical leaf on the main stem. The specimens were killed and fixed for at least 48 hours in F.A.A. solution (10 ml formalin + 5 ml glacial acetic acid + 85 ml ethyl alcohol 70%), washed in 50% ethyl alcohol, dehydrated in a series of ethyl alcohols (70, 90, 95 and 100%), infiltrated in xylene, embedded in paraffin wax of a melting point 60-63°C (Sass, 1950), sectioned at 20 µ using a rotary microtome, double stained with fast green and safranin (Johanson, 1940), cleared in xylene and mounted in Canda balsam.

The prepared sections were microscopically examined. Counts and measurements (µ) were taken using a micrometer eye piece. Averages of readings from 4 sections / treatment were calculated.

V-Flowering as well as yield and its components characters:

Ten plants per each treatment were randomly chosen and labeled in the field from the start of flowering to harvesting time and the following characters were studied and recorded :

a) No. of opened flowers/plant: Counting was started at 60 days of plant age with 3 days intervals until 100 days.
b) No. of setted pods/plant: Counting was started at 75 days of plant age with 3 days intervals until 125 days.
c) No. of survived (mature) pods/plant: It was recorded at harvest time.
d) $$\%\ \text{of flower shedding} = \frac{\text{Total No. of flowers/plant} - \text{No. of setted pods/plant}}{\text{Total No. of flowers/plant}}$$
e) $$\%\ \text{of pod shedding} = \frac{\text{No. of setted pods/plant} - \text{No. of survived pods/plant}}{\text{Total No. of setted pods/plant}}$$
f) No. of seeds/plant, seed yield (g)/plant and seed index [100-seed weight(g)], were recorded at harvesting time.
g) Relative total seed yield was calculated as a percentage of control yield.

VI-Chemical constituents in the seeds:

Samples from faba bean seeds at harvesting time were taken to determine total nitrogen (Horneck and Miller. 1998), phosphorus (Sandell, 1950) potassium (Horneck and Hanson, 1998), and total and reducing sugars and total carbohydrates (Dubois *et al*., 1956). Also, crude protein was calculated according to A.O.A.C (1990) using the following equation :

Crude protein = Total nitrogen X 6.25

VII-Statistical analysis:

Data of the vegetative growth, flowering as well as yield and its component were subjected to statistical analysis according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

I-Vegetative growth characters:

I-1) Stem characters :

Data in Table (1) indicate that application of garlic extract (GE) at 100&200 ml/l and salicylic acid (SA) at 100&200 ppm as seed-soaking treatments significantly increased the height of treated faba bean plants compared with untreated ones. That was true at the two sampling date during the two seasons. Besides, increases were in parallel to the applied concentrations of GE and SA with superiority of SA in this respect. On the contrary, application of the growth retardant paclobutrazol (PP_{333}) at 10&20 ppm caused a significant reduction in this parameter at the two stages of growth during the two growing seasons.

With regard to number of branches and stems dry weight/plant as shown in Table (1), it was found that all applied seed-soaking treatments significantly increased these parameters at the two sampling date in the two grown seasons compared with the control treatment. Here, it could be noticed that PP_{333} at 20 ppm gave the highest number of branches/plant followed by GE at 200ml/l, meanwhile GE was the most effective in case of stems dry weight comparing with SA and PP_{333}. Increment of branches number/plant is of great importance, because it indicates more dry matter being allocated for the formation of new branches which could be later carried an additional yield

I-2) Leaf characters :

As shown in Table (1) different estimated growth characters of leaves (number, dry weight and total leaf area/plant) at 75 and 105 days from sowing were significantly increased with all applied treatments compared with those of the control during the two growing seasons. Increases were mostly in parallel to the applied concentrations of GE, SA and PP_{333}. Also, the highest increases in leaf parameters, specially at 105 days of plant age existed with GE followed by PP_{333} and SA, respectively. Increment of leaf number and total leaf area could be mainly attributed to an increase of the formed branches which, in turn, reflected upon increment of leaves dry weight. In addition, the assimilation rate, i.e., the leaf area in cm^2 required for producing one gram of dry matter, exhibited its significant reduction with all applied treatments. It means that the efficiency of photosynthesis was positively affected by the applied seed-soaking treatments. Also, increases of photosynthetic area and its activity lead to more photosynthates creation and finally could be reflected upon vigorous growth and productivity.

Regarding the enhancable effect of GE on faba bean growth, it might be due to its stimulatory effect on auxins, gibberellins and cytokinins biosynthesis (Wanas *et al.,* 1998), chlorophyll and carbohydrate formation and protein synthesis (El-Desouky *et al.,* 1998 and Seham, 2002), beside its content of amino acid, sugars, protein, vitamins and other growth factors (Watt and Merrill, 1963).

