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Enhancing Growth and Increasing Yield of Peas (*Pissum sativum* L.) by Foliar Application of Ascorbic Acid and Cobalt Chloride

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ABSTRACT: Enhancing plant growth with some antioxidants and/or microelements is very crucial for many crops i.e., pea plants. So that, this experiment was conducted to study the effect of ascorbic acid (AA), cobalt chloride ($CoCl_2$) and their combinations on growth, yield and yield components along with the protein content of three cultivars of pea under the Middle Egypt growing conditions. Results revealed that the three cultivars varied in their horticultural characteristics and in their response to the applied treatments. Seeds dipped in the combination of AA (2mg/L)+ $CoCl_2$ (150ppm/L) treatment gave plants which showed most of the desirable horticultural characteristics and high values of N and protein contents comparing to the other treatments and the non-treated seeds. Furthermore, the interaction between cultivars and treatments had significant effects on most of the studied parameters. This study may be very beneficial for pea growing farmers especially for organic cultivations under the experiment growing conditions and similar conditions.

***Keywords*:** Ascorbic acid, Cobalt Chloride, Peas, Cultivars evaluation, Growth Enhancement, Yield.

INTRODUCTION

Cobalt is unequivocally essential for leguminous crops as it is required for nitrogen fixation by bacteria in root nodules and it even has beneficial effects on some non-leguminous crops (Locke *et. al.*, 2000; Witte *et. al.,* 2002; Kandil, 2007). Cobalt also promotes many developmental processes including stem and coleoptiles elongation, opening of hypocotyls hooks, leaf disc expansion and feet development (Ibrahim *et. al.*, 1989). Cobalt also promotes the growth of seedlings and alleviates the senescence of aged tissues as it inhibits the activities of ACC oxidase and reduced ethylene production (Lau and Yang, 1976).

Cobalt is a natural element found in rocks, soil, water, plants, and animals and has diverse industrial importance (Gál *et. al.*, 2007). It is essential in trace amounts for humans and other mammals as it is an integral component of the vitamin B_{12} complex (Smith and Carson, 1981). Although Co is essential in higher, non-leguminous plants is not clearly proven, there is some evidence of a favourable effect of Co on plant growth (Kabata-Pendias and Pendias, 1992). Cobalt is reportedly an essential element for the growth of many marine algal species, including diatoms, chrysophytes, and dinoflagellates. It is also a micronutrient required by microorganisms for nitrogen fixation in legumes (Gál *et al*, 2007). No biological use of Co is known other than its presence in vitamin B_{12} (Hsdb, 2000). Although Co is an essential nutrient, excessive oral doses result in a variety of adverse responses (Nagpal, 2004). Moreover, cobalt reduces the peroxdase activity which is known to affect the breakdown of Indole acetic acid (IAA). Plant hormones, especially abcissic acid (ABA) appear to play an important role in plant water relations through their effect on stomata and abcissic acid reduces opening of stomata (Gad, 2005). Cobalt, a transition element, is an essential component of several enzymes and co-enzymes. It has a role in affecting growth and metabolism of plants in different stages, depending on the concentration and status of Cobalt in rhizosphere and soil (Palit and Sharma, 1994). The beneficial effects of Cobalt include retardation of senescence of leaf, increase in drought resistance in seeds, regulation of alkaloid accumulation in medicinal plants, and inhibition of ethylene biosynthesis (Palit and Sharma, 1994).

Ascorbic acid has long been known to have many critical physiological roles in plants (Conklin *et. al.*, 1999). Ascorbate is a major metabolite in plants. It is an antioxidant and, in association with other components of the antioxidant system, protects plants against oxidative damage resulting from aerobic metabolism, photosynthesis and a range of pollutant (Smirnoff, 1996). Vitamin C (L-ascorbic acid) acts as a potent antioxidant and cellular reductant in plants and animals.

This study aimed to study the effect of foliar application of ascorbic acid, cobalt chloride and their combination on growth, yield and yield components of three peas cultivars under the Middle Egypt growing conditions.

MATERIALS AND METHODS

Two field experiments were carried out at the experimental farm in Sids Agricultural Research Station (Egyptian Agricultural Research Center Branch in Bani Sueif), Egypt in two successive winter seasons of 2009/2010 and 2010/2011. Seeds of three cultivars of peas (Master B, Jaguar, and Palmoral) wear pre-planting soaked in the used solutions in different concentrations (single and mixtures) for 24 hours as described in:

Table 1. Pre-planting peas seed-soaking solutions used in different concentrations

Ser.	Materials	Concentration
1	Distilled water (H_2O)	-
2	$CoCl_2$	20mg
3	$CoCl_2$	40 mg
4	Ascorbic acid	150 ppm
5	Ascorbic acid	300 ppm
6	Mix 1($CoCl_2$ + Ascorbic acid)	20 mg + 150 ppm
7	Mix 2 ($CoCl_2$ + Ascorbic acid)	40 mg + 300 ppm

Soaked seeds were planted in the field in October, 26th of the years of 2009/2010 and 2010/2011.

