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IMPROVING GROWTH, YIELD QUALITY AND CHEMICAL CONSTITUENTS OF SESAME PLANTS BY FOLIAR APPLICATION OF ASCORBIC ACID, BENZYL ADENINE AND PACLOBUTRAZOL

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Abstract

The effect of ascorbic acid (50 and 100 ppm), benzyl adenine (50 and 100 ppm) and paclobutrazol (25 and 50 ppm) foliar application on growth, yield and some physiological parameters of sesame (*Sesamum indicum* var. Shandawil 3) plants were determined. All treatments caused a great improvement in growth parameters (shoot height, root lengths and number of leaves as well as fresh and dry weights of shoots and roots) of the developed plants. Paclobutrazol was more effective than other treatments in enhancing chlorophyll contents and carotenoid content. The results also showed that nearly all of the treatments tended to increase total soluble carbohydrates and protein contents in sesame plants. The changes in proteolytic, amylolytic and lipolytic activities were also recorded. This was associated by improving yield quality and the nutritional value of the seeds. The effect of paclobutrazol was superior to that of ascorbic acid, benzyl adenine on increasing yield components. The percentage of the highest lipid was recorded by 50 ppm of ascorbic acid, whereas the highest carbohydrates and proteins of the yielded seeds were observed with plants treated with 100 ppm benzyl adenine.

Introduction

Sesame (*Sesamum indicum* L.) is one of the most ancient oilseed crops used by man and is cultivated extensively from tropical to temperate regions of the world (Weiss 1971). Sesame is one of the most important oilseed crops worldwide, uses as a traditional health food. Sesame seeds are used in the making of tahini (sesame butter) and halva, and for the preparation of rolls, crackers, cakes and pastry products in commercial bakeries (Nzikou *et al*. 2009). Shalaby *et al*. (2005) clearly indicated that plant growth retardants significantly affected growth parameters of sesame plants (*Sesamum indicum*). It could be seen that foliar application with 20 mg/L uniconazole caused significant stimulatory effect on plant height, number of branches, leaves and capsules/plant, dry weight of stem + branches, leaves and capsules/plant compared with control. Also, revealed that treatment with uniconazole (20 and 30 mg/L.) to sesame plants caused significant effect on sesame leaves photosynthetic pigments content. Foliar application with 20 mg/L. uniconazole caused significant stimulatory effect on photosynthetic pigment contents compared with control and 30 mg/L. uniconazole. Growth regulators and vitamins are known to affect plant growth through primary and secondary metabolism (Ewais *et al*. 2003 and Reda *et al.* 2007). Rafique *et al*. (2011) showed the best results on seedling growth, fresh and dry matter production of pumpkin seedlings due to 30 mg L^{-1} ascorbic acid treatments. Seedlings fresh weight, protein contents, protease and nitrate reductase activities were significantly affected by 30 mg L^{-1} ascorbic acid. Moreover, Mazher*et al*. (2011) found stimulatory effect of ascorbic acid (100 and 200 ppm) on all growth parameters (plant height, number of branches, number of leaves, stem diameter, root length as well as fresh and dry weights of all plant organs) of *Codiaeum variegatum* L.

Several researchers, mentioned that benzyl adenine (BA) improve vegetative growth and yield quality, such as Mazrou (1992) on datura, Menesi *et al*. (1994) on *Tagetes erecta*, *Zinna elegans* and *Celusia argentia*, Farahat *et al*. (2002) on fennels, Vijay and Laxmi (2001) on mungbean, El-Abagy *et al*. (2003) on faba bean. El-Maadawy *et al*. (2006) indicated that treating pot marigold plants with BA at 100 ppm gave the highest number of inflorescences, which was significantly higher than the control in both seasons. Different benzyl adenine concentrations significantly increased inflorescence diameter, compared to control. Spraying plants with BA had also generally favorable effect on fresh and dry weight of inflorescences as compared to unsprayed plants. Other investigators; Zedan (2000) working on Coriander and Zhang *et al*. (2006) working on soybean observed that paclobutrazol treatments caused significant reductions in plant height, internodes length, leaf length and leaf area/plant, while dry weight per plant was increased.