As for the reducable effect of PP_{333} on plant height, Grossman (1990) reported that growth retardants caused shortening in shoots by inhibiting cell division and elongation.

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The action of PP_{333} as a growth retardant has been attributed to its inhibition of GAs biosynthesis (Grossmann, 1990, and Bondok *et al.,* 1995). However, enhancement of branching as a result of PP_{333} application might be due to its stimulative effect on cytokinins biosynthesis that had know enhancable effect on branching (Abd El-Dayem and El-Deeb, 2000). Cytokinins have an important role in stimulating growth and development of lateral buds by increasing their sink capacity and promoting cell division and elongation (Chen, 1997).

With regard to the promotive effect of SA on faba bean growth, it might be due to its stimulatory effect on biosynthesis of the growth promotive hormones, i.e., gibberellins, auxins and cytokinins (Shehata *et al.*, 2000).

II-Photosynthetic pigments :

As shown in Table (2), the all applied seed-soaking treatments obviously increased photosynthetic pigments as chlorophyll a, b and carotenoids in the leaves of treated faba bean plants during the two seasons compared with those of untreated ones. Increases were mostly in parallel to the applied concentrations of GE , SA or PP_{333}. Besides, the highest increments in chlorophyll a, b as well as total determined pigments were obtained with PP_{333} followed by GE, *vice versa* in case of carotenoids. Meanwhile, SA ranked the last in all cases. In addition, the positive effect of such treatments on photosynthetic pigments may be attributed, in part, to the efficient plant growth and in another to their enhancable effect on the endogenous cytokinins level (findings of Wanas *et al.,* 1998 for GE, Abd El-Dayem and El-Deeb, 2000 for PP_{333} and Shehata *et al.*, 2002 for SA). Cytokinins have been established to induce the biosynthesis of chloroplast pigments in many plants (Fletcher and Arnold, 1986 and Bondok *et al.,* 1995).

Table (2) : Photosynthetic pigments concentrations (mg/g f.wt.) in faba bean leaves as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2004/05 and 2005/06 seasons.

Characters / Treatments		Chlorophylls a		Chlorophylls b		Carotenoids		Total determined pigments	
		$\bar{X}$	± %	$\bar{X}$	± %	$\bar{X}$	± %	$\bar{X}$	± %
		Season 2004/05							
Control		0.89	0.00	0.44	0.00	0.58	0.00	1.91	0.00
GE	100ml/l	0.95	+ 6.74	0.48	+9.09	0.66	+13.79	2.09	+9.42
	200ml/l	1.00	+12.36	0.54	+22.73	0.71	+22.41	2.25	+17.8
SA	100ppm	0.94	+5.62	0.45	+2.27	0.65	+12.07	2.04	+6.81
	200ppm	0.98	+10.11	0.49	+11.36	0.66	+13.79	2.13	+11.52
PP_{333}	10ppm	0.98	+10.11	0.52	+18.18	0.62	+6.90	2.12	+10.99
	20ppm	1.08	+21.35	0.58	+31.82	0.66	+13.79	2.32	+21.46
		Season 2005/06							
Control		0.78	0.00	0.39	0.00	0.49	0.00	1.66	0.00
GE	100ml/l	0.80	+2.56	0.44	+12.82	0.58	+18.37	1.82	+9.64
	200ml/l	0.91	+16.67	0.49	+25.64	0.61	+24.49	2.01	+21.08
SA	100ppm	0.80	+2.56	0.43	+10.26	0.55	+12.24	1.78	+7.22
	200ppm	0.88	+12.82	0.43	+10.26	0.59	+20.41	1.90	+14.46
PP_{333}	10ppm	0.92	+17.95	0.47	+20.51	0.53	+8.16	1.92	+15.66
	20ppm	0.94	+20.51	0.52	+28.21	0.58	+14.29	2.04	+22.89

± % = ± % relative to the control value

III-NPK and some bioconstituents in the leaves :

Data in Table (3) indicate that application of GE, SA and PP_{333} considerably increased the levels of N, P, K, crude protein, reducing, non-reducing and total sugars in the leaves of treated faba bean plants compared with those of untreated ones in both seasons. Again, the higher concentration used of GE, SA or PP_{333} was more effective than the lower one. In addition, GE caused the highest increments in case of NPK and crude protein followed by PP_{333}, *vice versa* in case of sugars ,meanwhile, SA ranked the last one in all cases. Here, the increases of photosynthetic pigments (Table, 2) and increment of the dry matter accumulation in the leaves (Table, 1) indicate the positive and stimulatory effects of these treatments upon the efficiency of photosynthesis process and more photosynthates being created as well as enhancement of mineral translocation from roots to leaves. These results and interpretation are in agreement with those of El-Desouky, *et al.* (1998) using GE on squash, Seham (2002) using SA on squash and Ahmed (2002) using PP_{333} on cotton.