Experimental design

The Randomized Complete Bloch Design (RCBD) in strip plots was used. The three cultivars were used in the main plots and treatments (7 solutions) were randomly used in the sub plots in three replications. Each replicate consisted of 21 plots and each plot contained 4 lines (two lines for the fresh yield and the other two lines were for the dry yield of pods and seeds). The area of each line was 70cm wide and 400cm long, so, the plot area was 11.2 m^2.

Harvesting time

Green pods and dry pods were harvested according to the following:

Table 2. harvesting time (days after plantation) of peas fresh and dry pod of the three cultivars used in two successive seasons

Season	Cultivar	Harvesting time (days after plantation)		
		Fresh yield		Dry yield
		First harvest	Second harvest	
First season (2009/2010)	Master B	90 days	102 days	140 days
	Jaguar	103 days	117 days	150 days
	Palmoral	117 days	126 days	160 days
Second season (2010/2011)	Master B	87 days	101 days	145 days
	Jaguar	101 days	114 days	155 days
	Palmoral	118 days	127 days	171 days

Collected data

The following data were recorded at various stages of the plant growth after twenty pods from each replicate of all treatments and cultivars were randomly collected as follow:

1- Time of the first flower (days) as fruiting earliness.
2- Number of branches/plant (after 55 days from planting).
3- Fresh yield, ton/fed (as described in Table 2).
4- Pod length, cm (after the first harvest).
5- Pod width, cm (after the first harvest).
6- Pod weight, g (after the first harvest).

7- Number of seeds/pod (after the first harvest).
8- Seeds weight/pod, g (after the first harvest).
9- Plant length, cm (after the second harvest).
10- Dry yield of pods/fed, ton/fed (after the second harvest).
11- Seeds weight/fed, ton/fed (after the second harvest).
12- Seed drop rate, % (after the second harvest).
13- 1000 seeds weight, g (after the second harvest).
14- 1000 seeds volume, cm^3 (after the second harvest).

Chemical composition

Samples of the dry seeds of the three cultivars were collected randomly to determine the nitrogen (N) and protein content as described by Bremner and Malvaney (1982)

Soil samples analyses

Randomly collected soil samples from the experiment area before plantation were sent to the Egyptian Agricultural Soil Analysis Laboratory, Bani Suef Governorate and results are described in Table 3.

Table 3. Physical and chemical analyses of the experimental soil

Item	Year	
	2009/2010	2010/2011
Coarse sand	0.64	0.78
Fine sand	8.50	10.19
Silt	24.37	19.22
Clay	66.50	69.84
Texture	Clay	Clay
pH (1:2.5 soil/water ratio	7.7	7.3
E.C. (1:2.5 extract) mm hour/cm	0.6	0.8
$CaCO_3$ (%)	2.6	2.9
Organic matter (%)	1.90	2.02
Total nitrogen (ppm)	15.0	23.8
Available phosphorus (P) ppm	7.7	5.8
Available potassium (K) ppm	1.1	0.93

E.C. = Electrical conductivity

The concentration from AsA at 200 ppm + $CoCl_2$ at 20 ppm was prepared by weighing 0.2 (g) of a synthetically AsA + 0.02 g of a commercial $CoCl_2$ into 1000 ml distilled sterilized water.

Statistical analysis

All recorded data were subjected to the analysis of variance procedures and treatment means were compared using the L.S.D. at 95% of confidence as described by (Gomez and Gomez, 1984). The statistical analysis was done by using the computer program MSTAT-C software version 4.

RESULTS AND DISCUSSION

Generally, results showed that almost all applied treatments significantly enhanced pea plants growth, yield and yield components compared to those non-treated plants (water treatment). The mixture of $CoCl_2$ + Ascorbic acid was the best treatment to increase most of the desirable characteristics and give the highest values of the three pea cultivars used in these experiments in both growing winter seasons.

Fruiting earliness (time of the first flower)

Data in Table (4) describes the effect of these treatments on time of the first flowers of the non-treated or treated three used pea cultivars as an indication of flowering and fruiting earliness of these cultivars. Data shows that the cultivars varied in their flowering earliness as the cultivar Master B was the earliest one to begin flowering after 34.15 days followed by Jaguar (45.01 days) and then, Palmoral (55.67 days) in the first season and also, the same results were obtained in the second season (34.81, 45.54 and 55.70 days, respectively). Plants treated with the treatment No. 6 (Mix of $CoCl_2$ + Ascorbic acid) gave the lowest average number of days to flowering (44.18 days) comparing to those of the control treatment which gave 45.67 days in the first season with significant differences between the two treatments. In the second season, both this mix and the ascorbic acid treatment (No. 5) gave the best value (44.55 and 44.35 days, respectively) compared to the control treatment (46.05 days).