Therefore, the aim of this study was auggested to increase *Sesamum indicum* productivity and promote beneficial effects on growth by the application of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac).

Materials and Methods

Seeds of sesame "*Sesamum indicum*" (Shandawil 3) was obtained from Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt. Uniform sesame seeds were planted in natural loamy soil conditions in Botanical garden, Botany and Microbiology Dept., Fac. of Sci., Al- Azhar Univ., Nasr City, Cairo, Egypt, in a plot (4 m width and 15 m. length) containing 7 groups representing the following treatments: Ascorbic acid at 50 ppm and 100 ppm were applied to the 2nd and 3rd groups, respectively; benzyl adenine at 50ppm and 100ppm were applied to the 4th and 5th groups, respectively. The 6th and 7th groups were treated with paclobutrazol at 25 and 50ppm, respectively. The first group was left aside untreated serving as control. The seeds were sown on one side of the ridge, with 20 cm apart between the hills. The developed plants were irrigated whenever required. Concentrations of the used plant growth regulators and vitamin C were chosen according to a preliminary experiment in which they caused a maximum germination percentage. The plants were sprayed twice with the above mentioned treatments, the first and second was added at 33 and 65 days of plant age respectively. The plant samples were collected for analysis when the plants were 40 (Stage I) and 72 (Stage II) days old. At the end of the growth season, analysis of the seeds yielded from the different treatments and the control were done. Chlorophylls contents of were estimated using the method of Vernon and Selly (1966). Carotenoids contents of were estimated according to Lichtentahler (1981). soluble carbohydrates were measured according to the method of Umbriet *et al.* (1969). Contents of soluble proteins were estimated according to the methods of lowery *et al*. (1951). Activities of amylases were determined using the method of Afifi *et al*. (1986). Proteases activities were estimated using the method of Ong and Guacher (1972). Lipase activities were determined by method of Elwan *et al*. (1976).Total lipids were determined by using a soxhlet apparatus according to Guenther (1972). Statistical analysis of the obtained results were done using (L.S.D.) according to Snedecor and Cochran (1982).

Results and Discussion

1. *Growth parameters*

The obtained results (Tables 1) revealed that application of ascorbic acid or benzyl adenine at 50 and 100 ppm and paclobutrazol at 25 and 50 ppm showed significant improvement effects on growth parameters of sesame plants in most cases. These effects were clear with the resulted induced increases in shoot heights and root lengths and number of leaves/plant. Benzyl adenine was more effective than other treatments in enhancing shoot lengths during the two stages. These findings are in accordance with Ibrahim *et al*. (2010) who found that foliar application of benzyl adenine (BA) at (50, 100 and 150 ppm) were significantly affected on croton plant height and number of branches. This may be as a result of its role in the regulation of many aspects of growth and differentiation including cell division, apical dominance, nutrient mobilization, chloroplast development, senescence and flowering (Binns 1994, and Hare *et al*. 1997).

Moreover, paclobutrazol was most effective in enhancing root lengths and number of leaves during stage I. These results are in harmony with those reported by Chaturvedi *et al*. (2009) who found significant increment in root length of *Saussurea costus* (Falc) seedlings at treatment with 25, 50, 100 ppm of paclobutrazol.

The obtained results (Tables 2) revealed that application of ascorbic acid at 50 or benzyl adenine at 50 and 100 ppm and paclobutrazol at 25 and 50 ppm created significant increases in fresh and dry weight of shoots and roots of sesame plants. These findings are in accordance with Ewais (2003) who reported that application of ascorbic acid improved growth and yield characteristics of broad bean plants. Recently, Rafique *et al*. (2011) found that the best results on seedling growth, fresh and dry matter production of pumpkin seedlings resulted by 30 mg L^{-1} ascorbic acid treatments. With respect to benzyl adenine, many investigators obtained similar positive effects on the growth of other plants such as mungbean (Vijay and Laxmi 2001); faba bean (El-Abagy *et al*. 2003) marigold (El-Maadawy *et al*. 2006a). Also, Ibrahim *et al*. (2010) found that foliar application of benzyl adenine (BA) at 50, 100 and 150 ppm were significantly affected on croton plant height, number of branches and leaves/plant, root length, leaf area and fresh and dry weights of stem, leaves and roots.

