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RESPONSE OF PEA PLANTS (*Pisum sativum* L.) TO FOLIAR APPLICATION OF PUTRESCINE, GLUCOSE, FOLIAFEED D AND SILICON

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ABSTRACT

The investigation was carried out during two successive seasons, viz., 2002-2003 and 2003-2004, to study the effect of putrescine, glucose, foliafeed D and silicon (in the form of sodium meta silicate) on growth, yield and chemical composition of peas (*Pisum sativum* L., cv Master B).

Pea plants were sprayed twice, 40 and 60 days after sowing with 1 and 2 ppm of putrescine and 0.625 and 1.250 g/L of the micronutrients (foliafeed D), as well as 1 and 2 g/L from each of glucose and sodium meta silicate (Silicon). Two samples were taken after 50 and 70 days from sowing during the both seasons of study.

The obtained results indicated that there were significant differences between treatments for most trials during the two seasons of study. Using putrescine, glucose, foliafeed D and silicon foliar application on pea plants, especially at the high doses significantly increased plant height, number of leaves/plant, the plant leaf area, earliness of flowering. Also, a significant enhancement occurred in some trials viz., weight and number of fresh pods/plant, total fresh yield/feddan, average of pod fresh weight, number of seeds/pod, fresh weight of 100 seeds, shell out% of the fresh pods and the dry matter of seeds%. In addition putrescine foliar application at 2 ppm significantly increased N concentration and the total protein % of pea seeds, while using foliafeed D at 0.625 g/L and sodium meta silicate at 2 g/L significantly increased K and Na contents of pea seeds. On the other hand, spraying pea plants with glucose or foliafeed D caused a significant increase in P content of pea shoots. Generally, the effect of the various rates of putrescine, glucose, foliafeed D and sodium meta silicate (silicon) on the organic components of pea shoots (i.e., total sugars, total free amino acids and the total soluble phenols) varied within the two seasons. On the other hand, while the organic components were increased in the first season, they were decreased or not affected by the external addition of the previous chemical substances under study in the second season.

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important vegetable crops that belongs to the leguminosae family. It is commercially grown to produce the green pods as well as the dry seeds. Pea is considered a high protein food that is rich in many of the essential amino acids, especially lycine. Also, it is rich in calcium, phosphorus, iron, sodium and potassium in addition to vitamins A and B (Muehlbover and McPhee, 1997).

Increasing the production of green pods and dry seeds with high quality is very important aims to meet the increment in human population, that may be achieved horizontally by increasing the cultivated area and/or vertically by increasing the total yield in the unit area. The increase in total yield per feddan can be achieved by application of certain chemical substances (nutrients) that increase the yield with high quality. In Egypt the soils tend to be alkaloidy, thus the availability of most nutrients especially the micro-elements is low. In this case, supplementation of micronutrients or certain chemical substances as a foliar spraying is very important and certainly of a great value. This application method could be more efficient than that of adding nutrients in or on the soil because of the quick absorption by the leaves. Moreover, loss of the nutrients through fixation or leaching could be avoided (Ismail, 2002).

Many investigators hypothesized that putrescine (put) plays an important regulatory role in plant growth and development owing to its effect on cell division and differentiation such results are confirmed in bean (Altman *et al.*, 1982), mung bean (Friedman *et al.*, 1985), chicory (Bais *et al.*, 1999) and *Myrtus commuis* (Hanafy Ahmed *et al.*, 2002a).

Also, putrescine has been played an important regulatory role in various plants by increasing yield and its components of many crops such as tomato (Cohen *et al.*, 1982), soybean (Sharma *et al.*, 1998) and sweet pepper (Talaat, 2003).

Much interest is focused on the role of carbohydrates such as glucose as well as C/N ratio in pushing the plants towards the flowering stage and enhancement the fruting set. Similar suggestion was reported by Repka, (1979); Jana and Arkal, (1996) and Mansour (2000).

Furthermore, micronutrients as well as silicon are considered very important factors for plant nutrition to protect the plants against adverse environmental conditions. Also, it has been implicated in plant response to stress conditions (Liang *et al.*, 1996; Ismail, 2002; El-Sweify *et al.*, 2002 and Hanafy Ahmed *et al.*, 2002C and 2004).

Thus, the aim of the present study was to investigate the effect of putrescine, glucose, micronutrients (foliafeed D) and sodium meta silicate (silicon) foliar application on growth, yield and its components as well as chemical composition of pea plants.

MATERIALS AND METHODS

Two field experiments were conducted during the two winter growing seasons of 2002/2003 and 2003/2004 at the Agriculture Eperimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt, to investigate the influence of foliar spray application of putrescine, glucose, micronutrients (Foliafeed D) and sodium meta silicate (as a resource of silicon) on growth, yield and its components as well as chemical composition of pea plants.

The soil type at the experimental site was clay-loam with pH 7.2 and 1.6% organic matter content. Seeds of peas cv Master B were sown on October 10^{th} in both seasons of study at 20 cm spacing between plants. The area of each experimental plot was 10.5 m^2 and consisted of three rows. Each row was 5 m long with 0.7 m between rows. A guard row was left between each two experimental units to avoid drift spray. Irrigation, fertilization and the pest control were applied as recommended by the Ministry of Agriculture.