Moreover, treatment No. 6 enhanced pea plants of the three cultivars to flower earlier than the other treatments including the control treatment (about 2 days for Master B; one day for Jaguar and one day for Palmoral) as compared to the control treatment and the same trend was observed for the second season Table 4.

Number of branches/plant

Studied cultivars differed in their number of branches/plant characteristic as their vegetative growth is different (Table 4). The treatments had a great effect on cultivars as treatment No. 6 significantly increased the number of branches/plant from 3.2 and 3.1 (for the control treatment) to 4.4 and 4.2 in the first and second seasons, respectively. Furthermore, the interaction effect between cultivars and treatments was significant in the two seasons. Pea plants treated with treatment No. 6 increased the number of branches for Master B (from 2.2 and 2.2 to 3.4 and 3.3branches), for Jaguar (from 3.2 and 3.1 to 4.5 and 4.3 branches) and for Palmoral (from 4.1 and 4.0 to 5.4 and 5.2 branches), in the first and second season, respectively.

Table (4) Effect of cobalt chloride, ascorbic acid, and their two mixtures on time of the first flower and number of branches/plant of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	Time of the first flower (days)								Number of branches/plant							
		First season			Mean	Second season			Mean	First season			Mean	Second season			Mean
		[1]Palm	[2]Jag	[3]Mast	of (B)	Palm	Jag	Mast	of (B)	Palm	Jag	Mast	of (B)	Palm	Jag	Mast	of (B)
1	Water	56.30	45.63	35.10	45.67	56.33	46.13	35.70	46.05	4.1	3.2	2.2	3.2	4.0	3.1	2.2	3.1
2	$CoCl_2$ (2mg)	55.53	44.83	34.13	44.83	55.90	45.63	34.60	45.37	4.3	3.6	2.5	3.5	4.3	3.3	2.3	3.3
3	$CoCl_2$ (4mg)	56.10	45.56	34.86	45.51	56.06	46.06	35.23	45.78	4.3	3.4	2.3	3.3	4.2	3.2	2.1	3.2
4	Ascorbic acid	55.86	45.23	34.20	45.10	55.73	45.76	34.86	45.45	4.1	3.9	2.8	3.6	4.0	3.7	2.6	3.4
5	Ascorbic acid	55.60	45.00	34.13	44.91	55.70	45.46	34.90	45.35	4.3	3.6	2.7	3.5	4.1	3.4	2.8	3.4
6	Mix (2 + 4)	55.06	44.36	33.13	44.18	54.93	44.66	34.06	44.55	5.4	4.5	3.4	4.4	5.2	4.3	3.3	4.2
7	Mix (3 + 5)	55.23	44.50	33.53	44.42	55.23	45.06	34.30	44.86	5.1	4.3	3.3	4.2	4.8	4.1	3.1	4.0
Mean of cultivars (A)		55.67	45.01	34.15		55.70	45.54	34.81		4.5	3.8	2.7		4.3	3.6	2.6	
L.S.D. at 0.05 for A			0.98				0.44				0.20				0.34		
for B			0.41				0.44				0.17				0.13		
for AB			0.53				0.42				0.29				0.13		

Pod length (cm) and pod width (cm)

This characteristic showed obvious differences among the three cultivars as Master B pods were longer (9.7 and 9.5 cm) but thinner (1.37 and 1.40 cm) than Jaguar (7.3 and 7.0 cm long and 1.44 and 1.55 cm wide) and Palmoral (7.9 and 7.8 cm long and 1.40 and 1.55 cm wide) cultivars in the first and second seasons, respectively as shown in Table (5). The treatments positively affected pod length and width as plants treated with the treatment No. 6 gave the highest values (8.8 and 8.6 cm long and 1.52 and 1.56 cm wide) in the first and second season, respectively comparing to those treated with water (the control treatment) which gave an average value of 8.0 and 7.7 cm long and 1.34 and 1.38 wide in the two seasons, respectively. Moreover, the interaction between cultivars and treatments effect was sometimes significant and other times insignificant in this characteristic as the treatment No. 6 with Master B showed the highest pod length (10.2 and 9.8 cm in the first and second season, respectively) but the highest pod width was observed with the cultivar Palomral (1.59 and 1.60 cm) in the first and second season, respectively comparing to the control treatment with the three cultivars.