VI-Anatomical features :

a) Stem anatomy :

The vascular collateral bundles of faba bean stems as seen in transverse sections are arranged in a complete cylinder. Two types of collaterals bundles are present, i.e., large and small bundles. The large bundles are separated by few small collateral bundles (Fig. 1a).

As shown in Table (4) and Fig. (1) GE , SA and PP_{333} applied as seed-soaking materials with the two assigned concentrations of each, obviously affected many anatomical features in stems of treated faba bean plants. In this respect, dimension of whole section was increased to reach 124.7 & 134.4%, 110.5 & 119.9% and 110.4 & 139.2 % of the control value (100%) with GE at100 & 200 ml/l , SA at100 & 200 ppm and PP_{333} at 10 & 20 ppm, respectively. Here. PP_{333} at 20 ppm was the most effective treatment followed by GE at 200 ml/l. The obtained data indicate that increment of stem dimension was mainly due to increases of hollow pith diameter and stem wall thickness. Since, e.g. the thickness of stem wall was increased from 100% of the control to reach 138.5 & 130.9%, 108.9 & 124.9% and 102.4 & 123.2% with GE at 100 &200 ml/l , SA at 100 & 200 ppm and PP_{333} at 10 & 20 ppm , respectively. Here garlic extract (GE) was most effective than the two growth regulators (SA & PP_{333}). In addition, increment of stem wall thickness was accompanied with an increase in most of its anatomical features, i.e., thickness of epidermis, cortex and parenchymatous pith, number of vascular bundles and dimensions (length and width) of the large vascular bundles compared with those of the control. Moreover, increasing length of the large vascular bundle was accompanied with an increase in thickness of phloem and xylem tissues and number of xylem vessels /cortical bundle as well. Increase values were in most cases in parallel to the applied concentrations of GE, SA or PP_{333} with the superiority of GE than the two growth regulators in this respect.

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Fig. (1) Transverse sections through the middle part of the 4th apical internode of the main stem of faba been as affected by GE, SA and PP_{333} applied as seed – soaking treatments (X24)

a) Control **b) Garlic extract (GE) at 200 ml/l**

c) Salicylic acid (SA) at 200ppm **d) Paclobutrazol (PP_{333}) at 20 ppm**

Abb : ep. = epidemis , cx. = cortex, pa. pi. = parenchymatous pith, p.f.= pericyclic fibers, ph. = phloem tissue, xy. = xylem tissue and s.w. = stem wall.

The increase in stem dimension due to GA, SA and PP_{333} at the two concentrations used may be attributed to the increase in cortex and parenchymatous pith thickness resulted from their action in cell division and enlargement. Barlow *et al.*, (1991) stated that the increase in stem diameter by uniconazol may be attributed to its effects on promotion of lateral cell division and enlargement. Furthermore, activation in cell division occurred in vascular cambium initial cells forming more xylem and phloem elements.

Herein, of interest to note that these positive responses of different anatomical aspects to GE, SA and PP_{333} treatments were completely reflected upon vegetative growth and productivity of treated plants. So, present study revealed those increase of xylem tissues, i.e., the route of mineral nutrients and water translocation from roots to leaves and the phloem tissue, i.e., the pathway of different assimilates from leaves to seed and other sinks. Thereby, improvement of translocation events directly may be considered a direct reason for increment the final seed yield.

b) Leaflet blade anatomy :

Data in Table (5) and Fig. (2) indicate that most of the studied anatomical features of faba bean leaflet blades were increased with the assigned treatments of GE, SA and PP_{333}. Among these anatomical features were the most important ones, i.e., thickness of midrib region, length and width of vascular bundle, thickness of phloem and xylem tissues and number of xylem vessels in the vascular bundle. Once again GE was the most effective compared with the two growth regulators (SA and PP_{333}) regarding the above mentioned characters.

On the other hand, all applied treatments obviously increased thickness of lamina. Also, increment of lamina thickness was accompanied with increases in the thickness of its comprising tissues, i.e., upper and lower epidermis, palisade and spongy tissues. Here, increase values were mostly in parallel to the applied concentrations of GE, SA or PP_{333}. Also, GE was the most effective treatment followed by PP_{333} , while SA ranked the last one in this concern.

In general, these positive alterations in stem and leaf anatomy of faba bean plants treated with GE, SA and PP_{333} as seed-soaking application led to vigorous growth (Table, 1) causing induction of flowering and fruit setting of treated plants (Table, 6). That as will mentioned afterwards reflected upon significant increases in the final seed yield. Similar results have been reported about yield increases through doing alternations in the anatomical features of some economical plants as affected by natural extracts (Wanas *et al.,* 1998 and Wanas, 2002b). and PP_{333} (Ahmed, 2002 and Hyam, 2006).