Pea plants were sprayed twice using the diamine putrescine ($NH_2CH_2CH_2CH_2CH_2NH_2$, MW 88.15, produced by Sigma Chemical Co.) at the rate of 1 and 2 ppm, foliafeed D (a micronutrient compound fertilizer contains 3% Fe and 7% Zn in the chelated form of EDTA as well as 5% Mn, 0.5% Cu, 0.5% B, 0.5% Mg and 0.2% Mo in mineral forms) at the rates of 0.625 and 1.250g/L, glucose or silicon (in the form of sodium meta silicate ($Na_2SiO_35H_2O$)) at the rate of 1 and 2 g/L, in addition to distilled water as a control treatment. Spraying was carried out at 40 and 60 days after sowing using a knapsasck sprayer having a conical nozzle delivering 100 ml water /m^2.

The treatments were arranged in the field in three replications using a randomized complete block design. Three plants sample was taken from each plot 10 days after each of the 1st and 2nd spraying time, i.e. the two samples were taken after 50 and 70 days from sowing. In the two successive samples, the following growth characters were recorded: plant height, fresh and dry weight of shoots, number of branches and leaves per plant as well as the plant leaf area. Also, the chlorophyll concentration of leaves was recorded by A Minolta SPDAD Chlorophyll-Meter, model SPAD502 (Yadava, 1986). Flowering date was determined as a number of days from sowing date till anthesis of the flowers. Harvesting started on December 15th and continued for 45 day in both seasons of the study. Plant yield (weight and number of pods/plant) as well as the total yield of green pods per feddan were recorded. Moreover, the pod characteristics including weight and length of pod as well as number of seeds/pod were determined. Shell out (%) of fresh pod was calculated using the following equation:

$$\textbf{shell out percentage} = \frac{\text{Weight of green seeds}}{\text{Weight of green pods}} \times 100$$

In addition, the fresh weight of 100 seeds as well as the dry matter accumulation of seeds were recorded.

Determination of N, P, K and Na was carried out on the ground dry material (shoots and seeds). Nitrogen was determined using the modified "microkjeldahl" apparatus of Parnas and Wagner as described by Van Schouwenburg and Walinga (1978).

Phosphorus was estimated calorimetrically using the chlorostannous reduced molybdophosphoric blue colour method according to Chapman and Parker (1961). Potassium and sodium were determined using the flame photometer (ELE) as described by Brown and Lillil and (1964). Total protein % of seeds was calculated using the following equation: Crude protein percentage = Nitrogen value x 6.25 (Stewart, 1989).

Ethanol extract of shoots was used for the determination of total sugars, total free amino acids and the total soluble phenols. Total sugars were determined by using the phosphomolybdic acid method (A.O.A.C., 1965). Total free amino acids were determined by using ninhydrin reagent (Moore and Stein, 1954). Total soluble phenols were estimated by using the Folin-ciocalteu colorimetric method (Swain and Hillis, 1959).

All data were processed by analysis of variance according to the method described by Steel and Torrie (1960) and the means were compared using the least significant difference test (L.S.D.) at 5% (Sindecor and Cochran, 1980).

RESULTS AND DISCUSSION

1. Growth Characters and Flowering:

The effects of Putrescine, glucose, foliafeed D and sodium meta silicate foliar applications on vegetative growth characters as well as flowering of peas were summarized in Table 1. Generally, there were significant differences between treatments for some growth characters in the two samples i.e., plant height and shoot dry weight as well as for number of leaves/plant and the plant leaf area especially in the 2nd sample. Moreover, significant differences were obtained for early of starting of flowering in the two successive seasons. On the contrary, no significant differences were observed in the two samples for shoot fresh weight, number of branched/plant as well as for number of leaves and total leaves area/plant in the first sample. No significant differences were observed in the total chlorophylls concentration in both seasons of the study (Table 1).

It was evident from Table 1 that in the first sample, spraying pea plants with glucose, foliafeed D or sodium meta silicat at any of the two different doses in the first season or at the higher doses in the second season caused significant increase in plant height comparing with the untreated control. Meanwhile, in the second sample, using putrescine and glucose at the higher doses or using putrescine and foliafeed D at any of the two different doses increased plant height during the 1st and 2nd seasons, respectively.

As shown in the same Table, the two used doses of putrescine or glucose increased shoot dry weight in the 1st sample of the two successive seasons. The effect of the two doses of glucose and the lower dose of foliafeed D on shoot dry weight in the 2nd sample took a similar trend to that recorded in the 1st sample in both seasons (Table 1).

On the other hand, spraying pea plants with the higher dose of each of putrescine, glucose, foliafeed D and sodium meta silicate increased the number of leaves/plant as well as the plant leaf area in the 2nd sample of the two successive seasons (Table 1).

Concerning flowering date, it was clear from the results in Table 1 that application of putrescine or glucose as well as foliafeed D at any of the two different doses caused significant decrease in number of days from sowing to anthesis of the flowers comparing with the untreated control in both seasons of study. This indicated the positive effects of putrescine or glucose as well as the microelements (foliafeed D) on the increment earliness of pea flowering.

