J. Plant Production, Mansoura Univ., Vol. 9 (12): 1189- 1196, 2018

Foliar Application of Ascorbic Acid Combined with Nitrogenous Fertilizer Positively Enhanced the Response of Pea Plants

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ABSTRACT

This study was conducted on pea (*Pisum sativum* L.) cv. Master B in the Experimental Farm of Vegetable Research Station, Faculty of Agriculture, Mansoura University, Egypt during two winter seasons of 2015/2016 and 2016/2017 under silty clay loam conditions by using furrow irrigation system to investigate the effect of ascorbic acid (AsA), inorganic nitrogen (N) fertilization and their interactions on growth, productivity and quality of pea. Therefore, four concentrations of AsA, *viz,* 0, 100, 200 and 400 mg L^{-1} (ppm) applied as a foliar application combined with three N-fertilization levels, *i.e.,* 60, 80 and 100 kg $fed.^{-1}$ as a soil application were studied. The experiment was laid out as split plot in randomized complete block design (RCBD) with three replications. The obtained results revealed that fertilization of pea plants with 100 kg N/fed. combined with foliar application of AsA at 400 mg L^{-1} followed by 80 kg N/fed. with 400 mg L^{-1} of AsA gave significant increases for the traits of plant vegetative growth (plant height and fresh weight, branches and leaves number/plant, leaves fresh weight, leaves area/plant and partially leaves dry matter percentage), leaves chemical composition (N, P and K percentages and chlorophyll a, b and carotenoids contents), pods and seeds yield components (number and fresh weight of green pods/plant, green pods yield/fed., 100 seeds fresh weight and green seeds yield/fed.), seeds quality (Vit. C, TSS, total carbohydrates, crude protein, N, P, and K contents) and moderate values for both seeds nitrate (NO_3) and dry matter percentage of pea compared with control treatment (60 kg N/fed. only), without significant differences between two interaction treatments in both seasons. Concerning the effect of nitrogen fertilization levels, all above mentioned parameters significantly increased with increasing N-fertilization level from 60 kg /fed. to 100 kg /fed. and vice versa for leaves and seeds dry matter percentages and seeds nitrate (NO_3) content in both seasons. As for the impact of AsA, the rate of 400 ppm recorded significant increases for all forecited parameters with the lowest nitrate content of dry seeds compared with control treatment (untreated plants), with no significant differences among AsA concentrations in this respect in both seasons. Therefore, adding 100 kg N/fed. combined with AsA at 400 mg L^{-1} as a foliar application was the best treatment of which this study recommends to use followed by the treatment of 80 kg N/fed. + 400 mg L^{-1} of AsA to reduce the costs of production, environmental pollution and produce safe food for human health.

Keywords: Pea, *Pisum sativum* L, Nitrogen fertilizer, Ascorbic acid (AsA), Vitamin C, Foliar application, Growth, Yield, Nitrate content, Quality.

INTRODUCTION

Pea (*Pisum sativum* L.) belongs to Leguminosae family and it is second important and popular food legume of the world. It occupies a significant rank concerning the local consumption and exportation. Edible part of pea plant has high nutritional value, where it is rich in protein, fibers, carbohydrates, vitamins A, B6, C, folic acid, iron, phosphorus, calcium and appropriate amino acids blend with high digestibility (Thomas, 2008). Thus, pea yields are considered one of the most valuable source in human nutrition in Egypt and many counties over the world.

In Egypt, the cultivated area of peas in 2017 was 138,004 and 43,264 feddan for both dry and green peas, respectively. The total production of these cultivated areas was 166000 ton for dry peas and 189539 ton for green peas, consecutively, with an average of 1.20 ton/feddan for dry peas and 4.38 ton/feddan for green peas (FAO, 2018).

Pea plant has a great demand to macro-nutrients particularly nitrogenous fertilizer. Nevertheless, many producers not aware of suitable rates of these nutrients that could be apply to achieve high pea growth, yield and quality. Therefore, inappropriate application of these nutrients especially nitrogenous fertilizers could materially reduce the growth and productivity of plants with prejudicial effect on environment and human. Increment of pea crop performance in terms of yield and quality is considered an essential goal for any producer. This demand is influenced by plenty of factors such as climatic and soil conditions, employed variety, biotic or a biotic stresses as well as utilized fertilization program. Using proper and moderate amounts of NPK nutrients and foliar application with some safety and efficient antioxidant compounds e.g. ascorbic acid, salicylic acid, acetyl salicylic acid and citric acid, etc. can ameliorate yield and quality of pea (Dawa *et al*., 2013; Abdel Naby *et al*., 2016 and El-Afifi *et al.,* 2017).

The acceleration and earliness of peas vegetative growth is necessary for insurance high crop productivity and quality that are affected by the nitrogenous fertilizer. Investigations conducted by many researchers have indicated that the growth and yield of peas was significantly influenced by nitrogen application (Kakar *et al*., 2002; Dawa *et al*., 2013; Abdel Naby *et al*., 2016) on pea. The principal factor impacting the quality of vegetables is the amount of absorbed nitrogen and the way in which it is used in the plant metabolism, which has an effect on the NO_3-N content in the edible plant tissues (Savvas *et al*., 2013).