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Fig. (2) Transverse sections through the leaflet blade of the 4th apical leaf on the main stem of faba been as affected by GE, SA and PP_{333} applied as seed – soaking treatments (X60)

a) Control **b) Garlic Extract (GE) at 200 ml/l**

c) Salicylic acid (SA) at 200ppm **d)Paclobutrazol (PP_{333}) at 20 ppm**

Abb : up. ep. = upper epidemis , l. ep. = lower epidemis, pa. = palisade tissue, sp.= spongy tissue, ph. = phloem tissue, xy. = xylem tissue and v.b. = vascular bundle.

V-Reproductive growth:

V-1) Flower formation and shedding :

Data in Table (6) indicate that different applied seed-soaking treatments (GE, SA, and PP_{333} at the two assigned concentrations of each) caused a significant increase in the number of flowers/plant and a significant reduction in the percentage of shedded flowers compared with the control during the two growing seasons. Here, GE was the most effective in this respect followed by PP_{333} and SA respectively.

Table (6) : Flowering as well as yield and its characteristics of faba bean plant as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2004/05 and 2005/06 seasons

Characters / Treatments		No. of flowers /plant	% of flower shedding	No. of setted pods / plant	% of pod shedding	No. of mature pods / plant	No. of seeds/ plant	Seed index (g)	Seed yield (g)/ plant	Relative seed yield (%)
		Season 2004/05								
Control		109.20	74.91	27.40	39.42	16.60	58.20	58.20	33.87	100.00
GE	100ml/l	126.40	71.04	36.60	36.07	23.40	67.80	66.40	45.02	132.92
	200ml/l	134.40	69.79	40.60	35.47	26.20	73.40	67.16	49.30	145.56
SA	100ppm	118.20	71.57	33.60	36.90	21.20	64.60	62.47	40.36	119.16
	200ppm	128.20	71.76	36.20	36.46	23.00	70.60	64.63	45.63	134.72
PP_{333}	10ppm	120.20	70.55	35.40	35.59	22.80	63.80	66.90	42.68	126.01
	20ppm	130.60	69.83	39.40	36.55	25.00	67.20	70.09	47.10	139.06
LSD	0.05	6.11	2.34	2.92	1.76	2.21	3.61	2.03	4.11	-
		Season 2005/06								
Control		94.60	72.73	25.80	37.21	16.20	54.60	59.40	32.43	100.00
GE	100ml/l	113.00	69.73	34.20	33.92	22.60	62.60	67.69	42.37	130.65
	200ml/l	120.40	68.60	37.80	33.86	25.00	66.40	67.87	45.07	138.98
SA	100ppm	103.40	70.60	30.40	34.21	20.00	61.80	64.12	39.62	122.17
	200ppm	116.20	70.40	34.40	34.88	22.40	66.20	66.16	43.80	135.06
PP_{333}	10ppm	110.40	69.38	33.80	34.32	22.20	59.40	67.96	40.37	124.48
	20ppm	118.20	68.87	36.80	34.24	24.20	64.80	68.52	44.40	136.91
LSD	0.05	5.16	1.86	2.24	1.57	1.75	2.94	2.36	3.28	-

V-2) Pod yield:

As shown in Table (6) application of GE, SA and PP_{333} significantly increased the number of setted pods/plant, whereas significantly reduced the percentage of shedded ones in proportional to the applied concentrations of each. So, in the two assigned seasons, number of mature pods, i.e., the yielded pods were also significantly increased with all applied treatments. Again, GE was the most pronounced in this respect comparing with the two growth regulators, i.e.,PP_{333} and SA, respectively.

In addition, significant increases were obtained dominantly in the number of seeds/plant, total seed yield/plant and the calculated relative seed yield as affected by the applied treatments. Here, it could be noticed that the highest increases of total seed yield/plant relative to the control yield (100%)

were obtained with GE at 200 ml/l (45.56 & 38.98%) followed by PP_{333} at 20 ppm (39.06 & 36.91%) then SA at 200 ppm (34.72 & 35.06%) during 2004/05 & 2005/06 seasons, respectively. Moreover, seed index, i.e., weight of hundred seeds was also positively responded. Since, its significant increase proportionally existed with the two applied concentrations of GE , SA and PP_{333} .