2- Photosynthetic Pigments:

The contents of chlorophyll a; b; total chlorophyll (a+ b) and carotenoids of sesame plants (Table 3) showed, consistent and gradual decreases in response to various treatments applied of Asc and BA at all doses. The obtained results agree with those observed by a number of investigators for example, El-Maadawy *et al*. (2006) who observed that the lowest BA concentration (50 ppm) caused a decrease in the total chlorophyll content of *Calendula afficinalis* L. plants compared with that of untreated plants. On the contrary, the obtained results showed that Paclobutrazol at 25 ppm was more effective than other treatments in enhancing chlorophyll contents and carotenoid content at stage II while, at stage I it was found that Paclobutrazol at 50 ppm was more effective. The obtained results agree with those observed by Hamza *et al*. 2007 who recorded that treating plants of *Pelargonium zonale* with paclobutrazol significantly increased the total chlorophyll content when compared with the untreated control plants.

3- . Soluble Carbohydrates:

Results of the present work (Table 4) revealed that total soluble carbohydrates contents of sesame plants were tended to increase, with some exceptions, in response to the treatment with ascorbic acid, benzyl adenine and paclobutrazol at all doses. In agreement with these results a number of investigators observed stimulating effect regarding the effect of ascorbic acid (Abdel Aziz *et al*. 2006; Farahat *et al*. 2007and Eid *et al*. 2010), benzyl adenine (Youssef 2004a) or paclobutrazol (Amin 2007 and Hamza *et al*. 2007) on carbohydrate contents. On the other hand, Elgayar (2004) revealed that treatment of soybean with benzyl adenine (25 and 50 ppm) resulted in slight effects on carbohydrate. On the contrary, El-

Abagy *et al*. (2003) found that spraying faba bean plants with benzyl adenine (25 and 50 ppm) decreased carbohydrate percentage content.

4- Soluble Proteins:

In the present study, it was found (Table 5) that protein contents in roots and fruits of sesame plants, mostly, were significantly decreased in response to all doses applied of ascorbic acid, benzyl adenine and paclobutrazol. On the contrary El-Abagy *et al*. (2003) cleared that spraying faba bean plants with benzyl adenine significantly increased crude protein content.

On the other hand, application of 50 ppm Asc at both stages I& II; 100 ppm Asc during first stage and 50 or 100 ppm benzyl adenine during two stage and 50 ppm paclobutrazol at stage I caused significant increases in soluble protein contents of sesame shoot. These obtained results are in harmony with those reported by Abdel-Halim (1995) who observed that ascorbic acid increased protein content of wheat grains; El-Abagy *et al*. (2003) who found that spraying faba bean plants with benzyl adenine significantly increased crude protein content and Wanas (2007) indicated that application of paclobutrazol considerably increased the levels of crude protein in leaves of treated faba bean plants compared with those of untreated ones.

5- Enzymes Activities:

The obtained data (Table 6) indicated that both applied doses of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac), significant increased the activities of proteases at stage I of plant growth. The same results appeared at stage II with only Asc. The most proteases activities were recorded by Pac at 25 ppm (stage I), Asc 100 ppm at stage II. The stimulating effect of ascorbic acid on protease activity, obtained in the present study, are harmony with those observed by Rafique *et al*.(2011) who found that protease activity was higher in pumpkin seedling from seeds treated with $15 mgL^{-1}$Asc.

Concerning the activities of amylases, results in table (6) indicated that foliar application of Asc, BA and Pac caused, with one exception case, significant increases at stage II. In this respect, Husein (1993) showed that the activities of amylases in Datura plants were significantly increased as a result of treatments with benzyl adenine. The exceptional case was represented by significant decreased in the activity of amylase at stage II in response to BA at 100 ppm.