Ascorbic acid (vitamin C) is the most abundant antioxidant which protect cell, it is currently considered to be a regulator of plant growth, development and productivity of various plants owing to its effect on cell division and differentiation. Also, ascorbic acid is involved in a wide range of important plant functions as antioxidant defense, photo-protection and regulation of photosynthesis, hormone biosynthesis and growth processes (Gallie, 2012; Lisko *et al*., 2014 and Thomson *et al*, 2017). In addition, ascorbic acid as a non-enzymatic antioxidant is the first line of plant defense, since it inhibits cell membrane oxidation, acts on the reactive oxygen species (ROS) snipe from cell (Arrigoni and De Tullio, 2002 and Naz *et al*., 2016), and it is plays an important role in controlling of oxidation and reduction processes, particularly stress resistance, because of its vital role as a cofactor for several enzymatic activity systems (Smirnoff and Wheeler, 2000 and Zhang, 2013). Many investigators reported that spraying pea plants with AsA positively increased plant growth, productively and quality parameters (Gad El-Hak *et al.,* 2012 and Dawa *et al*., 2014).

Thus, the present investigation aimed to study the effect of nitrogen fertilizer levels and foliar spraying with ascorbic acid concentrations as well as their interactions on vegetative growth characters, leaves chemical composition, pods and seeds yield components and seeds quality of pea plants and moreover determine the best treatment which reduce production costs, pollution of environment and gave safe product for human.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of Vegetable Research Station, Faculty of Agric., Mansoura Univ., Egypt during the two consecutive winter seasons of 2015/2016 and 2016/2017 to study the effect of foliar application with ascorbic acid combined with inorganic nitrogen fertilization levels as a soil application on vegetative growth characters, leaf chemical composition, pods and seeds yield components and seeds chemical quality of pea (cv. Master B) cultured under silty clay loam soil conditions by employing furrow irrigation system. The physical and chemical properties of the experimental soil are exhibited in Table (1).

Table 1. Physical and chemical parameters of the cultured soil during two successive seasons of 2015/2016 and 2016/2017.

Soil parameters	Sand %	Silt %	Clay %	Texture	pH	EC (dSm^{-1})	Organic matter %	$CaCO_3$ %	N ppm	P ppm	K ppm
1st seasons	35.87	39.97	24.16	Silty clay loam	8.19	1.48	1.89	3.24	51.9	5.98	178.1
2nd seasons	35.54	40.10	24.36	Silty clay loam	8.15	1.54	1.93	3.36	53.4	6.13	182.5

Pea seeds were sown in the moderately moist soil on 18th and 15th of October in the two successive seasons, consecutively in hills (5-7 seeds/hill) on three rows/ridge at spacing 20 cm between the hills. The experimental unit area was 12.0 m^2 and it includes five ridges with 3 m length for each and 80 cm width. The emerging plants of each hill were then thinned to be three plants only after three weeks of sowing time.

Treatments of nitrogen fertilizer rates, *i.e*., 60, 80 and 100 kg N/fed. were applied as ammonium sulfate fertilizer (20.5 % N). The nitrogenous fertilizer was divided into 2 equal amounts; the first one was added with the 1st irrigation (21 days after sowing, DAS) and the second one was applied with the 2nd irrigation (42 DAS).

Four different concentrations of ascorbic acid AsA at zero (control treatment which was sprayed with Nile water only), 100, 200 and 400 ppm were done as a foliar application two times at 22 and 43 DAS by using 3 liter of spray solution/experimental unit. AsA was obtained from Al-Gomhoreya Co. for Chemical Industries, Mansoura, Egypt.

All experimental units were received the total amount of farmyard manure at 20 m^3/fed. during soil preparation. Also, phosphorus at 40 kg/fed. as granulated single calcium superphosphate (12.5 % P_2O_5) as 100 % of the recommended dose was equally added for all treatments, where 75% of this fertilizer (240 kg/fed.) was applied during soil preparation, while the another 25% of it (80 kg/fed.) was added at the first irrigation (21 DAS). As well as, potassium at 80 kg/fed. as potassium sulphate (50 % K_2O) which represents 100 % of the recommended dose was also equally applied for all sub plots in two equal doses, the first one was at the first irrigation and the other one was at the second irrigation. The subsequent two irrigations were executed each three weeks.

Experimental design:

The experiments were conducted at split-plots in a randomized complete blocks design with three replicates. The main plots were assigned for treatments of nitrogen fertilization levels, while the sub plots were allocated to ascorbic acid concentrations.

Data recorded:

Five plants were randomly taken from each sub plot to estimate the following parameters in the first and second seasons:

1- Vegetative growth characters:

Plant height, plant fresh weight, branches and leaves number, leaves fresh weight, leaf area and leaves dry matter percentage were recorded after 75 days from sowing.

2- Leaves chemical composition:

Nitrogen, P and K percentage and chlorophyll a, b and total carotenoids content were estimated after 75 days from sowing according to AOAC (1990).

3- Pods and seeds yield components:

Green pods number and fresh weight, green pods yield, 100 seeds fresh weight and green seeds fresh yield were estimated after 90 days from sowing.