Here, it could be concluded that reduction in shedding percentages of flowers and pods, in turn enhancement of pod setting and development obtained with GE, SA and PP_{333} treatments may be due to the enhancable effect of such treatments on total sugars, total protein and mineral concentrations in leaves (Table, 3) as well as their stimulatory effect on the increment of endogenous growth promotors (findings of Wanas, *et al.,* 1998 with GE, Abd El-Dayem and El-Deeb, 2000 with PP_{333} and Shehata, 2000 with SA). Auxins and other growth promoters has been shown to effectively retard the process of abscission by prevent structural weackening of the abscission zone. However, once weakening of this specialized layer of cells has begun, auxins and other endogenous growth promotors can effectively block the action of ethylene as well as they can retard the development of senescence in the pulvinal cells on the distal side of the abscission zone in faba bean plant. In addition, auxin prevents synthesis of cellulase seem to be in line with the known action of auxin as an abscission inhibitors (Kozlowski, 1979 and Sakr, 1980). Besides, cytokinins have a direct role in stimulating nutrient mobilization and auxin production (Oosterhuis and Janes, 1997). Hence, all of these advantages positively could reflect on flower initiation, flower development and fruit set and growth as well as inhibiting flowers and young pods shedding and hence increasing the final seed yield.

IV-NPK and some bioconstituents in the seeds:

As shown in Table (7) different applied seed-soaking treatments obviously increased NPK, crude protein, total sugars and total carbohydrate concentrations in seeds of treated faba bean plants compared with those of untreated ones. Increases were also in proportional to the applied concentration of GE, SA or PP_{333}. In addition, GE at 200 ml/l was the most effective either when compared with its lower one or with the two concentrations of SA & PP_{333} regarding different estimated constituents.

In general, the applied seed-soaking treatments improved seed yield of faba bean plants (Table, 6) due to increment of flower formation and the reduction of flowers and pods shedding as well as increasing their ability to accumulate more bioconstituents and NPK (Table, 7). These positive effects of GE, SA and PP_{333} treatments upon seed yield and its characters could be considered as a reversion of their effects on the early vigorous growth of faba bean plants, specially that obvious increase in total leaf area (Table, 1) and photosynthetic pigments (Table, 2) and their reflection on increasing the net photosynthesis per unit of leaf area (effects at the source) and increasing the seed weights (Table, 6).

The present study strongly admit the use of GE at 200 ml/l, SA at 200 ppm and PP_{333} at 20 ppm as soaking treatments with faba bean seeds for getting the highest seed yield with good quality.

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استجابة نباتات الفول لمعاملة البذور بمستخلص الثوم وحمض السلسيليك والباكلوبيوترازول

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أدى استخدام مستخلص الثوم بتركيزى ١٠٠ ، ٢٠٠ ملى/لتر وحمض السلسيليك بتركيزى ١٠٠ ، ٢٠٠ جزء فى المليون والباكلوبيوترازول بتركيزى ١٠ ، ٢٠ جزء فى المليـون كمعـاملات نقـع لبـذور الفـول قبـل الزراعـة فـى موسـمى ٢٠٠٤/٢٠٠٥ ، ٢٠٠٥/٢٠٠٦ إلى زيادة معنوية فى العديد من قياسات النمو الخضرى مثل ارتفاع النبات – عدد الأفرع – عدد الأوراق – الوزن الجاف لكل من السوق والأوراق وكذلك مساحة الأوراق الكلية/نبات. باستثناء النقص المعنوى فى ارتفاع النبات والذى ظهر فقط مع الباكلوبيوترازول بتركيزيه (١٠ ، ٢٠ جزء فى المليون) ، بجانب ذلك فقد أدت جميع المعاملات المستخدمة إلى زيادة واضحة فى تركيز صبغات التمثيل الضوئى - النيتروجين والفسفور والبوتاسيوم – البروتين الخام – السكريات الكلية بأوراق النباتات المعاملة بعد ٩٠ يوم من الزراعة ، بالإضافة إلى ذلك فقد سببت معاملات نقع البذور المستخدمة تغيرات ايجابيةفى العديد من الصفات التشريحية للسوق والأوراق. حيث سببت جميع المعاملات المستخدمة زيادة سمك جدار الساق ومكوناته النسيجيه (البشر – القشرة – النخاع البرانشيمى) وكذلك زيادة فى سمك منطقة العرق الوسطى والنصل وكل من البشره العليا والبشرة السفلى والنسيج العمادى والنسيج الاسفنجى فانصال الأوراق. كما زادت أيضا ابعاد الحزم الوعائية وسمك نسيجى اللحاء والخشب وكذلك عدد الاوعية الخشبية/حزمة وعائية فى سوق وأوراق النباتات المعاملة. علاوة على ذلك ، ومع حلول مرحلة الازهار سببت جميع المعاملات المستخدمة كمواد نقع للبذور زيادة فى عدد الأزهار وعدد القرون المتكونة/نبات فى حين سببت نقص فى النسبة المئوية لتساقط الأزهار والثمار وبالتالى أدت إلى زيادة فى عدد الثمار الناضجة (المتبقية)/نبات وكذلك محصول البذور النهائى/نبات.