Results in table (6) also, indicated that foliar application of Asc, BA and Pac resulted, with two exception cases, significantly increased (at stage I). The exceptional cases were represented by significant decreases in proteases at stage I in responses to 50 ppm of Asc and Pac at 50 ppm. In this regard, Prusakova *et al*. (2004) reported a similar view that the growth retarding activity of triazole compounds such as paclobutrazol appears in the inhibition of amylase activity in barley (*Hordium vulgare* L.).

It was also observed (Table 6) that 100 ppm of BA at both stages of growth and 50 and 100 ppm of Asc at stage II caused significant increases in the lipolitic activities of sesame plants. In this regard, Dowiadar *et al.* (1996) working on *Raphanus sativus* plants, reported that the increase in the activity of all hydrolytic enzyme and β amylases were run parallel to the increase in soluble sugars. In the contrary, the obtained results showed that BA and Pac at 50 ppm during stages I& II; 50 and 100 ppm Asc at stage I and 25 ppm Pac at stage II caused significant decreases of these activities.

6- Yield components and nutritional value of the yielded seeds:

Results recorded in table (7) indicated that foliar application of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac) caused significant increases in yield components of sesame plants. The highest value of all yield were obtained with the plants that treated with Pac (50 ppm). The sequence of increase in number and weight of fruits/plant and weight of 1000 seeds was as follows Pac > BA >Asc. The increments of weight of 1000 seeds estimated by 36.71%, 20.57% and 17.41% in response to treating with Pac, BA and Asc, respectively compared with the control plants. Paclobutrazol showed better stimulation on yield components than other treatments. In this connection, Nassar *et al*. (2001) working on sweet paper, mentioned that Pac application at 10–30 ppm reduced plant height and increased number of flowers/plant, Abdul Galeel *et al*. (2007) reported that the application of Pac on *Catharanthus roseus* had significant effects on photosynthetic and anatomical responses thus can be used for improving productivity in medicinal plants. Moreover, Lolaei *et al.* (2012) reported that the highest leaf number, leaf area, petiole length, and total soluble solid percent were observed in control plants, while highest fruit number, fruit weight, fruit set, flower number and yield of strawberry were obtained in plants treated with 90 mg L^{-1} Pac. They also mentioned that foliar application of Pac prior to flowering is recommended to increase the yield of strawberry.

The obtained results (Table 8) showed that Asc, BA and Pac significantly increased carbohydrates contents and total lipids of the yielded seeds for most cases.

It was also observed that applied Asc (50 ppm) and BA (100 ppm) tended to significant increases in proteins contents of the yielded seeds. The increases in the contents of total lipid % of the seeds yield were shown to be the following order: Asc> Pac > BA. In this regard, Vasudevan *et al*. (1996) reported that spraying three sunflower cultivars with cytokinin produced the highest seed oil content. Talaat and Youssef (1998) showed that oil in seeds of rosella plants were significantly increased as a result of BA application, especially at 40 mg/L. Abed (2001) observed that BA significantly increased oil and protein % in seeds of cotton plants. Ibrahim *et al*. (2001) found that treatment of sunflower plants with kinetin 50 ppm gave a significant increase in crude fat %, respectively. Yousif *et al*. (2012) observed that0.5 g l^{-1} sucrose plus 150g l^{-1} ascorbic acid increased fresh and dry weight, and total carbohydrates contents in snapdragon cut spike flowers.

In conclusion, from the bulk of data obtained in the present investigation, it can be recommended that foliar applications of ascorbic acid, benzyl adenine and paclobutrazol had a beneficial effect on growth and chemical constituents and caused high yield quality of sesame plants.

Table (1): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac) on shoot length, root length and number of leaves of sesame *Sesamum indicum* (var. Shandawil 3) plants. Values given are means of ten replicates.