These results are in agreement with those obtained by the investigators who used putrescine on rice (Krishnamurthy, 1991), on *Myrtus communis* (Hanafy Ahmed *et al.,* 2002a) and on sweet pepper (Talaat, 2003) where they reported that using putrescine at different concentrations increased plant height, number leaves and the total leaves area/plant as well as fresh and dry weights of shoots. In this respect, Altman *et al.,* 1982; Egea-Cortines and

Mizrahi, 1991; Rajam, 1993 and Tiburcio *et al.,* 1993 hypothesis that putrescine play an important regulatory role in plant growth and development. Also, they assumed that the diamine putrescine and the polyamines (Sperimine and Spermidine) are essential for cell growth and may serve as intermediates in cellular responses to the growth factors. Moreover, they described polyamines as plant growth substances with a wide range of action. Their mechanism of action is related to binding with nucleic acids and probably with membranes. On the other hand, Martin-Tanguy *et al.,* 1982; Crisosto *et al.,* 1988 and Kaur-Sawhney *et al.*, 1990 indicated that putrescine and polyamines seem to play a regulatory role in morphogenetic preceding fruit set; that is, in the formation of the flowers and to enhance pollen germination and fertilization. In addition, Galston and Flores, 1991; Kakkar and Rai, 1993; Galston *et al.,* 1994 and Iannotta *et al.,* 1996 proposed that increases in putrescine immediately preceded the activation of cell diviation in meristems passing from the vegetative to the floral stage and developing inflorescence by decreased ovary abortion.

The present results concerning the effect of glucose and foliafeed D foliar application on vegetate growth and flowering of pea plants confirmed those obtained Repka, (1979); Jana and Arkal, (1996); and Mansour (2000) and Ismail, (2002) who noticed the enhancing effects of biofertilizers and minerals nutrition on growth and flowering of pea plants. In addition, Hanafy Ahmed *et al.,* (2004) indicated that foliafeed C increased the growth caracters and flowering of flax plants.

Regarding the effect of sodium meta silicate as a source of silicon on the growth and flowering of peas, data presented in Table 1 show the favourable effect of sodium meta silicate on most of growth characters under the study. Similar results were obtained on wheat plants by Hanafy Ahmed *et al.,* (2002a) who added sodium meta silicate to the soil at 1000 ppm SiO_2. In this respect, it can be suggested that silicon may play many of important roles in plant metabolic processes. In this connection, Miyake and Takahashi, (1983), working on cucumber, mentioned that the pollen fertility of silicon-free plants was lower than that of silicon supplied plants. In addition, Aleshin *et al.,* (1989), working on rice, mentioned that silicon stabilized metabolic processes in chloroplasts and participated in regulation of all 3 types of phosphorylation. Moreover, Agrie *et al.,* (1992), working on rice, reported that silicon reduced transpiration and increased water use efficiency in leaves, which in turn reduced the decline in photosynthesis and chlorophyll destraction in older leaves. Also, Liang *et al.,* 1996 pointed out that silicon treatment increased CO_2 assimilation of barley leaves.

Table 1: Effect of putrescine, glucose, foliafeed D and sodium meta silicate (silicon) foliar application on vegetative growth, total chlorophyll concentration and Flowering of pea plants during 2002-2003 and 2003-2004 seasons.

Seasons	Sample No.	1st						2nd						Total Chlorophyll (SPAD unit)	Starting of flowering (day)
	Treatments	Plant Height (cm)	Shoot weight (g)		No. of branches / plant	No. of leaves /plant	Leaf area/ plant (cm^2)	Plant Height (cm)	Shoot weight (g)		No. of branches /plant	No. of leaves /plant	Leaf area/ plant (cm^2)		
			Fresh	Dry					Fresh	Dry					
2002-2003	Control (distilled water)	24.6	13.42	1.94	1.3	8.3	98.7	38.8	15.52	2.73	1.3	8.7	105.5	52.47	50.0
	Putrescine 1ppm	27.2	14.98	2.85	1.3	8.7	111.8	44.1	16.46	2.72	1.7	11.7	153.5	53.13	46.3
	Putrescine 2ppm	28.4	18.06	2.88	1.0	9.0	128.4	47.3	19.11	2.99	2.3	13.0	191.6	54.30	46.7
	Glucose 1g/L	31.6	15.19	2.71	1.3	7.7	109.8	43.1	19.20	3.99	2.0	11.3	196.0	51.70	47.3
	Glucose 2g/L	32.6	16.52	2.98	1.3	9.0	118.9	49.1	17.27	3.95	1.7	12.7	215.5	52.23	47.1
	Foliafeed D 0.625g/L	29.8	13.21	1.96	1.3	8.3	105.1	42.6	18.90	3.79	2.1	10.3	149.9	51.07	46.0
	Foliafeed D 1.250g/L	34.4	16.40	2.34	1.0	9.7	121.6	46.2	19.72	2.36	1.5	11.7	191.7	51.63	47.5
	Sodium meta silicate 1g/L	31.5	13.21	2.07	1.3	7.3	100.1	40.5	17.87	2.95	1.7	13.0	168.5	50.98	49.3
	Sodium meta silicate 2g/L	32.3	13.71	2.08	1.0	8.7	112.4	45.6	17.55	2.55	1.6	13.3	183.1	51.17	49.7
	L.S.D. at 0.05	**5.0**	**N.S.**	**0.62**	**N.S.**	**N.S.**	**N.S.**	**8.3**	**N.S.**	**0.78**	**N.S.**	**2.7**	**76.3**	**N.S.**	**2.6**
2003-2004	Control (distilled water)	26.6	12.26	1.70	1.0	8.7	100.8	33.6	22.80	3.28	1.3	10.0	101.3	53.30	49.0
	Putrescine 1ppm	28.6	13.67	2.17	1.3	9.3	109.3	43.7	22.75	3.33	1.7	13.3	147.3	54.50	45.7
	Putrescine 2ppm	27.4	15.97	2.71	1.3	9.3	122.2	45.5	26.41	3.99	2.0	17.7	170.2	53.23	46.9
	Glucose 1g/L	31.5	14.18	2.22	1.3	9.3	121.1	42.1	24.35	4.43	2.1	14.3	186.6	51.77	47.1
	Glucose 2g/L	32.2	15.62	2.46	1.3	9.7	111.9	47.7	24.48	4.55	1.7	15.9	189.4	52.17	47.0
	Foliafeed D 0.625g/L	28.1	15.73	2.06	1.3	9.7	111.3	42.6	23.33	4.32	2.0	13.6	138.9	52.20	46.7
	Foliafeed D 1.250g/L	33.3	12.63	1.94	1.3	9.3	118.9	45.7	20.23	3.56	1.7	15.0	176.8	53.00	47.1
	Sodium meta silicate 1g/L	30.6	12.44	2.03	1.0	8.7	102.5	41.7	20.80	3.58	1.8	16.5	169.9	51.89	48.0
	Sodium meta silicate 2g/L	32.0	12.71	1.79	1.0	9.7	110.3	43.0	25.31	3.75	2.0	17.1	177.6	52.06	47.6
	L.S.D. at 0.05	**5.3**	**N.S.**	**0.44**	**N.S.**	**N.S.**	**N.S.**	**8.7**	**N.S.**	**0.86**	**N.S.**	**4.6**	**69.5**	**N.S.**	**1.8**