4- Seeds chemical quality:

Seeds dry matter (%), Vitamin C (Vit. C), total soluble solids (TSS), N, P, K and nitrate (NO_3) content were determined as reported by AOAC (1990) after 90 days from sowing. Also, total carbohydrates percentage was estimated according to anthrone reagent method described by Sadasivam and Manicham, 1996. As well as, crude protein (%) was calculated by multiplying the total N by 5.75 factor.

Statistical analysis:

Data obtained were statistically analyzed according to the method of analysis of variance (ANOVA) as published by Gomez and Gomez (1984). Least significant difference (LSD) technique was employed to test the differences among treatment means at probability level of 5 % as reported by Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Vegetative growth characters:

Application of nitrogen fertilization to pea plants during the first season of 2015/2016 and the second season of 2016/2017 improved its vegetative growth characters (Table 2). The characters of plant height and fresh weight, number of branches and leaves per plant and plant leaf area were significantly affected by the two highest nitrogen fertilization levels, 100 kg N/fed. and 80 kg N/fed. compared with the lowest level (60 kg N/fed.) during the both seasons, respectively. The highest values in this regard were recorded with pea plants received 100 kg N/fed. While, the lowest values were achieved with the lowest N-level. On the contrary, 60 kg N/fed. level was significantly superior on the two highest N-fertilization levels for leaves dry matter percentage parameter in the two seasons (Table 2).

Such favorable effects of nitrogen fertilizer on growth characters might be expected, since N is known as an essential plant nutrient promoting the merestimatic activity to obtain more tissues and organs and it is plays a major role in nucleic acids and protein synthesis, cell division and

elongation and protoplasm formation (Marschner, 2012 and Gianquinto *et al*., 2013). These results are in agreement with those stated by Ishaq (2002), Kakar *et al*. (2002), Gabr *et al*. (2007), Mishra *et al*. (2010), Dawa *et al*. (2013), El-Waraky *et al*. (2013), El-Sherbiny *et al*. (2014) and Abdel Naby *et al*. (2016) on pea plants.

Concerning the effect of foliar application of ascorbic acid, data in Table 2 show that the AsA at 400 ppm gave significant increases for all above mentioned growth characters of pea compared with control treatment (untreated plants). In general, it is notice that all AsA concentrations registered higher records of all previous growth characters than control treatment, without significant differences among all AsA concentrations in the both seasons, consecutively. The improvement of pea vegetative growth parameters due to foliar application of ascorbic acid may be attributed to that ascorbic acid play multiple roles in plant growth, such as in cell division, cell wall expansion, photosynthesis regulation, root elongation and other developmental processes as well as increasing plant tolerance against various environmental stresses (Gallie, 2012). The advantages of increasing ascorbic acid on enhancing plant growth have been previously reported by Gad El-Hak *et al*. (2012), Dawa *et al*. (2014) and Al-Kaisy *et al*. (2018) on pea.

Table 2. Effect of foliar application with ascorbic acid combined with N-fertilization levels on vegetative growth characters of pea plant during the two seasons of 2015/2016 (S1) and 2016/2017 (S2).

Treatments		Plant Height (cm)		Plant fresh weight (g)		Branches No./plant		Leaves No./plant		Leaves fresh weight (g/plant)		Leaf area (cm^2/plant)		Leaves dry matter (%)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Nitrogen fertilization levels (kg/fed.)															
60		51.1	52.5	25.5	26.2	0.70	0.74	6.37	6.55	6.45	6.63	243	249	20.94	21.47
80		63.0	64.7	31.3	32.2	0.87	0.87	7.89	8.11	7.99	8.21	301	309	17.54	18.03
100		74.7	76.8	37.3	38.3	1.03	1.05	9.32	9.58	9.44	9.70	355	365	13.69	14.07
LSD 5%		11.9	12.6	6.2	6.8	0.16	0.20	1.48	1.55	1.50	1.53	57	69	3.48	3.01
Foliar application with ascorbic acid (ppm)															
zero		57.6	59.4	28.7	29.5	0.80	0.81	7.25	7.46	7.32	7.54	275	284	15.87	16.28
100		62.4	64.1	31.1	31.9	0.86	0.87	7.77	7.98	7.88	8.10	297	305	17.21	17.69
200		63.2	64.9	31.4	32.3	0.87	0.91	7.86	8.07	7.97	8.19	300	309	17.77	18.25
400		68.5	70.3	34.3	35.2	0.95	0.96	8.57	8.79	8.66	8.88	326	334	18.71	19.19
LSD 5%		9.4	9.3	4.5	4.8	0.12	0.14	1.18	1.22	1.19	1.18	45	49	2.60	2.15
Interaction between nitrogen levels and ascorbic acid concentrations															
60	zero	44.5	45.8	22.3	22.9	0.60	0.64	5.56	5.73	5.62	5.79	211	218	19.24	19.61
	100	50.7	52.1	25.2	26.0	0.69	0.71	6.31	6.48	6.40	6.58	241	246	20.97	21.56
	200	50.8	52.2	25.3	26.0	0.71	0.76	6.32	6.49	6.41	6.59	242	248	21.25	21.83
	400	58.3	59.8	29.0	29.9	0.81	0.83	7.30	7.49	7.37	7.56	277	284	22.29	22.87
80	zero	58.9	60.6	29.2	29.9	0.83	0.86	7.49	7.71	7.57	7.79	284	293	16.31	16.80
	100	61.7	63.4	30.7	31.6	0.85	0.87	7.68	7.89	7.80	8.00	294	302	17.30	17.77
	200	63.2	64.9	31.4	32.3	0.87	0.87	7.86	8.07	7.97	8.19	300	309	17.78	18.26
	400	68.2	70.0	34.1	35.0	0.94	0.89	8.54	8.76	8.62	8.85	324	333	18.79	19.28
100	zero	69.5	71.6	34.8	35.8	0.96	0.94	8.69	8.95	8.77	9.04	330	340	12.06	12.42
	100	74.8	76.9	37.2	38.3	1.03	1.03	9.31	9.57	9.45	9.72	356	366	13.36	13.74
	200	75.5	77.6	37.6	38.6	1.04	1.09	9.40	9.65	9.54	9.79	359	369	14.29	14.68
	400	79.0	81.0	39.5	40.5	1.09	1.13	9.88	10.14	9.98	10.24	376	386	15.04	15.43
LSD 5%		16.3	16.2	7.8	8.2	0.21	0.27	2.04	2.12	2.06	2.04	78	85	4.50	3.73