Table 5. Effect of cobalt chloride, ascorbic acid, and their two mixtures on pod length (cm) and pod width (cm) of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	Pod length (cm)								Pod width (cm)							
		First season			Mean	Second season			Mean	First season			Mean	Second season			Mean
		[1]Palm	[2]Jag	[3]Mast	of (B)	Palm	Jag	Mast	of (B)	Palm	Jag	Mast	of (B)	Palm	Jag	Mast	of (B)
1	Water	7.6	7.0	9.5	8.0	7.3	6.6	9.2	7.7	1.34	1.39	1.30	1.34	1.42	1.42	1.32	1.38
2	$CoCl_2$ (2mg)	8.1	7.3	9.7	8.3	7.7	6.9	9.5	8.0	1.46	1.43	1.34	1.41	1.51	1.50	1.37	1.46
3	$CoCl_2$ (4mg)	7.6	7.1	9.7	8.1	7.6	6.8	9.3	7.9	1.35	1.40	1.30	1.35	1.45	1.46	1.34	1.42
4	Ascorbic acid	7.7	7.2	9.5	8.1	7.7	7.2	9.5	8.1	1.34	1.44	1.38	1.39	1.51	1.50	1.40	1.47
5	Ascorbic acid	8.1	7.1	9.7	8.3	7.9	6.7	9.4	8.0	1.34	1.45	1.39	1.39	1.53	1.52	1.41	1.49
6	Mix (2 + 4)	8.4	7.8	10.2	8.8	8.4	7.5	9.8	8.6	1.59	1.50	1.47	1.52	1.60	1.58	1.51	1.56
7	Mix (3 + 5)	8.2	7.5	9.9	8.5	8.3	7.3	9.6	8.4	1.37	1.48	1.41	1.42	1.58	1.57	1.48	1.54
Mean of cultivars (A)		7.9	7.3	9.7		7.8	7.0	9.5		1.40	1.44	1.37		1.51	1.51	1.40	
L.S.D. at 0.05 for A		0.56				0.49				NS				0.04			
for B		0.29				0.15				0.07				0.04			
for AB		0.37				NS				NS				0.05			

The three cultivars varied in their number of green seeds/pod as Master B pods contained more seeds (8.5 seeds/pod in both seasons) than the other two cultivars but seeds of Palmoral and Jaguar were heavier than those of Master B with almost insignificant differences among them(Table 6). Data in this table also showed significant effects of the treatments on these two characteristics as the highest value of number of green seeds/pod was recorded with treatment No. 6 (9.1 and 9.0 seeds/pod in the first and second season, respectively) comparing to the control treatments (7.4 and 7.5 seeds/pod in the first and second season, respectively). Plants treated with the same treatment gave the highest value of green sedds/pod (4.63 and 4.62 g in the first and second season, respectively). The interaction between cultivars and treatments was significant for number of seeds/pod as treatment No. 6 with Master B gave the highest value (9.1 and 9.0 seeds/pod in the first and second season, respectively). On the contrary, the effect of this interaction was insignificant for weight of green seeds/pod.

Table 6. Effect of cobalt chloride, ascorbic acid, and their two mixtures on No. of seeds/pod and weight of green seeds/pod (g) of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	No. of seeds/pod								Weight of green seeds/pod (g)							
		First season			Mean of (B)	Second season			Mean of (B)	First season			Mean of (B)	Second season			Mean of (B)
		[1]Palm	[2]Jag	[3]Mast		Palm	Jag	Mast		Palm	Jag	Mast		Palm	Jag	Mast	
1	Water	7.3	7.2	7.8	7.4	7.4	7.2	7.9	7.5	4.15	3.90	3.63	3.89	4.14	3.85	3.53	3.84
2	$CoCl_2$ (2mg)	7.6	7.5	8.4	7.8	7.7	7.4	8.4	7.9	4.45	4.01	4.02	4.16	4.39	3.93	3.95	4.09
3	$CoCl_2$ (4mg)	7.5	7.3	8.3	7.7	7.5	7.3	8.4	7.7	4.30	3.89	3.92	4.03	4.25	3.85	3.83	3.98
4	Ascorbic acid	7.8	7.6	8.5	8.0	7.7	7.7	8.5	8.0	4.64	4.19	4.32	4.38	4.58	4.12	4.24	4.31
5	Ascorbic acid	7.9	7.6	8.6	8.0	7.9	7.6	8.5	8.0	4.96	4.08	4.06	4.37	4.89	4.02	3.92	4.27
6	Mix (2 + 4)	8.2	8.0	9.1	8.4	8.1	8.0	9.0	8.4	4.87	4.46	4.55	4.63	5.03	4.39	4.46	4.62
7	Mix (3 + 5)	8.0	7.9	8.8	8.2	7.9	7.8	8.8	8.2	4.79	4.33	4.31	4.47	4.74	4.26	4.22	4.41
Mean of cultivars (A)		7.7	7.6	8.5		7.8	7.6	8.5		4.59	4.12	4.11		4.57	4.06	4.02	
L.S.D. at 0.05 for A		0.36				NS				NS				0.42			
for B		0.20				0.24				0.23				0.15			
for AB		0.15				0.18				NS				0.19			

[1]Palm: Palmoral; [2]Jag: Jaguar; [3]Mast: Master B.

Plant height (cm)

Palmoral showed the highest plants (95.23 and 95.29 cm) followed by those of Jaguar (85.24 and 84.89 cm) and then Master B (72.97 and 71.91 cm in the first and second season, respectively) with significant differences among them (Table 7). Moreover, all used treatments increased plant heights of the three cultivars comparing to the control treatment (water-treated plants) and treatments No. 6 as usual gave the highest plants (88.82 and 88.41 cm) comparing with the non-treated plants (81.01 and 80.25 cm in the first and second season, respectively). The interaction effect was significant in the first season and insignificant in the second one and treatment No. 6 with Palmoral gave the highest value (98.30 and 98.16 cm in the first and second season, respectively) as shown in Table (7).