وقد ظهرت أعلى قيم لمحصول البذور مع معاملة مستخلص الثوم بتركيز ٢٠٠ ملى/لتر يليها الباكلوبيوترازول بتركيز ٢٠ جزء فى المليون ثم حمض السلسيليك بتركيز ٢٠٠ جزء من المليون . فضلا عن ذلك ، فقد زاد تركيز عناصر النيتروجين والفسفور والبوتاسيوم والبروتين الخام و السكريات والكربوهيدرات الكلية فى البذور نتيجة لتأثرها بالمعاملات المستخدمة.

وبناء على ذلك يمكن التوصية باستخدام مستخلص الثوم وحمض السلسيليك وكذلك الباكلوبيوترازول كمعاملات نقع لبذور الفول بهدف تحسين النمو وتقليل تساقط الأزهار والثمار مما يؤدى الى زيادة محصول البذور النهائى فى هذا النبات الاقتصادى.

Table (1): Growth behaviour of faba bean plants as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2004/05 and 2005/06 seasons

Characters / Treatments		Days after sowing													
		75							105						
		Plant height (cm)	No. of branches/plant	Stems dry weight(g)/plant	No. of leaves/ plant	Leaves dry weight(g)/plant	Total leaf area (cm^2)/plant	*A.R. $(cm)^2/g$	Plant height (cm)	No. of branches/ plant	Stems dry weight(g)/plant	No. of leaves/ plant	Leaves dry weight(g)/plant	Total leaf area $(cm)^2$/ plant	*A.R. cm^2/g
		Season 2004/05													
Control		74.80	2.00	7.16	35.20	8.24	1766.24	214.35	105.20	2.20	20.91	56.20	16.50	4017.37	243.48
GE	100ml/l	80.00	2.40	9.75	45.60	11.47	2283.19	199.06	113.40	3.00	26.28	71.00	23.74	4894.89	206.18
	200ml/l	83.80	3.40	11.48	52.80	13.20	2450.24	185.62	115.40	3.40	29.82	75.20	25.68	5116.99	195.45
SA	100ppm	81.20	2.00	9.58	40.60	9.88	2100.81	212.63	113.80	2.40	24.38	62.80	19.68	4412.25	224.20
	200ppm	87.80	2.40	11.26	44.20	11.17	2288.97	204.27	118.00	2.80	28.46	69.80	21.38	4748.95	222.10
PP_{333}	10ppm	65.20	2.40	7.95	38.40	9.76	2007.92	205.73	91.60	2.80	24.18	67.80	20.36	4476.96	219.39
	20ppm	59.40	3.80	8.25	48.00	10.34	2089.96	202.12	86.40	3.60	28.89	78.20	24.90	5093.62	204.06
LSD	0.05	4.12	0.31	0.62	2.21	0.98	76.30	4.66	5.37	0.56	1.83	3.16	2.51	94.21	6.36
		Season 2005/06													
Control		68.00	1.80	6.79	32.80	7.69	1620.01	210.66	95.80	2.00	18.82	52.00	15.01	3786.45	252.26
GE	100ml/l	75.40	2.20	8.44	41.40	10.38	2084.29	200.80	106.20	3.00	24.14	67.20	22.14	4703.35	212.44
	200ml/l	79.80	3.00	10.50	46.40	11.79	2314.43	196.30	109.00	3.00	28.42	71.60	23.58	4890.10	207.38
SA	100ppm	77.60	2.00	9.28	38.20	9.52	1970.36	206.97	102.30	2.00	22.40	56.60	17.44	4110.55	235.70
	200ppm	80.40	2.20	10.66	42.80	10.80	2209.55	204.59	108.20	2.60	27.31	63.60	19.78	4540.54	229.55
PP_{333}	10ppm	60.40	2.80	8.52	44.20	10.20	2063.81	202.33	84.40	3.00	26.28	71.60	21.92	4659.34	212.56
	20ppm	56.00	3.20	8.06	43.60	9.72	1958.32	201.97	81.80	3.40	27.72	75.00	22.72	4772.52	210.06
LSD	0.05	4.85	0.26	0.76	2.14	0.81	68.00	3.81	6.67	0.49	2.05	2.98	2.18	78.18	7.68

*** A.R.= Assimilation rate**

Table (3) :NPK and some bioconstituent concentrations (mg/g d.wt.) in faba bean leaves as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2004/05 and 2005/06 seasons