2. Yield and its components:

Data presented in Table 2 show the effect of putrescine, glucose foliafeed D and sodium meta silicate foliar applications on the plant yield (based on weight and number of pods/plant), total fresh yield/feddan, physical characteristics of pods and seeds as well as mineral concentrations of pea seeds. It is clear from results in Table 2 that, in the two successive seasons, there was a significant increase in the plant yield (on weight and number of pods basis) and the total fresh yield per feddan by using putrescine at the two different levels (1 and 2 ppm) as well as by using glucose or foliafeed.D at the higher doses.

Concerning the effect of putrescine, glucose, foliafeed D and sodium meta silicate on pod and seed characteristics, the obtained results in Table 2 show that there were significant differences between the treatments for pod fresh weight and number of seeds/pod, while no significant difference was obtained for length of pod. It could be noticed from the same Table that putrescine at the two different doses under the study as well as glucose and folia fed D at the higher doses caused significant increment for pod fresh weight and number of seeds/pod. Also, using sodium meta silicate at the higher dose affected the number of seeds/pod in both seasons of the study. Moreover, as shown in Table 2, treating pea plants with putrescine, glucose, foliafeed D or silicon (sodium meta silicate) especially at the higher doses caused significantly increment in shell out % of the fresh pod, fresh weight of 100 seeds as well as dry matter accumulation % of seeds comparing with the untreated control.

Similar results were obtained by Cohen *et al.*, (1982) on tomato; costa and Bagni, (1983) on apple; Kaur-Sawhney and Applewhite, (1993) and Sharma *et al.*, (1998) on soybean and Hanafy Ahmed *et al.*, (2002b) on *Myrtus communis*. All of them indicated that putrescine was found to improve fruit set and ripening. They also found that the application of exogenous putrescine before or at time of flowering caused an increase in the final size of the fruit and finally improved the total yield/plant. In addition, the enhancing effect of putrescine on yield and its components has been reported by Talaat, (2003) who noticed that spraying putrescine at 1 or 2 ppm on the plants of sweet pepper significantly increased number of fruits/plant as well as the total fresh and dry weights of fruits/plant.

Moreover, the favourable results of putrescine foliar application of fruit growth and consequently on yield could be explained by Bagni *et al.* (1984) who reported that putrescine was absorbed by leaves and translocated to the fruitlet and *Vice-versa*. Moreover, the absorbed putrescine was metabolized to sperimine and spermidine and the translocation occurred *via* the peduncle and did not appear to be polar. Indeed, these polyamins are ubiquitous in biological systems and have been shown to be closely associated with many growth and developmental processes (Slocum *et al.*, 1984). In this concern, Kaur-Sawhney and Galston, (1991) mentioned that polyamins promote protein synthesis and associate with photosynthetic activity.

Table 2: Effect of putrescine, glucose, foliafeed D and sodium meta silicate (silicon) foliar application on yield and its components of pea plants in 2002-2003 and 2003-2004 seasons.