Data presented in the same Table (2) indicate the interaction impact between N-fertilization levels and AsA foliar concentrations on all aforementioned characters. The obtained results in this concern clearly show that interaction treatments between 100 kg N/fed. level and all AsA rates (zero, 100, 200 and 400 ppm) followed by the interaction treatments between 80 kg N/fed. level and all AsA concentrations (100, 200 and 400 ppm) gave significant increases for all forecited characters, except leaves dry matter one as compared with control treatment (60 kg N/fed. and without foliar application of AsA), with no significant differences between interaction treatment of 100 kg N/fed. level with 400 ppm of AsA foliar application and 80 kg N/fed. level accompanied with AsA at 400 ppm in both seasons, respectively. The highest records in this connection were attained with 100 kg N/fed. level combined with 400 ppm of AsA. Whereas, the control treatment registered the lowest records in this respect. On the other hand, interaction treatments between 60 kg N/fed. level and all AsA concentrations had significant effect on leaves dry matter percentage character as compared with the interaction between 100 kg N/fed. level and without foliar spraying of AsA in both seasons. As mentioned above, both nitrogen fertilization levels and ascorbic acid concentrations (each alone) increased growth parameters of pea plant which in turn they together might maximize their effects leading to taller plants, more branches and leaves and heaviest leaves. These results are in the same line with those of Dawa *et al*. (2014) and Abdel Naby *et al*. (2016) on pea.

2- Leaves chemical composition parameters:

Regarding the effect of N-fertilization levels, data shown in Table (3) illustrate that nitrogen, phosphorus and potassium content and chlorophyll a and b as well as total carotenoids contents of pea leaves were significantly influenced with the highest two N-fertilization levels, *i.e*., 100 kg N/fed. and 80 kg N/fed. compared with the lowest one (60 kg N/fed.) in both seasons, respectively, without significant differences between the highest two N-fertilization levels in both seasons for aforementioned parameters. In this connection, Gabr *et al*. (2007) demonstrated that N, K and chlorophyll contents of pea leaves were increased by nitrogen fertilization application over the control treatment. These results are in line with those reported by Zaghloul *et al*. (2015) and Abdel Naby *et al*. (2016) on pea.

Table 3. Effect of foliar application with ascorbic acid combined with N-fertilization levels on NPK percentages and photosynthetic pigment contents in leaves of pea plant during two seasons of 2015/2016 (S1) and 2016/2017 (S2).

Treatments		N (%)		P (%)		K (%)		Chl. a[1] (mg/100g FW*)		Chl. b[2] (mg/100g FW*)		Carotenoids (mg/100g FW*)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Nitrogen fertilization levels (kg/fed.)													
60		2.10	2.11	0.268	0.276	3.04	3.07	47.6	48.9	23.1	23.7	12.3	12.6
80		2.66	2.74	0.336	0.345	3.84	3.94	59.0	60.6	28.4	29.2	14.6	15.0
100		3.17	3.26	0.399	0.410	4.56	4.69	69.6	71.6	33.6	34.6	16.7	17.1
LSD 5%		0.53	0.57	0.066	0.067	0.79	0.83	11.1	11.4	5.2	5.4	2.2	2.3
Foliar application with ascorbic acid (ppm)													
zero		2.39	2.47	0.306	0.315	3.46	3.56	54.0	55.6	25.9	26.6	13.6	14.0
100		2.61	2.69	0.335	0.344	3.82	3.86	58.2	59.9	28.1	28.9	14.4	14.8
200		2.73	2.81	0.340	0.350	3.88	3.99	58.9	60.5	28.7	29.4	14.5	14.9
400		2.84	2.86	0.357	0.367	4.09	4.19	63.8	65.5	30.9	31.7	15.6	16.0
LSD 5%		0.35	0.38	0.046	0.047	0.54	0.53	8.8	9.0	4.2	4.1	1.7	1.6
Interaction between nitrogen levels and ascorbic acid concentrations													
60	zero	1.80	1.86	0.242	0.249	2.66	2.73	41.4	42.7	20.0	20.6	11.2	11.5
	100	2.03	2.10	0.272	0.280	3.10	2.99	47.3	48.6	22.9	23.6	12.3	12.6
	200	2.28	2.35	0.273	0.283	3.12	3.21	47.4	48.6	23.1	23.8	12.3	12.6
	400	2.28	2.14	0.287	0.294	3.29	3.37	54.3	55.7	26.6	27.3	13.7	14.0
80	zero	2.49	2.57	0.313	0.323	3.59	3.70	55.8	57.5	26.7	27.5	14.0	14.5
	100	2.63	2.70	0.331	0.340	3.78	3.88	57.6	59.2	27.8	28.6	14.3	14.8
	200	2.69	2.77	0.340	0.349	3.88	3.99	58.9	60.5	28.7	29.4	14.5	15.0
	400	2.85	2.93	0.359	0.368	4.11	4.21	63.6	65.2	30.3	31.1	15.5	16.0
100	zero	2.88	2.97	0.362	0.373	4.15	4.27	64.7	66.6	30.9	31.8	15.7	16.2
	100	3.18	3.28	0.402	0.413	4.58	4.71	69.8	71.8	33.6	34.6	16.7	17.1
	200	3.22	3.31	0.406	0.417	4.64	4.77	70.4	72.3	34.2	35.1	16.8	17.2
	400	3.40	3.49	0.426	0.437	4.87	5.00	73.6	75.5	35.8	36.8	17.5	17.9
LSD 5%		0.62	0.66	0.080	0.081	0.93	0.92	15.2	15.5	7.3	7.2	2.8	2.9