Table 7. Effect of cobalt chloride, ascorbic acid, and their two mixtures on plant height (cm) and average green pod weight (g) of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	Plant height (cm)								Average green pod weight (g)							
		First season			Mean of (B)	Second season			Mean of (B)	First season			Mean of (B)	Second season			Mean of (B)
		[1]Palm	[2]Jag	[3]Mast		Palm	Jag	Mast		Palm	Jag	Mast		Palm	Jag	Mast	
1	Water	93.53	81.30	68.20	81.01	93.03	80.80	66.93	80.25	7.72	7.16	6.57	7.15	7.61	7.11	6.50	7.07
2	$CoCl_2$ (2mg)	94.50	82.43	71.26	82.73	95.23	83.30	71.23	83.25	8.18	7.28	7.57	7.68	8.11	7.19	7.49	7.59
3	$CoCl_2$ (4mg)	92.70	82.73	70.03	81.82	93.53	82.80	68.76	81.70	7.88	7.32	7.19	7.46	7.85	7.22	7.11	7.39
4	Ascorbic acid	95.43	85.40	73.66	84.83	94.30	84.70	72.50	83.83	8.28	7.50	7.64	7.81	8.24	7.40	7.60	7.75
5	Ascorbic acid	95.70	86.36	74.50	85.52	95.90	85.00	71.90	84.26	8.42	7.57	7.34	7.78	8.35	7.50	7.29	7.71
6	Mix (2 + 4)	98.30	90.40	77.76	88.82	98.16	89.93	77.13	88.41	8.80	7.90	8.16	8.29	8.70	7.84	8.11	8.22
7	Mix (3 + 5)	96.46	88.10	75.36	86.64	96.90	87.73	74.96	86.53	8.54	7.70	7.86	8.03	8.39	7.65	7.78	7.94
Mean of cultivars (A)		95.23	85.24	72.97		95.29	84.89	71.91		8.26	7.49	7.47		8.18	7.41	7.41	
L.S.D. at 0.05 for A		5.06				4.72				NS				0.51			
for B		1.08				1.21				0.12				0.12			
for AB		2.41				NS				0.15				0.14			

[1]Palm: Palmoral; [2]Jag: Jaguar; [3]Mast: Master B.

Average green pod weight (g)

This variable was almost the same as other values but cultivars did not vary much in their values of average pod weight (g) and the differences among values were significant in the first season and insignificant in the second one (Table 7). Pre-planting treated seeds with the mixture of both $CoCl_2$ and ascorbic acid (treatment No. 6) gave the highest values of average green pod weight (8.29 and 8.22 g) while, those treated with water (the control treatment) gave the lowest values (7.15 and 7.07 g) in the first and second season, respectively. The interaction effect for this variable was significant and the treatment No. 6 with Palmoral shoed the highest values (8.80 and 8.70 g) while the same treatment with Master B gave the lowest values (6.57 and 6.50 g) in the first and second season, respectively.

Fresh yield and dry seed yield (ton/fed)

The three cultivars differed much and significantly in their fresh yield of green pods as Palmoral gave the highest yield (6.78 and 6.90ton/fed) followed by Jaguar (5.72 and 6.00ton/fed) and then Master B (4.60 and 4.66 ton/fed) in the first and second season, respectively (Table 8). Moreover, the applied treatments affected the fresh yield significantly as the treatment No. 6 gave the highest values (5.99 and 6.13 ton/fed) comparing to the control treatment (No. 1) which gave the lowest values (5.37 and 5.59 ton/fed) in the first and second season, respectively. The interaction between cultivars and treatments had a significant effect in the first season and insignificant effect in the second season as treatment No. 6 with Palomral showed the highest fresh yield (7.01 and 7.19ton/fed) while treatment No 1 with Master B showed the lowest fresh yield (4.16 and 4.34ton/fed) in the first and second season, respectively (Table 8). The same trend was observed with the dry seed yield characteristic for the three cultivars which varied significantly. Palmoral gave the highest yield of dry seeds (1.75 and 1.87 ton/fed) two times like those of Master B (0.93 and 1.05ton/fed), while Jaguar gave values in between both of them (1.44 and 1.53ton/fed) in the first and second season, respectively. Seeds treated with treatment No. 6 gave the highest yield of dry seeds (1.67 and 1.78ton/fed) comparing to the control treatment which gave the lowest values (1.08 and 1.18ton/fed) in the first and second season, respectively. The interaction between cultivars and treatments showed significant effects and treatment No. 6 with Palmoral gave the highest yield of dry seeds (2.09 and 2.21ton/fed) while, treatment No. 1 with Master B gave the lowest values (0.72 and 0.80ton/fed) in the first and second season, respectively.