Seasons	Treatments	Fresh weight of pods/ plant (g)	Number of pods/ plant	Total fresh yield (ton/fed)	Single pod fresh weight (g)	Pod length (cm)	No. of seeds/ Pod	Shell out% of fresh pod	Fresh weight of 100 seeds (g)	Dry matter of seeds (%)	Protein % of seeds	Mineral concentrations (mg/g d.w.) of seeds			
												N	P	K	Na
2002-2003	Control (distilled water)	113.4	17.7	3.118	6.4	6.9	8.4	62.75	47.81	24.13	22.79	36.47	3.34	16.50	0.67
	Putrescine 1ppm	169.7	24.6	4.668	6.9	7.0	10.2	79.37	56.46	26.20	23.00	36.80	3.83	17.47	0.65
	Putrescine 2ppm	180.5	25.4	4.963	7.1	7.1	11.4	91.97	57.28	27.53	17.58	28.13	2.55	17.20	0.56
	Glucose 1g/L	133.8	20.0	3.680	6.7	7.2	10.0	83.21	55.75	26.87	19.71	31.53	3.65	17.93	0.59
	Glucose 2g/L	146.3	20.9	3.896	7.0	7.2	10.8	88.62	57.44	27.90	20.38	32.60	3.23	15.13	0.59
	Foliafeed D 0.625g/L	127.2	19.3	3.497	6.6	7.1	9.7	84.51	54.68	24.83	23.00	36.80	3.72	17.20	0.59
	Foliafeed D 1.250g/L	149.4	21.3	4.109	7.0	7.3	10.7	86.76	56.76	28.27	22.79	36.47	2.85	14.97	0.55
	Sodium meta silicate 1g/L	130.4	20.1	3.585	6.5	7.0	9.3	75.19	52.55	25.87	22.13	35.40	3.03	16.77	0.65
	Sodium meta silicate 2g/L	135.3	20.5	3.720	6.6	7.3	10.6	82.41	51.31	28.13	23.00	36.80	2.97	16.27	0.61
	L.S.D. at 0.05	**25.1**	**3.1**	**0.611**	**0.35**	**N.S.**	**1.7**	**22.31**	**6.48**	**2.89**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**
2003-2004	Control (distilled water)	129.8	21.6	3.570	6.0	6.9	9.7	64.92	46.34	24.87	24.23	38.77	2.85	20.19	0.73
	Putrescine 1ppm	180.2	26.5	4.956	6.8	7.1	10.9	80.48	55.28	26.27	22.92	36.87	2.82	17.58	0.83
	Putrescine 2ppm	174.9	25.3	4.809	6.9	7.2	11.3	85.37	52.13	27.13	20.58	32.93	3.21	19.17	0.71
	Glucose 1g/L	160.7	24.7	4.244	6.5	6.9	10.6	93.70	57.46	27.47	21.88	35.00	3.47	17.50	0.71
	Glucose 2g/L	154.3	23.0	4.418	6.7	7.2	10.7	88.31	55.30	28.50	23.10	36.97	3.56	22.09	0.74
	Foliafeed D 0.625g/L	144.8	23.4	3.983	6.2	6.8	10.3	91.72	55.21	25.77	18.96	30.33	3.24	16.27	0.86
	Foliafeed D 1.250g/L	162.5	23.9	4.320	6.8	7.0	11.0	88.23	54.54	29.07	21.00	33.60	3.34	24.83	0.76
	Sodium meta silicate 1g/L	140.5	22.0	3.864	6.4	6.7	9.9	80.22	52.78	27.87	18.48	29.57	2.23	20.70	0.74
	Sodium meta silicate 2g/L	144.8	21.9	3.981	6.6	6.9	10.8	92.86	56.75	27.63	20.68	33.08	3.12	23.33	0.94
	L.S.D. at 0.05	**26.0**	**2.2**	**0.726**	**0.63**	**N.S.**	**1.0**	**15.22**	**4.76**	**1.89**	**3.2**	**5.06**	**N.S.**	**3.11**	**0.12**

Moreover, Galston, (1983) indicated that the diamine putrescine and the polyamins: spevimine and spermidine, have been frequently described as endogenous plant growth regulators or intracellular second messengers mediating the effects of phytohormones. Therefore, polyamins have been implicated to affect a variety of molecular and cellular functions (Tiburcio *et al.,* 1993), thereby influencing various physiological and developmental processes (Galston and Kaur-Sawhney, 1990 and Rajam, 1993) including pollen fertility (Martin-Tanguy *et al.,* 1982), different phases of the cell cycle (Serafini-Fracassini *et al.,* 1989) and in flowering and fruit ripening (Kakkar and Rai, 1993).

With regard to the favourable results of foliafeed on yield and its components, Hanafi, Ahmed *et al.* (2004) reported that there was a significant increase in seed, straw, fiber, yield and its components of flax plants grown under clay loam and moderately saline soil by using cotngein or foliafeed C application as micronutrients compounds. In this respect, Hanafy Ahmed *et al.,* (1995) working a faba bean suggested that the influence of micronutrients on growth and yield is rather relevant to the enzymatic systems responsible for the biosynthesis of chlorophyll, amino acids, protein, plant hormones and photosynthesis as well as through improvement of nutritive status, which may lead to more fertile branches and seed filling. Furthermore, the foregoing results are of interest since the favourable effects of micronutrients on pea plants may support the view that the old soils in Egypt show now incipient micronutrient deficiencies. Thus, the micronutriens fertilization policy should be taken into consideration to fulfill the optimum nutritional plant requirements. Similar suggestion was reported by Hanafy Ahmed *et al.,* (1995) on faba bean and wheat plants.

Concerning the enhancement effect of sodium meta silicate on growth and yield of pea plants Hanafy Ahmed *et al.,* (2002a) reprted that addition of high rate of sodium meta silicate (1000 ppm SiO_2) to salinized soil may correct to some extent the negative effect of salinity either on growth, yield or the nutrient uptake by the roots of wheat plants. In this respect, Jarvis, (1987) working on wheat mentioned that the maintenance of erect leaves of wheat plants as a result of silicate application can easily account for a 10% increase in the photosynthesis of the canopy and consequently a similar increase in yield. Moreover, Aleshin *et al.,* (1989) pointed out that the increase in paddy yield of rice with silicon fertilizer was associated with the effect of silicon on bioenergy processes. In addition, Pershin *et al.,* (1995) mentioned that during the reproductive stage silicon in perfentially transported into the flog leaves of rice and interruption of silicon supply at this stage is detrimental for spikelet fertility.