Determinations / Treatments		N	P	K	N + P + K		Crude Protein		Reducing sugars	Non-reducing sugars	Total sugars	
					$\overline{x}$	± %	$\overline{x}$	± %			$\overline{x}$	± %
Season 2004/05												
Control		28.30	2.24	31.28	61.82	0.00	176.88	0.00	3.62	21.03	24.65	0.00
GE	100ml/l	30.92	2.73	35.58	69.23	+11.99	193.25	+9.25	4.30	27.30	31.60	+28.19
	200ml/l	34.36	3.08	40.15	77.59	+25.51	214.75	+21.41	5.57	32.73	38.30	+55.38
SA	100ppm	29.98	2.75	34.83	67.56	+9.29	187.38	+5.94	4.12	27.18	31.30	+26.98
	200ppm	31.64	2.92	37.34	71.90	+17.33	197.75	+11.80	5.30	29.70	35.00	+41.99
PP_{333}	10ppm	31.18	2.68	34.34	68.20	+10.32	194.88	+10.18	4.67	28.33	33.00	+33.87
	20ppm	34.22	3.02	39.32	76.56	+23.84	213.88	+20.92	5.63	33.73	39.36	+59.68
Season 2005/06												
Control		27.63	2.38	30.73	60.74	0.00	172.69	0.00	3.56	20.20	23.76	0.00
GE	100ml/l	30.32	2.84	34.27	67.43	+11.01	189.50	+9.73	4.12	26.58	30.70	+29.21
	200ml/l	33.98	3.02	38.92	75.92	+24.99	212.38	+22.98	5.23	31.25	36.48	+53.54
SA	100ppm	29.16	2.64	32.83	64.63	+6.40	182.25	+5.54	4.26	25.74	30.00	+26.26
	200ppm	31.25	2.88	36.38	70.51	+16.08	195.31	+13.10	4.53	28.75	33.28	+40.07
PP_{333}	10ppm	31.74	2.70	35.26	69.70	+14.75	198.38	+14.88	4.30	27.80	32.10	+35.10
	20ppm	33.68	2.88	36.77	73.33	+20.73	210.50	+21.89	5.46	32.20	37.66	+58.50

± % = ± % relative to the control value

Table (4): Anatomical features of faba bean stems as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2005/06 season

Treatments		Counts and measurements (µ)	Dimension of whole section	Diameter of hollow pith	Thick.. of stem wall	Thick. of epidermis	Thick. of cortex	Thick. of parrenchymatous pith	No. of vascular bundles	Length of Large bundle	Width of large bundle	Thick. of phloem tissue	Thick .of xylem tissue	No. of Xylem vessels /cortical bundle	Thick. of pericyclic fibers
*Control		X	5208.8	2552.0	1328.4	55.8	452.7	819.90	29.0	441.9	466.2	65.7	376.2	50.3	297.9
GE	100ml/l	X	6496.7	2818.3	1839.2	59.4	558.5	1221.3	32.0	553.5	539.1	94.5	459.0	67.3	425.7
		%	124.7	110.4	138.5	106.5	123.4	149.0	110.3	125.3	115.6	143.8	122.0	133.8	142.9
	200ppm	X	6998.7	3422.2	1739.2	61.2	540.9	1186.2	32.5	626.4	644.4	103.5	540.9	70.5	387.0
		%	134.4	134.1	130.9	109.7	119.5	144.7	112.1	141.8	138.2	157.5	143.8	140.2	129.9
SA	100ml/l	X	5756.5	2862.1	1447.2	57.6	469.8	919.8	32.0	575.1	609.3	81.0	494.1	58.0	326.8
		%	110.5	112.2	108.9	103.2	103.8	112.2	110.3	130.1	130.7	119.6	131.3	115.3	109.7
	200ml/l	X	6245.0	2925.8	1659.6	55.8	488.7	1115.1	29.8	594.4	567.0	81.9	512.5	63.3	358.2
		%	119.9	114.6	124.9	100.0	108.0	136.00	102.8	134.5	121.6	124.7	136.2	125.8	120.2
	10ppm	X	5748.8	3027.2	1360.8	63.0	468.0	829.8	30.5	470.7	541.8	81.0	389.7	55.8	327.6
		%	110.4	118.6	102.4	112.9	103.4	101.2	105.2	106.5	116.2	119.6	103.6	110.9	110.0
PP_{333}	20ppm	X	7251.5	3978.9	1636.3	64.8	595.8	975.7	32.5	597.7	715.5	90.0	507.7	65.5	458.1
		%	139.2	155.9	123.2	116.1	131.6	119.0	112.1	135.3	153.5	137.0	135.0	130.2	153.8

***Control values are considered as 100 %**

$$\text{Stem wall} = \frac{\text{Stem dimension} - \text{hollow pith}}{2}$$

Table (5) : Anatomical features of faba bean leaf blades as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2005/06 season