Treatment (ppm)	Shoot length (cm)		Root length (cm)		Number of leaves	
	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
Control	35.20	120.39	12.80	21.59	13.60	46.00
Asc 50	38.20	145.60	15.90	21.40	15.30	51.20
Asc 100	26.40	127.80	11.40	16.90	14.40	43.80
BA 50	48.50	146.40	14.70	18.50	17.00	69.20
BA 100	37.70	144.40	12.90	19.86	13.00	55.00
Pac 25	43.10	128.06	16.00	17.22	17.30	54.40
Pac 50	40.50	128.90	15.60	15.30	15.90	54.20
LSD at 0.05	**0.91**	**1.74**	**0.52**	**0.74**	**0.42**	**1.74**

Table (2): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac) on fresh and dry weight of shoots and roots of sesame plants. Values given are means of ten replicates.

Treatment (ppm)	F.wt. of shoots (g.)		D.wt. of shoots (g.)		F.wt. of roots (g.)		D.wt. of roots (g.)	
	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
Control	13.61	86.31	1.87	19.45	1.89	11.10	0.42	3.73
Asc 50	19.84	131.00	2.94	26.70	3.28	15.06	0.68	4.43
Asc 100	7.41	93.63	1.08	19.96	1.35	11.79	0.24	4.19
BA 50	34.13	206.60	4.55	41.20	5.13	25.19	0.87	7.85
BA 100	20.51	205.36	2.77	40.91	3.32	26.31	0.53	7.57
Pac 25	26.72	220.88	3.46	39.05	4.29	20.08	0.65	5.33
Pac 50	21.18	229.25	2.95	43.26	4.66	23.62	0.90	6.98
LSD at 0.05	**1.35**	**9.06**	**0.22**	**1.95**	**0.35**	**0.97**	**0.07**	**0.43**

Table (3): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac) on chlorophyll and carotenoids contents (mg/g. F. wt) of sesame plants. Values given are means of three replicates.

Treatment (ppm)	Chlorophyll a		Chlorophyll b		Chlorophyll a+b		Carotenoids	
	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
Control	6.24	9.47	2.65	3.13	8.89	12.61	2.74	4.28
Asc 50	4.18	9.19	1.79	2.84	5.98	12.03	1.86	4.50
Asc 100	3.97	6.03	1.87	2.38	5.84	8.41	1.22	3.01
BA 50	5.48	7.24	2.38	2.32	7.86	9.56	2.24	3.61
BA 100	4.31	9.51	2.21	2.83	6.52	12.34	1.71	4.69
Pac 25	5.89	10.91	2.67	3.67	8.56	14.58	2.52	4.94
Pac 50	8.43	9.70	3.98	3.09	12.41	12.79	3.28	4.71
LSD at 0.05	**0.81**	**0.042**	**0.09**	**0.06**	**1.31**	**0.08**	**0.054**	**0.032**

Table (4): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol(Pac) on total water soluble carbohydrates contents (mg/g. dry weight) of sesame plants. Values given are means of three replicates.

Treatment (ppm)	Roots		Shoots		Fruits
	Stage I	Stage II	Stage I	Stage II	
Control	62.03	64.41	58.66	78.51	102.18
Asc 50	83.30	77.36	56.74	72.15	155.59
Asc 100	76.82	77.13	53.64	100.27	150.31
BA 50	74.67	55.13	110.11	70.73	112.91
BA 100	78.08	86.89	73.45	73.68	154.41
Pac 25	75.40	92.87	110.38	131.23	61.03
Pac 50	168.97	117.51	156.55	134.41	139.23
LSD at 0.05	**7.66**	**7.23**	**3.39**	**1.82**	**4.44**

Table (5): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazole (Pac) on soluble proteins contents (mg/g. dry weight)of sesame plants. Values given are means of three replicates.

Treatment (ppm)	Roots		Shoots		Fruits
	Stage I	**Stage II**	**Stage I**	**Stage II**	
Control	107.22	120.29	98.52	90.60	140.20
AA 50	107.59	96.83	122.87	102.63	124.61
AA 100	103.84	103.38	138.89	95.16	124.34
BA 50	95.36	97.10	112.86	105.04	124.37
BA 100	86.85	105.64	118.54	137.81	128.26
Pac 25	89.56	86.31	100.24	81.69	89.69
Pac 50	82.58	115.62	111.27	87.17	73.59
LSD at 0.05	**7.73**	**8.85**	**11.52**	**8.46**	**7.19**

Table (6): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac) on activities of proteases, amylases and lipases enzymes (mg/g. dry weight equivalent) of sesame plants. Values given are means of three replicates.