3. Chemical composition:

Data of protein % as well as minerals concentrations of pea seeds as affected by the two different doses of putrescine, glucose, foliafeed D and sodium meta silicate foliar application treatments in the two successive seasons are presented in Table 2. It is clear from data that no significant differences were detected between treatments for mineral concentrations of pea seeds in the first season, while the reverse was true in the second season. As shown in the same Table, spraying putrescine at 2 ppm caused significant increase in N concentration and protein % of pea seeds. Similar results were obtained by Hanafy Ahmed *et al.*, (2002a) on *Myrtus communis* plants and Talaat, (2003) on sweet pepper plants. Concerning the effect of foliafeed D and sodium meta silicate, data presented in Table 2 indicate that using foliafeed D at the lower dose and silicon at the higher dose significantly increased potassium and sodium concentrations of pea seeds. These results agreed with those obtained by Hanafy Ahmed *et al.*, (2002a) when they used sodium meta silicate on wheat plants. and Hanafy Ahmed *et al.*, (2004) when they used foliafeed C on flax plants.

Data of organic components (total sugars, total free amino acids and total soluble phenols) of pea shoots as affected by various rates of putrescine, glucose, foliafeed D and silicon meta silicate foliar applications in the two samples of the two successive seasons are presented in Table 3. Generally, no significant differences obtained between the treatments for either total free amino acids or the total soluble phenols in the first sample of the two seasons. On the other and, there were significant differences between treatments on total sugars, amino acids and soluble phenols concentrations in the second sample as well as on total sugars in the first sample of the two successive seasons.

Concerning the effect of putrescine exogenous application on the organic compounds of pea shoots, data presented in Table 3 reveal that putrescine foliar application (at 1 or 2 ppm) generally increased all of the studied organic components concentrations especially in the second sample of the first season. In a contrast, putrescine foliar application reduced the total soluble phenols in the second season. These results are confirmed with those reported by Flores and Galston (1984) on oat plant, David (1996) on *euphorbia esula*, Bais *et al.*, (1999) on chicory and Hanafy Ahmed *et al.*, (2002a) on *Myrtus communis* plants who suggested that putrescine is a diamine which is involved in important biological processes, such as ionic balance and DNA, RNA and protein stabilization, hence, leading to the enhancement of free amino acids and protein synthesis. In this connection, Talaat, (2003) working on sweet pepper mentioned that using putrescine foliar application (at 1 or 2 ppm) enhanced either total amino acids or total soluble phenols. Meanwhile decreased the total sugar concentrations in shoot and fruits. Indeed, this reduction in the concentrations of total sugars by the addition of putreccine treatments might be attributed to the positive effect of polyamines on the functional activity of the photosynthetic apparatus in the plants and to polyamines pronounced effects of the ability of the plants to condensate sugars into more complex form.

Regarding the effect of sodium meta silicate, it is clear from the results in Table 3 that using the two rates of silicon (1 or 2 g/L of $Na_2SiO_35H_2O$) significantly increased all of the studied organic components concentrations in the second sample of the first seaon. Meanwhile, only the higher dose of sodium meta silicate enhanced each of total sugars as well as total soluble phenols in the second season (Table 3). These results are in agreement with those obtained by Hanafy Ahmed *et al.*, (2002a) who recorded high values of total sugars and total free amino acids in wheat shoots, of the plants treated with silicon at 500 or 1000 ppm SiO_2, soil application. Furthermore, no constant trend could be detected as regards the effect of the two different rates of silicon on the total soluble phenol concentrations in both roots and shoots of wheat plants. In this connection, Parry and Kelso, (1975) reported that silicon seems to influence the content and metabolism of polyphenols in xylem cell walls. Moreover, (Rani *et al.,* 1997) working on rice mentioned that the supply of silicon changed the content of phenol.

It is worthy to mention from the results presented in Table 3 that no significant differences were obtained between treatments concerning N, K and Na concentrations in the first season as well as for N and P concentrations in the second one. On the other hand, significant differences were detected between treatments for the other nutrients concentrations of pea shoots during the two successive seasons of the study.

As regard to the effects of putrescine and sodium meta silicate on N concentration, it was noticed from the results in Table 3 that in the first sample of the second season, putrescine and silicon foliar applications at the higher doses enhanced N concentration in pea shoots. Similar results were also reported by Hanafy Ahmed *et al.,* 2002a and Talaat, (2003) when they used putrescine on *Myrtus communis* and sweet pepper, respectively and by Hanafy Ahmed *et al.,* (2002C) when they used silicon on wheat plants. Concerning phosphorus concentration of pea shoots, data presented in Table 3 indicated that spraying pea plants with either glucose or foliafeed D at 1 g/L caused significant increase in phosphorus concentration especially in the first season. These results agreed with those obtained by Hanafy Ahmed *et al.,* (2004) when they used foliafeed C on flax plants.