Table 8. Effect of cobalt chloride, ascorbic acid, and their two mixtures on fresh yield/fed (ton) and dry seeds yield /fed (ton) of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	Fresh yield/fed (ton)								Dry seeds yield /fed (ton)							
		First season			Mean of (B)	Second season			Mean of (B)	First season			Mean of (B)	Second season			Mean of (B)
		1Palm	2Jag	3Mast		Palm	Jag	Mast		Palm	Jag	Mast		Palm	Jag	Mast	
1	Water	6.56	5.39	4.16	5.37	6.60	5.84	4.34	5.59	1.32	1.18	0.72	1.08	1.44	1.29	0.80	1.18
2	$CoCl_2$ (2mg)	6.81	5.72	4.53	5.69	6.90	5.99	4.58	5.82	1.79	1.44	0.89	1.37	1.89	1.53	0.99	1.47
3	$CoCl_2$ (4mg)	6.71	5.50	4.45	5.55	6.73	5.83	4.49	5.68	1.53	1.29	0.78	1.20	1.65	1.38	1.01	1.35
4	Ascorbic acid	6.70	5.62	4.65	5.66	6.92	5.90	4.67	5.83	1.84	1.40	0.90	1.38	1.93	1.50	1.00	1.48
5	Ascorbic acid	6.78	5.74	4.70	5.74	6.90	5.96	4.73	5.86	1.77	1.43	1.02	1.40	1.91	1.51	1.13	1.51
6	Mix (2 + 4)	7.01	6.09	4.88	5.99	7.19	6.26	4.95	6.13	2.09	1.76	1.18	1.67	2.21	1.83	1.29	1.78
7	Mix (3 + 5)	6.89	5.98	4.86	5.91	7.09	6.18	4.86	6.24	1.92	1.56	1.05	1.51	2.09	1.65	1.17	1.63
Mean of cultivars (A)		6.78	5.72	4.60		6.90	6.00	4.66		1.75	1.44	0.93		1.87	1.53	1.05	
L.S.D. at 0.05 for A		0.24				0.42				0.04				0.07			
for B		0.10				0.06				0.03				0.04			
for AB		0.16				NS				0.05				0.07			

Volume and weight of 1000 seeds

Data in Table (9) showed that the mean value of 1000-seed volume from Jaguar cultivar was higher than both of Palmoral and Master B, while those of former two cultivars differed insignificantly in the first season but all of them significantly differed in the second season. On the other hand, the applied treatments significantly affected the 1000-seed volume characteristic as treatment No. 6 significantly increased the mean value of this variable to be 198.2 and 194.3cm^3 comparing to the control treatment (176.2 and 171.4cm^3) in the first and second season, respectively. The interaction between cultivars and treatments for this characteristic, it had an insignificant effect in the first season and a significant one in the second season. Regarding the 1000-seed weight characteristic, only the treatment effect was significant and both cultivars and the interaction factors effect was insignificant. Furthermore, seeds pre-planting treated with the treatment No. 6 gave the highest values in both seasons (197.9 and 200.2g) comparing to those pre-planting treated with water (treatment No. 1) gave the lowest values (174.2 and 178.3g) in the first and second season, respectively.

Table 9. Effect of cobalt chloride, ascorbic acid, and their two mixtures on 1000 seeds volume (cm^3) and 1000 seeds weight (g) of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	1000 seeds volume (cm^3)								1000 seeds weight (g)							
		First season			Mean of (B)	Second season			Mean of (B)	First season			Mean of (B)	Second season			Mean of (B)
		[1]Palm	[2]Jag	[3]Mast		Palm	Jag	Mast		Palm	Jag	Mast		Palm	Jag	Mast	
1	Water	174.6	180.0	174.1	176.2	173.1	174.6	166.3	171.4	172.6	177.2	172.9	174.2	176.9	185.0	173.0	178.3
2	$CoCl_2$ (2mg)	187.7	195.9	183.8	189.1	189.3	191.2	186.0	188.8	182.7	191.1	181.3	185.1	189.8	195.8	182.7	189.5
3	$CoCl_2$ (4mg)	177.2	184.1	177.4	179.5	177.1	179.5	175.1	177.2	173.6	181.3	177.0	177.3	181.0	186.2	177.0	181.4
4	Ascorbic acid	184.9	189.3	183.0	185.7	180.5	182.8	176.9	180.1	179.9	186.1	180.8	182.2	185.3	191.7	181.9	186.3
5	Ascorbic acid	190.2	195.0	186.9	190.7	188.7	192.9	183.5	188.4	178.1	187.4	185.0	183.5	183.4	194.2	181.0	186.2
6	Mix (2 + 4)	197.0	200.7	196.9	198.2	194.4	196.9	191.5	194.3	193.0	200.7	199.9	197.9	197.7	209.0	194.1	200.2
7	Mix (3 + 5)	191.6	195.5	192.1	193.0	191.4	194.0	188.8	191.4	186.6	195.6	189.6	190.6	192.3	184.1	188.2	188.2
Mean of cultivars (A)		186.2	191.5	184.9		184.9	187.4	181.2		180.9	188.5	183.8		186.6	192.3	182.6	
L.S.D. at 0.05 for A		4.41				1.08				NS				NS			
for B		3.71				1.66				3.15				8.07			
for AB		NS				1.89				NS				NS			