FW*: Fresh weight Chl. a[1]: Chlorophyll a Chl. b[2]: Chlorophyll b

In respect to the impact of As A on the above mentioned parameters, data of also Table 3 reveal that such previous parameters were significantly affected by As A foliar application at 400 ppm as compared with untreated plants (control treatment) in both growing seasons, successively, without significant differences among the three AsA concentrations (100, 200 and 400 ppm). The maximum values in this regard were achieved with As A at 400 ppm, while the minimum ones were recorded with the control treatment. The accumulation of N, P and K by ascorbic acid foliar application may be due to the positive effect of ascorbic acid on uptake minerals and accumulation them in plant leaves. These results are in accordance with those stated by Helal *et al*. (2005) and Dawa *et al*. (2014) on pea and Youssif (2017) on potato.

As for the combination influence between N-fertilization levels and AsA foliar spraying concentrations, data listed in the same Table (3) declare that aforementioned parameters were significantly increased with 100 kg N/fed. level combined with all AsA treatments followed by the interaction treatments between 80 kg N/fed. level and the three AsA concentrations compared with control one (60 kg N/fed. only) in both seasons, with no significant differences between interaction treatment of 100 kg N/fed. + AsA foliar application at 400 ppm and 80 kg N/fed. + 400 ppm of AsA foliar application. In this concern, the interaction treatment of 100 kg N/fed. level with 400 ppm of AsA recorded the highest values for all mentioned parameters, whereas the control treatment registered the lowest records during both seasons. Regarding the interaction effect between nitrogen fertilization level and ascorbic acid concentration on minerals uptake and pigments contents, similar results were reported by Dawa *et al*. (2014) and Abdel Naby *et al*. (2016) on pea.

3- Pods and seeds yield components:

Respecting the effect of nitrogen fertilization levels on green pods and seeds components, *i.e*., pods no. / plant, pods weight/plant, pods yield/fed. 100-seeds weight and green seeds yield/fed., data of Table (4) indicate that all previous parameters were significantly increased with the highest two N-levels, namely 100 kg/fed. and 80 kg/fed., respectively compared with the lowest one (60 kg/fed.) in both seasons, with no significant differences between the highest two N-levels in this connection. The maximum records were achieved with 100 kg N/fed., while the minimum ones were obtained with pea plants receiving 60 kg N/fed. These increments in pea yield and its components allied with increasing N-fertilization levels may be ascribed to the role of nitrogen in increasing cell division and elongation, meristematic activity and enhancement of chlorophyll, enzymes, protein and protoplasm formation (Marschner, 2012). As well the increment of pea yield and its components may be attributed to increase of plant growth characters as shown from data presented in Table 2. These results are in coincided with those obtained by Achakzai *et al*. (2006), Dawa *et al*. (2013), El-Waraky *et al*. (2013), El-Sherbiny *et al*. (2014) and Abdel Naby *et al*. (2016).

The obtained results in the same Table 4 apparently reveal that all aforementioned parameters significantly influenced with AsA foliar application at 400 ppm as compared with untreated plants (control treatment) in both seasons, with there were approximately no significant differences among all AsA concentrations, *i.e*., 100, 200 and 400 ppm for most above parameters during two seasons, except for pods weight/plant and pods yield/fed. characters. The highest values of forecited traits were resulted from AsA at 400 ppm, whereas the lowest values of these traits were recorded with control treatment in both seasons, respectively. The positive effect of ascorbic acid on pods and seeds yield components may be referred to its role in translocation of metabolites from plant leaves into storage organs, as a result of involving it in the regulation of plant defense gene expression and modulation of growth and development of

plant by phytohormone signaling (Pastori *et al*., 2003) and thereby enhanced total yield. These results go in line with the findings of Kamal and Abo Al-Gaid (2008), Gheeth *et al*. (2013) and Dawa *et al*. (2014) on pea plants.