Regarding the effect of putrescine, glucose, foliafeed D and sodium meta silicate on K and Na concentrations of pea shoots, it can be seen from data in Table 3 that treated pea plants with the two different rates of putrscine, glucose, foliafeed D and sodium meta silicate resulted in a distinct increment in K and Na concentrations of pea shoots especially in the first sample of the first season. The same results of K and Na concentrations were detected in the second sample of the second season (Table 3). These results are confirmed by those obtained by Hanafy Ahmed *et al.* (2002a) and Talaat, (2003) working on putrescine on *Myrtus communis* and sweet pepper, respectively as well as by Hanafy Ahmed *et al.,*(2004) using foliafeed C on flax plants. In addition, Hanafy Ahmed *et al.,* (2004C) recorded high values of Si, N and K concentrations in the shoots of wheat plants as well as protein %and concentration of both P and K of the wheat grains, especially in the plants treated with the high rate of silicon (1000 ppm SiO_2). In contrast, low values of P and Na concentration as well as Na:K ratio were detected in shoots of wheat plants after treating with the same rate of silicon. In this connection, Kai, (1987) pointed out that the stimulating effect of Si on N content may be due to the pH raising rise by sodium meta silicate application which stimulates ammonification. However, Marschner, (1995) mentioned that Si had no direct effect on P uptake or translocation to the roots. Linang *et al.* (1996) pointed out that it could enhance the uptake of K and inhibit the uptake of Na by salt-stressed barley.

Table 3: Effect of putrescine, glucose, folia feed D and sodium meta silicate (silicon) foliar application on total sugars, total free amino acids and total soluble phenods (mg/g F.W.) as well as N, P, K and Na (mg/g d.w.) concentrations of pea hoots during 2002-2003 and 2003-2004 seasons.

Seasons	Sample No.	1st							2nd						
	Treatments	Total sugars	Total free amino acids	Total soluble phenols	N	P	K	Na	Total sugars	Total free amino acids	Total soluble phenols	N	P	K	Na
2002-2003	Control (distilled water)	16.00	1.36	1.04	29.50	2.39	38.83	0.95	13.62	0.98	0.63	23.13	1.93	28.30	1.00
	Putrescine 1ppm	17.35	1.33	0.84	28.73	2.03	27.07	0.75	17.85	2.27	1.10	33.00	1.25	29.00	1.10
	Putrescine 2ppm	20.00	1.73	1.01	30.40	2.36	32.23	0.83	22.64	3.40	1.08	27.70	1.58	29.30	1.68
	Glucose 1g/L	17.45	1.68	0.99	33.40	1.77	28.13	0.81	20.54	2.83	0.97	32.30	1.11	27.60	1.25
	Glucose 2g/L	19.56	1.99	1.01	29.27	2.00	28.33	0.71	21.22	2.88	0.96	28.50	1.97	27.61	1.74
	Foliafeed D 0.625g/L	18.24	1.61	0.93	26.47	1.69	25.60	0.70	19.05	2.34	0.76	30.87	1.12	28.20	1.40
	Foliafeed D 1.250g/L	19.56	1.97	1.05	26.40	2.26	30.80	0.83	21.60	1.96	1.13	31.70	1.82	29.80	1.16
	Sodium meta silicate 1g/L	16.76	1.31	0.89	28.73	2.31	29.33	0.82	19.03	2.75	1.04	26.40	1.57	28.37	1.67
	Sodium meta silicate 2g/L	21.01	1.63	0.94	28.60	2.32	29.67	0.85	20.02	2.19	0.97	27.20	1.82	28.57	0.97
	L.S.D. at 0.05	**3.08**	**N.S.**	**N.S.**	**N.S.**	**0.49**	**6.31**	**0.11**	**3.29**	**0.68**	**0.21**	**N.S.**	**0.75**	**N.S.**	**N.S.**
2003-2004	Control (distilled water)	21.66	4.29	2.20	34.93	4.02	30.43	1.45	19.97	4.05	2.85	30.43	4.59	23.67	1.83
	Putrescine 1ppm	23.44	4.95	2.25	36.04	2.95	26.80	1.82	26.98	4.78	3.12	31.23	3.60	29.97	1.34
	Putrescine 2ppm	20.71	4.36	2.16	25.49	4.27	31.60	1.61	24.03	5.27	3.13	30.17	3.92	20.20	1.67
	Glucose 1g/L	24.27	4.85	2.30	31.86	3.69	23.50	1.59	21.08	4.83	2.90	32.57	3.42	32.20	1.87
	Glucose 2g/L	23.30	3.86	1.63	33.60	3.88	34.27	1.51	24.63	4.53	2.57	27.90	2.84	19.27	1.44
	Foliafeed D 0.625g/L	23.86	4.20	2.07	29.39	3.67	19.22	1.55	20.25	4.70	2.75	33.57	3.85	31.70	1.99
	Foliafeed D 1.250g/L	19.60	3.68	1.49	31.33	3.84	32.77	2.31	29.11	4.43	2.77	31.03	3.97	30.10	1.37
	Sodium meta silicate 1g/L	21.93	4.99	1.93	30.50	3.15	22.32	1.91	19.27	4.45	2.52	34.23	3.00	32.13	1.82
	Sodium meta silicate 2g/L	30.27	4.40	2.08	26.77	4.65	25.40	1.62	27.47	4.70	2.20	30.43	3.30	20.26	1.64
	L.S.D. at 0.05	**5.30**	**N.S.**	**N.S.**	**6.13**	**N.S.**	**3.89**	**0.24**	**2.46**	**0.82**	**0.36**	**N.S.**	**0.61**	**4.41**	**0.15**

Finally, it can be concluded that, treating pea plants with the higher doses of putrescine, glucose, foliafeed D and sodium meta silicate (2ppm, 29/L, 1.25g/L and 2g/L respectively) caused a distinct increment in the plant higher, number of leaves/plant and the plant leaf area. In addition, it is obvious that spraying pea plants with putrescine and foliafeed D (as a micronutrients compound fertilizer) at the two different does may enhance the earlness of pea flowering. Moreover, it was evident from data that adding putrescine, glucose or foliafeed D at any dose as well as sodium meta silicate (as a source of silicon) especially at the higher dose caused significant increase in all of the studied traits of yield and its components (i.e. weight and number of pods/plant/total fresh yield/feddan, pod fresh weight, number of seeds/pod, shell out % of the fresh pod as well as fresh weight of 100 seeds and dry matter %of seeds) comparing with the untreated control. Also, it is worthy to mention that using putrescine at 2ppm caused significantly increase in N concentration and protein %of pea seeds, while using foliafeed D at O.625 g/L or sodium met silicate at 2g/L significantly increased K and Na concentrations of pea seeds.