Dry seeds content of nitrogen (N) and protein

Almost only the applied treatments had significant effects on dry seeds content of N and protein contents of the three used cultivars in the two seasons. Pre-planting treated seeds with the mixture of cobalt chloride and ascorbic acid (Treatment No. 6) gave the highest values of N and protein percentages in the dry seeds (3.69 and 3.71%, 23.0 and 23.2%) comparing with seeds pre-planting treated with water (treatment No. 1) which gave the lowest values of N and protein in the first and second seasons, respectively (3.45 and 3.49%, 21.6 and 21.8%) as shown in Table (10). Also, the effect of treatment No. 3 ($CoCl_2$, 4mg) on these characteristics was similar to that of the control treatment. On the contrary, the effect of both cultivars and the interaction factors was insignificant for N and protein contents in the dry seeds of the three used cultivars.

Table 1. Effect of cobalt chloride, ascorbic acid, and their two mixtures on nitrogen (N) and protein contents (%) of three cultivars of peas grown in two successive seasons of 2009/2010 and 2010/2011

Ser.	Treatments (B)	N %								Protein %							
		First season			Mean of (B)	Second season			Mean of (B)	First season			Mean of (B)	Second season			Mean of (B)
		[1]Palm	[2]Jag	[3]Mast		Palm	Jag	Mast		Palm	Jag	Mast		Palm	Jag	Mast	
1	Water	3.55	3.46	3.35	3.45	3.58	3.49	3.41	3.49	22.1	21.6	21.0	21.6	22.4	21.1	21.3	21.8
2	$CoCl_2$ (2mg)	3.68	3.59	3.45	3.57	3.72	3.61	3.53	3.62	23.0	22.5	21.6	22.4	23.3	22.6	22.1	22.6
3	$CoCl_2$ (4mg)	3.55	3.47	3.40	3.47	3.59	3.45	3.44	3.49	22.2	21.7	21.2	21.7	22.4	21.7	21.5	21.9
4	Ascorbic acid	3.61	3.59	3.51	3.57	3.72	3.61	3.59	3.64	23.1	22.4	22.0	22.5	23.3	22.6	22.4	22.8
5	Ascorbic acid	3.68	3.59	3.46	3.58	3.69	3.61	3.52	3.61	23.0	22.5	21.6	22.4	23.1	22.6	22.0	22.5
6	Mix (2 + 4)	3.76	3.67	3.64	3.69	3.77	3.69	3.66	3.71	23.5	22.9	22.7	23.0	23.6	23.1	22.9	23.2
7	Mix (3 + 5)	3.73	3.62	3.56	3.64	3.75	3.66	3.61	3.67	23.3	22.6	22.3	22.7	23.4	22.9	22.5	23.0
Mean of cultivars (A)		3.65	3.57	3.48		3.69	3.59	3.54		22.9	22.3	21.8		23.1	22.5	22.1	
L.S.D. at 0.05 for A		0.06				0.15				0.20				0.95			
for B		0.04				0.04				0.16				0.17			
for AB		NS				NS				0.20				NS			

Dicussion

There is evidence that cobalt has a positive effect on growth and yield of in some crops e.g., tomatoes. It is suggested that cobalt reduces the peroxdase activity which is known to affect the breakdown of Indole acitic acid (IAA). Plant hormones, especially abcissic acid (ABA) appear to play an important role in plant water relations through their effect on stomata and abcissic acid reduces opening of stomata (Gad, 2005a). The author added that data clearly indicated that cuticle tissues were increased as cobalt addition increased of two varieties. This indicates that 7.5 ppm cobalt has a promotive effect in increasing upper epiderm, plaseed, spongy, lower epidermis and blade thickness tissues. In fact, cobalt help tomato plants to resist stresses caused with high salinity. Lipskaya (1984) pointed out that low level of applied cobalt increased the leaf area as well as the size of chloroplasts in potato plants. It was found also that application of 2kg/ha cobalt increased both number and surface area of chloroplasts/unit leaf area, leaf pigment content and leaf area. Welser *et. al.* (1996) added that the application of 2.7 kg Co/ha of a field contain 0.81 mg available Co/kg soil increased tomato leaf number as well as surface of chloroplasts/unit leaf area, leaf chlorophyll content, leaf area and rate of photosynthesis, hormonal response were possibly involved. Bisht (1991) reported that cobalt and iron are competitive elements in the nutrition of tomato plants. Cobalt seemed to have efficient role in iron translocation from lower old leaves to the upper young leaves (Gad, 2005b). Cobalt level (7.5 ppm) helped tomato plants to resist stresses caused by high salinity and increase the water absorbance capacity and strongly bounds H_2O in the leaves of tomato plants grown in the new reclaimed soil (Anter and Gad, 2001and Gad, 2005b). Cobalt gave the highest figures of all growth and yield parameters of groundnut with 100% N followed by 75% N compared with the untreated plants (Gad, 2012).