Data presented in the Table (4) generally demonstrate that combination between N-fertilization level (particularly 100 kg N/fed.) and all foliar spraying treatments of AsA had significant influence on all former pea yield and its components compared with control treatment (plants fertilized with 60 kg N/fed. level only) in both seasons, followed by 80 kg N/fed. level interacted with all AsA foliar application concentrations, without significant differences between combination treatments of 100 kg N/fed. with 400 ppm of AsA and 80 kg N/fed. + AsA at 400 ppm for all above parameters in both seasons. The best interaction treatment in this concern was produced from application of 100 kg N/fed. and spraying pea plants with 400 ppm of ascorbic acid. As previously mentioned, both nitrogen fertilization levels and ascorbic acid concentrations (each alone) enhanced growth parameters of pea plant, thus; they together might maximize their effects leading to more yielding of pods and seeds per plant and per fed. These results are in harmony with those found by Dawa *et al*. (2013), El-Waraky *et al*. (2013), El-Sherbiny *et al*. (2014) and Abdel Naby *et al*. (2016) on pea plants.

Table 4. Effect of foliar application with ascorbic acid combined with N-fertilization levels on pods and seeds yield components of pea plant during two seasons of 2015/2016 (S1) and 2016/2017 (S2).

Treatments		Green pods number/plant		Green pods FW* (g/plant)		Green pods yield (ton/fed.)		100 seeds FW* (g)		Green seeds fresh yield (kg/fed.)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Nitrogen fertilization levels (kg/fed.)											
60		3.87	3.99	23.24	23.88	5.48	5.64	35.14	36.05	2591	2640
80		4.73	4.87	34.79	35.75	8.21	8.44	45.04	46.28	3321	3421
100		5.59	5.75	40.32	41.44	9.52	9.78	53.50	54.97	3945	4073
LSD 5%		0.89	0.93	0.63	0.83	0.15	0.20	8.94	8.87	660	539
Foliar application with ascorbic acid (ppm)											
zero		4.35	4.45	30.43	31.34	7.18	7.40	40.48	41.69	2986	3082
100		4.65	4.79	32.82	33.73	7.75	7.96	44.14	45.37	3256	3347
200		4.77	4.93	33.49	34.39	7.90	8.12	45.60	46.84	3362	3435
400		5.14	5.29	34.39	35.29	8.12	8.33	48.00	49.18	3539	3648
LSD 5%		0.66	0.70	0.87	1.44	0.20	0.34	6.66	6.61	491	501
Interaction between nitrogen levels and ascorbic acid concentrations											
60	zero	3.34	3.42	20.32	20.93	4.80	4.94	31.02	31.94	2288	2356
	100	3.78	3.90	23.39	24.04	5.52	5.67	34.27	35.23	2528	2599
	200	4.00	4.12	24.21	24.87	5.71	5.87	36.67	37.66	2703	2725
	400	4.36	4.50	25.03	25.68	5.91	6.06	38.59	39.38	2845	2881
80	zero	4.48	4.60	32.05	33.01	7.56	7.79	41.96	43.22	3095	3187
	100	4.60	4.74	34.54	35.48	8.15	8.37	44.36	45.58	3272	3362
	200	4.68	4.86	35.46	36.43	8.37	8.60	45.61	46.85	3362	3453
	400	5.14	5.28	37.12	38.08	8.76	8.99	48.21	49.47	3554	3681
100	zero	5.22	5.34	38.93	40.09	9.19	9.46	48.46	49.91	3574	3703
	100	5.58	5.74	40.55	41.68	9.57	9.84	53.79	55.30	3968	4079
	200	5.64	5.80	40.78	41.88	9.62	9.88	54.53	56.00	4020	4128
	400	5.92	6.10	41.04	42.10	9.68	9.94	57.20	58.69	4217	4383
LSD 5%		1.15	1.21	1.50	2.50	0.35	0.59	11.54	11.44	851	867

FW*: Fresh weight

4- Seeds chemical quality:

Data shown in Table (5) indicate the impact of nitrogen fertilization levels on pea seeds chemical quality parameters, namely Vit.C, TSS, total carbohydrates, crude protein, N, P, K, nitrate (NO_3) and seeds dry matter contents. The obtained data obviously elucidate that all above parameters were significantly influenced by N-levels. The means of all these parameters, except nitrate (NO_3) content and seeds dry matter percentage ones, were gradually increased with increasing nitrogen fertilization levels from 60 to 100 kg/fed. in both seasons, respectively. Application of 100 kg N/fed. or 80 kg N/fed. gave significant increases for mentioned attributes compared with 60 kg N/fed. level, without significant differences between the highest two N-levels for Vit.C, TSS, protein, N, P and K parameters during two seasons. On the contrary, both nitrate (NO_3) content and dry matter percentage of pea seeds were significantly decreased with increasing N-levels in both seasons. Where, the highest values of dry matter percentage and the lowest nitrate content of pea seeds were achieved when plants fertilized with 60 kg N/fed. compared with the highest two N-levels. The increments of pea seeds chemical quality as a consequence of nitrogen fertilization could be explained on the basis of nitrogen does a structural ingredient of all proteins comprise enzymes and coenzymes, which are participated in all biochemical reactions that simultaneously constitute the plant growth and development processes. In addition, it is an essential component of nucleic acids, nucleotides, phosphatides, hormones and is considered a central portion of chlorophyll molecules. Furthermore, it is exist in plant alkaloids, certain B complex vitamins and in various other compounds. Thus, it stimulates vegetative growth parameters and ensures formation of high flower rates, set fruits and flow assimilates into developing fruits (Marschner, 2012 and Gianquinto *et al*., 2013), and consequently enhancement of pea seeds quality attributes with the help of sufficient supply of other nutrients such as potassium and phosphorus. These results are in harmony with the obtained results by Dawa *et al.* (2013) and Abdel Naby *et al*. (2016) on pea.