Treatment (ppm)	Proteases		Amylases		Lipases	
	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
Control	1.32	2.22	1.63	1.47	14.06	7.03
Asc 50	1.44	2.29	1.38	1.73	3.51	11.72
Asc 100	1.55	2.36	1.72	1.80	2.34	24.60
BA 50	1.51	2.11	0.75	1.84	4.69	2.34
BA 100	1.63	1.60	1.78	1.31	16.40	11.72
Pac 25	1.86	1.53	1.72	1.98	4.69	4.69
Pac 50	1.73	1.60	1.55	1.70	2.34	7.03
LSD at 0.05	**0.031**	**0.026**	**0.057**	**0.06**	**1.65**	**2.13**

Table (7): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol (Pac) on yield components of sesame plants. Values given are means of ten replicates.

Treatment (p.p.m.)	No.of fruits/plant	Weight of fruits/plant	Weight of 1000 seeds(g)
Control	30.40	10.49	3.16
AA. 50	45.60	11.49	3.71
AA. 100	2.80	10.89	3.48
BA 50	68.80	19.95	3.81
BA 100	59.60	18.60	3.64
PAC 25	81.20	24.93	4.32
PAC 50	90.40	29.51	4.10
LSD at 0.05	**3.8**	**1.17**	**0.03**

Table (8): Effect of ascorbic acid (Asc), benzyl adenine (BA) and paclobutrazol(Pac) on soluble carbohydrates, proteins and total lipids of the seed yield of sesame plants. Values given are means of three replicates.

Treatment (ppm)	Carbohydrates	Proteins	Total lipids (%)
Control	41.91	110.70	42.2
AA. 50	49.48	117.26	54.8
AA 100	42.28	93.64	53.54
BA. 50	44.38	94.68	32.82
BA 100	48.34	116.93	45.87
PAC 25	43.87	80.49	47.43
PAC 50	47.13	92.75	49.65
LSD at 0.05	**0.54**	**5.68**	**1.65**

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الملخص العربي

أجريت تجربة حقلية لدراسة تأثير الرش الورقي من حامض الاسكوربيك (100,50 جزء في المليون)،البنزيل أدنين (100,50 جزء في المليون) والباكلوبوترازول (50,25 جزء في المليون) على النمو والمحصول لنبات السمسم. كانت جميع التركيزات المستخدمة فعالة في تنشيط أطوال المجموع الخضري والجذري وعدد الأوراق لكل نبات. أظهرت النتائج التي تم الحصول عليها أيضا أن استخدام حمض الاسكوربيك عند 50 جزء في المليون أو البنزيل أدنين عند 50 , 100 جزء في المليون و والباكلوبوترازول عند 25 , 50 جزء في المليون أظهر تأثيرات محفزة كبيرة على الوزن الرطب والجاف للمجموع الخضري والجذري.وجد أيضا أن الباكلوبوترازول أكثر فعالية من المعاملات الأخرى في تنشيط محتويات الكلوروفيل والكاروتين. جميع التركيزات المستخدمة فعالة في تنشيط الكربوهيدرات الذائبة في معظم أجزاء النباتات المعاملة وظهر العكس بالنسبة لمحتويات البروتين في الجذور والثمار من النباتات المعاملة. وسجلت أيضا التغيرات في أنشطة الانزيمات المحلله للبروتينات والنشويات والدهون. وارتبطت هذه التغيرات مع تحسين جودة المحصول والقيمة الغذائية للبذور. كان تأثير الباكلوبوترازول أعلى من حمض الأسكوربيك ، والبنزيل أدنين في زيادة المحصول. أعلى نسبة زيوت تم الحصول عليها من معاملة النباتات بحامض الأسكوربيك (50 جزء في المليون) ،بينما سجلت اعلي قيمة للكربوهيدرات والبروتينات الذائبة في البذور مع النباتات المعاملة بالبنزيل اأدنين (100 جزء في المليون).