Treatments / Counts and measurements (μ)			Thick. of midrib	length. of main vascular bundle	Width of main vascular bundle	Thick. of phloem tissue	Thick .of xylem tissue	No. of xylem vessels/main v. bundle	Thick .of lamina	Thick. of upper epidermis	Thick. of lower epidermis	Thick .of palisade tissue	Thick. of spongy tissue
*Control		X	999.9	272.7	183.6	55.8	216.9	23.5	312.3	36.0	30.6	90.0	155.7
GE	100ml/l	X	1278.9	330.0	272.7	63.0	267.0	32.5	381.6	38.7	33.3	102.6	207.0
		%	127.9	121.0	149.2	112.9	123.1	138.3	122.2	107.5	108.8	114.0	132.9
	200ppm	X	1174.5	363.6	280.8	71.1	292.5	35.8	405.9	42.3	34.2	1087	218.7
		%	117.5	133.3	152.9	127.4	134.9	152.3	130.0	117.5	111.8	120.7	140.5
SA	100ml/l	X	1118.7	318.6	288.0	57.6	261.0	30.3	361.0	38.7	33.3	104.4	185.4
		%	111.9	116.8	156.9	103.2	120.3	128.9	115.9	107.5	108.8	116.0	119.1
	200ml/l	X	1155.6	352.8	286.2	61.2	291.6	31.8	397.8	41.4	34.2	117.0	205.2
		%	115.6	129.4	155.9	109.7	134.4	135.3	127.4	115.0	111.8	130.0	131.8
	10ppm	X	1056.6	359.1	275.4	58.5	300.6	27.8	343.8	36.9	30.6	95.4	180.9
		%	105.7	131.7	150.0	104.8	138.6	118.3	110.1	102.5	100.0	106.0	116.2
PP_{333}	20ppm	X	1135.8	362.7	277.2	61.2	301.5	28.5	405.0	41.4	34.2	106.2	223.2
		%	113.6	133.0	151.0	109.7	139.0	121.3	129.7	115.0	111.8	118.0	143.4

***Control values are considered as 100 %**

Table (7): NPK and some bioconstituent contents (mg/g d.w.) in faba bean seeds as affected by garlic extract (GE), salicylic acid (SA) and paclobutrazol (PP_{333}) applied as seed-soaking treatments during 2004/05 and 2005/06 seasons

Determination / Treatments		N	P	K	N + P + K		Crude Protein		Reducing sugars	Non-reducing sugars	Total sugars		Total carbohydrates	
					$\overline{x}$	± %	$\overline{x}$	± %			$\overline{x}$	± %	$\overline{x}$	± %
Season 2004/05														
Control		41.12	2.96	43.45	87.53	0.00	257.00	0.00	13.38	34.94	48.32	0.00	456.40	0.00
GE	100ml/l	44.26	3.24	48.37	95.87	+9.53	276.63	+7.64	14.34	38.18	52.52	+8.69	485.30	+6.33
	200ml/l	46.14	3.98	51.75	101.87	+16.38	288.38	+12.21	15.87	43.73	59.60	+23.34	496.95	+8.89
SA	100ppm	43.58	3.16	44.17	90.91	+3.86	272.38	+5.98	13.92	37.68	51.60	+6.79	476.45	+4.39
	200ppm	45.26	3.70	44.55	93.51	+6.83	282.88	+10.07	15.08	42.14	57.22	+18.42	494.65	+8.38
PP_{333}	10ppm	44.56	3.30	47.82	95.68	+9.31	278.50	+8.37	14.22	41.38	55.60	+15.07	487.90	+6.90
	20ppm	46.82	3.76	49.34	99.92	+14.16	292.63	+13.86	15.96	45.26	61.22	+26.70	503.35	+10.28
Season 2005/06														
Control		39.64	2.85	42.10	84.59	0.00	247.75	0.00	12.25	34.23	46.48	0.00	448.65	0.00
GE	100ml/l	41.18	3.35	47.14	91.67	+8.37	257.38	+3.89	13.50	39.35	52.85	+13.70	473.90	+5.63
	200ml/l	44.96	4.22	49.72	98.90	+16.92	281.00	+13.42	15.16	42.12	57.28	+23.24	501.80	+11.85
SA	100ppm	41.62	3.05	43.62	88.29	+4.37	260.13	+5.00	12.40	36.15	48.55	+4.45	463.85	+3.39
	200ppm	43.84	3.54	44.86	91.60	+8.29	274.00	+10.60	13.68	40.12	53.70	+15.53	490.45	+9.32
PP_{333}	10ppm	43.18	3.18	44.58	90.94	+7.51	269.88	+8.93	13.64	40.50	54.14	+16.48	481.20	+7.26
	20ppm	46.22	3.96	47.85	98.03	+15.89	288.88	+16.60	15.84	43.62	59.46	+27.93	505.20	+12.60

± % = ± % relative to the control value