Concerning the effect of ascorbic acid concentrations, data also presented in Table (5) show that foliar spraying of AsA at 400 ppm gave significant increases for nearly all previous parameters of green seeds and seeds dry matter with the lowest nitrate content of dry pea seeds compared with the control treatment (untreated plants), without significant differences among all AsA concentrations (100, 200 and 400 ppm) for these parameters in both seasons, consecutively.

The maximum means were achieved with AsA at 400 ppm, whereas the minimum means were recorded with the control treatment. These results are in the same line with the findings previously mentioned by Kamal and Abo Al-Gaid (2008), Gheeth *et al*. (2013) and Dawa *et al*. (2014) on pea.

Table 5. Effect of foliar application with ascorbic acid combined with N-fertilization levels on seeds chemical quality of pea plant during the two seasons of 2015/2016 (S1) and 2016/2017 (S2).

Treatments		Vit. C (mg/100g FW*)		TSS (%)		Total carbohydrates (%)		Crude protein (%)	
		S1	S2	S1	S2	S1	S2	S1	S2
Nitrogen fertilization levels (kg/fed.)									
60		24.94	25.71	12.49	12.85	45.4	46.7	16.9	17.4
80		31.99	32.87	16.01	16.46	52.3	53.8	20.9	21.5
100		37.99	39.03	19.02	19.55	58.5	60.2	24.8	25.5
LSD 5%		6.34	6.80	3.18	3.40	3.4	3.5	3.9	4.1
Foliar application with ascorbic acid (ppm)									
zero		28.72	29.57	14.38	14.81	49.9	51.4	19.1	19.7
100		31.38	32.19	15.71	16.16	51.3	52.8	20.7	21.3
200		32.39	33.27	16.22	16.66	53.1	54.6	20.9	21.5
400		34.08	35.11	17.07	17.52	54.0	55.5	22.7	23.3
LSD 5%		4.73	5.04	2.37	2.43	2.2	2.3	3.1	3.2
Interaction between nitrogen levels and ascorbic acid concentrations									
60	zero	22.00	22.68	11.02	11.35	42.5	43.8	14.7	15.2
	100	24.36	24.86	12.20	12.57	43.7	45.0	16.8	17.3
	200	26.04	26.76	13.04	13.39	47.4	48.7	16.8	17.3
	400	27.38	28.54	13.72	14.08	48.1	49.4	19.3	19.8
80	zero	29.78	30.64	14.90	15.35	49.6	51.1	19.5	20.1
	100	31.56	32.42	15.79	16.23	52.0	53.4	20.5	21.0
	200	32.40	33.30	16.22	16.66	53.2	54.7	21.0	21.5
	400	34.24	35.12	17.15	17.59	54.5	55.9	22.6	23.2
100	zero	34.38	35.40	17.21	17.73	57.6	59.4	23.1	23.8
	100	38.24	39.30	19.15	19.68	58.2	59.8	24.8	25.5
	200	38.74	39.76	19.39	19.92	58.6	60.3	25.1	25.7
	400	40.62	41.68	20.34	20.89	59.6	61.2	26.2	26.9
LSD 5%		8.19	8.73	4.10	4.21	3.8	3.9	5.4	5.6