On the other hand, the effect of the two different rates of putrescence, glucose, foliafeed D and sodium meta silicate of the organic components of pea shoots was varied. Whereas, these organic components (total sugars, total free amino acids and the total soluble phenols) were increased especially in the first season, it was decreased or not affected in the second one. However, spraying pea plants with putrescence, foliafeed D and sodium meta silicate resulteu in a distinct increment N,K and N concentrations in shoots of pea plants, only the glucose and foliafeed D treatments caused significantly increase in P concentration of pea shoots.

Generally, these findings confirmed the previous hypothesis that putrescine plays an important regulatory role in plant growth and development. Moreover, it is considered as a growth substance with a wide rang of action and its mechanism of action if related to bindings with nucleic acids and probably with membrane. Furthermore, the favourable effects of micronutrients on pea plants may support the view that the old soils in Egypt show now incipient micronutrient deficiencies. Thus, the micronutrients fertilization policy should be taken into consideration to fulfill optimum nutritional requirements. Moreover, it can be suggest that silicon may play many of important roles on plant metabolic processes and it is necessary to enhance the nutrient uptake by the roots of plants in a various kinds of soils.

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استجابة نباتات البسلة للرش بالبتروسين والجلكوز والفلوليافيد-دى والصوديوم ميتا سليكات (سليكون)

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أجرى هذا البحث خلال الموسمين المتتالين ٢٠٠٢-٢٠٠٣، ٢٠٠٣-٢٠٠٤ لدراسة تأثير كلا من البتروسين والجلكوز الفوليافيد-دى (سماد عناصر صغرى) وكذلك السليكون على النمو الخضرى والمحصول والمكونات الكيماوية لنباتات البسلة صنف ماستر-بى حيث تم رش نباتات البسلة مرتين بهذه المواد وذلك بعد ٤٠، ٦٠ يوم من الزراعة. ولقد كانت تركيزات البتروسين المستعملة في هذا البحث هى ١، ٢ جزء في المليون بينما استعمل كلا من الجلكوز والسيلكون بتركيز ١، ٢ جرام/ لتر أما سماد العناصر الصغرى المركب (فوليافيد-دى) فقد استخدم بتركيزين وهما ٠,٦٢٥ جرام/لتر، ١,٢٥٠جم/لتر. هذا وقد تم أخذ عينتين للنمو الخضرى بعد ٥٠، ٧٠ يوم من الزراعة وذلك خلال موسمى الدراسة. ولقد أكدت النتائج المتحصل عليها وجود إختلافات معنوية بين المعاملات لمعظم الصفات تحت الدراسة، ولقد أدى رش نباتات البسلة بالبتروسين، الجلكوز، فلوليافيد - دى، السليكون خصوصا مع التركيزات العالية إلى زيادة معنوية فى ارتفاع النبات وعدد الأوراق على النبات والمساحة الكلية لأوراق النبات وكذلك التبكير فى التزهير. اتضح أيضا حدوث زيادة معنوية في بعض الصفات الخاصة بالمحصول ومكوناته مثل صفات وزن وعدد القرون الخضراء للنبات الواحد والمحصول الطازج الكلي للفدان ومتوسط الوزن الطازج للقرن وعدد البذور فى القرن والوزن الطازج للمائة بذرة والنسبة المئوية للتصافى فى القرون الخضراء وكذلك النسبة المئوية للمادة الجافة فى البذور.

بالإضافة إلى ذلك فإن استعمال البتروسين بتركيز ٢ جزء فى المليون أدى إلى زيادة معنوية فى محتوى كلا من النيتروجين والبروتين فى بذور البسلة بينما أدى استعمال الفوليافيد - دى بتركيز ٠,٦٢٥ جم/لتر والسليكون بتركيز ٢جم/لتر إلى زيادة معنوية فى محتوى كلا من البوتاسيوم والصوديوم فى بذور البسلة. وعلى الجانب الاخر فإن رش نباتات البسلة سواء بالجلكوز أو الفوليافيد - دى قد أدى إلى زيادة معنوية فى محتوى البذور من الفوسفور. وعموماص اتضح من البحث أن تأثير الجرعات المختلفة من البتروسين، الجلكوز، الفوليافيد - دى، السليكون على المكونات العضوية لعرش البسلة (مثل: السكريات الكلية والأحماض الأمينية الحرة الكلية وكذلك الفينولات الذائبة) كان متغيرا خلال سنوات الدراسة فبينما زادت هذه المكونات العضوية خلال السنة الأولى نجد أنها قد نقصت أو أنها لم تتأثر فى السنة الثانية نتيجة الإضافة الخارجية لهذه المواد الكيماوية تحت الدراسة على نباتات البسلة.