The obtained results by Eman *et. al.* (2007) showed that the application of Co and Ni at 20+25mg/kg-1soil gave the highest effect on increasing plant height, number of branches as well as fresh and dry weight of roselle calyces. Also, Young (1983) and Smith (1991) revealed that Cobalt is an essential element for the synthesis of vitamin B12, which is required for human and animal nutrition and is safe for human consumption. However, up to 8 mg can be consumed on a daily basis without health hazard (Young, 1983).

Cobalt is required in low levels for maintaining high yields of cucumber (Scott and William, 1976), and for increasing the growth of wheat (Wilson and Nicholes, 1967) tomato (El-Kobbia and Osman, 1987 and Gad, 1997) squash plants (Atta-Ali, 1998), parsley (Hilmy and Gad, 2002) and groundnut (Basu *et. al.*, 2006). Cobalt, in the form of fertilizer, pre-seeding, and pre-sowing chemicals, increased yield in potatoes (Kenesarina, 1972), groundnut (Joshi *et. al.*, 1987), “Chinese” cabbage (Yagodin and Romanova, 1982), apple (Barbat *et. al.*, 1979), Glycine hispida (Lixandru *et. al.*, 1979), buckwheat (Yagodin and Sablina, 1981), cowpea, and soybean (Yadav *et. al.*, 1986). Excess of Co induces yield reduction and an inhibition in assimilate production in leaves, and even inhibits the export of photo assimilates to roots and other sinks (Rauser and Samarakoon, 1980). Also, it causes oxidative stresses (Tiwari *et. al.*, 2002) and may result in phytotoxity to plants (Chatterjee and Chatterjee, 2003).

The highest yield is due to different factors. These include increased nodule number; percentage of nodules in groundnut and pea (Danilova *et. al.*, 1969); percentage of protein (Glycine hispida); higher concentration of rutin and N, P, Ca, and Mg (buckwheat); total increase in the quantity of acids like citric, malic, and aconitic acids in maize (Kameenova *et. al.*, 1981); increase in length of hypocotyl (Sawan *et. al.*, 1989); lint production in Gossypium barbadense (Sawan, 1985; Sawan *et. al.*, 1989); stem and leaf growth in melon (Ilamanova, 1987).

Ascorbic acid (AsA) is one of the most important and abundantly occurring water soluble antioxidants in plants (Smirnoff, 2000b). Ascorbic acid is an organic compound required in trace amount to maintain normal growth in higher plants (Podh, 1990), Furthermore, AsA affects nutritional cycle’s activity in higher plants and plays an important role in the electron transport system (Liu *et. al.*, 1997). It is also important as a co-factor for a large number of key enzymes in plants (Belanger *et. al.*, 1995; Arrigoni and De Tullio, 2000). Moreover, AsA is involved in the regulation of photosynthesis, cell expansion, root elongation, and trans-membrane electron transport (Noctor and Foyer, 1998; Smirnoff, 2000a). It is also involved in the cell cycle (Kerk and Feldman, 1995) and in several important enzyme reactions, such as violaxanthin deepoxidase (Hager and Holocher, 1994). It may also play a role in floral induction (Barth *et. al.*, 2006). Endogenous It is also involved in the cell cycle (Kerk and Feldman, 1995) and in several important enzyme reactions, such as violaxanthin deepoxidase (Hager and Holocher, 1994). It may also play a role in floral induction (Barth *et*. *al*, 2006). AsA can be increased by exogenous application of AsA through the rooting medium (Chen and Gallie, 2004), as a foliar spray or as seed priming. Some studies suggest that the total endogenous level of AsA influences induction of flowering and senescence (Barth *et. al.*, 2006). Recent investigations revealed that ascorbate content regulates plant defense gene expression and modulate plant growth and development via phytohormone signaling (Pastori *et. al.*, 2003).

CONCULSION

Our results revealed that the three evaluated pea cultivars varied in their horticultural characteristics, yield and chemical composition of nitrogen and protein contents. Moreover, the pre-planting seed treatments applied of cobalt chloride and ascorbic acid in different concentrations and their mixtures enhanced most of these pea characteristics. Pre-planting pea seeds treated with the treatment No. 6 which consisted of $CoCl_2$ (2mg) + ascorbic acid (150ppm) enhanced all the studied characteristics including yield and yield components and increased the dry seeds content of nitrogen and protein compared with the seeds pre-planting treated with water. The other treatments showed values came in between this treatment and the control treatment (the non-treated plants). We recommend pea farmers to use these treatments to enhance pea plants growth, yield and yield components as these used substances are very cheap, available and safe for human consumption and animal feeding.

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