Treatments		N (%)		P (%)		K (%)		NO_3 (mg/kg DW*)		Seeds dry matter (%)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Nitrogen fertilization levels (kg/fed.)											
60		2.95	3.03	0.284	0.295	1.79	1.86	13.1	13.5	26.69	27.42
80		3.64	3.74	0.350	0.360	2.21	2.26	16.2	16.6	23.04	23.68
100		4.31	4.43	0.415	0.427	2.62	2.70	19.2	19.7	20.62	21.19
LSD 5%		0.68	0.71	0.066	0.071	0.41	0.44	3.0	3.2	1.69	2.01
Foliar application with ascorbic acid (ppm)											
zero		3.33	3.43	0.320	0.330	2.02	2.06	17.6	18.1	21.92	22.58
100		3.60	3.70	0.347	0.356	2.19	2.25	16.2	16.7	23.34	23.99
200		3.65	3.75	0.351	0.366	2.22	2.28	16.0	16.5	23.72	24.36
400		3.96	4.06	0.381	0.391	2.40	2.49	14.8	15.2	24.82	25.46
LSD 5%		0.54	0.56	0.052	0.055	0.33	0.35	2.4	2.5	1.57	1.87
Interaction between nitrogen levels and ascorbic acid concentrations											
60	zero	2.57	2.65	0.247	0.255	1.56	1.61	15.0	15.4	24.52	25.25
	100	2.92	3.01	0.280	0.290	1.78	1.83	13.0	13.4	26.69	27.44
	200	2.93	3.02	0.282	0.305	1.78	1.83	13.0	13.4	27.11	27.84
	400	3.37	3.45	0.324	0.332	2.05	2.07	11.4	11.7	28.43	29.17
80	zero	3.40	3.50	0.327	0.337	2.07	2.16	17.5	18.1	22.24	22.90
	100	3.56	3.66	0.343	0.352	2.16	2.22	16.2	16.7	22.65	23.27
	200	3.65	3.70	0.351	0.361	2.22	2.28	15.9	16.3	23.32	23.96
	400	3.94	4.04	0.379	0.389	2.39	2.46	15.1	15.5	23.96	24.59
100	zero	4.02	4.14	0.387	0.398	2.44	2.51	20.3	20.9	19.01	19.58
	100	4.32	4.44	0.416	0.428	2.63	2.70	19.4	20.0	20.69	21.27
	200	4.36	4.48	0.420	0.432	2.65	2.72	19.2	19.7	20.72	21.29
	400	4.56	4.68	0.439	0.451	2.77	2.85	17.9	18.3	22.06	22.63
LSD 5%		0.94	0.97	0.090	0.096	0.57	0.60	4.2	4.3	2.72	3.24

FW*: Fresh weight DW*: Dry weight

The diverse interactions between nitrogen fertilization levels and foliar spraying with ascorbic acid concentrations on Vit.C, TSS, total carbohydrates, protein, N, P, K, nitrate (NO_3) content and seeds dry matter parameters in both growing seasons are presented in Table 5. The obtained results which shown in this table indicate that interactions between 100 kg N/fed. level and all AsA foliar spraying treatments, *i.e*., zero, 100, 200 and 400 ppm gave significant increases for Vit.C, TSS, total carbohydrates, protein, N, P and K parameters and moderate values for nitrate (NO_3) content and seeds dry matter % parameters of pea seeds, followed by interaction treatments between 80 kg N/fed. level and all AsA foliar spraying concentrations (100, 200 and 400 ppm) as compared with control treatment (plants received 60 kg N/fed. without foliar spraying with AsA) in both seasons, with there were no significant differences between interaction treatments of 100 kg N/fed. level and all AsA foliar spraying levels and 80 kg N/fed. level combined with AsA at 400 ppm. Generally, the highest values of Vit.C, TSS, total carbohydrates, protein, N, P and K were produced from

fertilization of pea plants with 100 kg N/fed. and foliar application with AsA at the rate of 400 ppm in both seasons. On the other hand, the interactions between 60 kg N/fed. and all AsA foliar spraying treatments had significant effects on nitrate (NO_3) content and seeds dry matter attributes comparing with the interaction between 100 kg N/fed. level and without foliar spraying with AsA in both growing seasons as shown from results presented in Table (5). In this connection, the highest mean for dry matter percentage and the lowest nitrate (NO_3) content of pea seeds were resulted from the interaction between 60 kg N/fed. and AsA at 400 ppm, and conversely with the treatment of 100 kg N/fed. and without foliar spraying with AsA.

The increases in pea seeds chemical quality that resulted from interaction between N-fertilization and ascorbic acid foliar spraying may be due to the important role of ascorbic acid as an efficient component of the plant's antioxidative system in modulating signaling networks that regulate physiological and biochemical processes and stress responses and thereby it detoxify oxygen free radicles that cause cellular damage by avoidance of nucleic acids, proteins and lipids oxidation (Pastori *et al*., 2003 and Zhang, 2013) and consequently ascorbic acid act with nitrogen on accumulation of these metabolites within plant parts especially fruits and thus improving seeds quality traits of pea. Also, the obtained stimulatory effect of fertilization with 100 kg N/fed. and foliar application of AsA on pea yield (pods no./plant, pods weight/plant, pods yield/fed. 100-seeds weight and green seeds yield/fed.) and seed quality (*i.e*., Vit.C, TSS, total carbohydrates, crude protein, N, P, K, nitrate and seeds dry matter contents) may be attributed to enhancing effect of this treatment on plant vegetative growth parameters (Table 2) and leaf mineral contents and photosynthetic pigments (Table 3) which in turn positively affected yield and quality parameters of pea plants. These results are in agreement with those of Kamal and Abo Al-Gaid (2008), Gheeth *et al*. (2013), Dawa *et al*. (2014) and Abdel Naby *et al*. (2016) on pea.

CONCLUSION

Under the conditions of this study, it is concluded that fertilization pea plants with 100 kg N/fed. as a soil application combined with foliar spraying two times with AsA at 400 ppm gave the highest yield and quality parameters, followed by the treatment of 80 kg N/fed. + 400 ppm of AsA to reduce the costs of inorganic nitrogen fertilizer, eco-pollution and produce safe food for human health.

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الرش الورقي بحامض الأسكوربيك بالتداخل مع التسميد النيتروجيني حسن إيجابياً إستجابة نباتات البسلة

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لقد أجريت هذه الدراسة على نبات البسلة صنف ماستر بي بالمزرعة التجريبية لمحطة بحوث الخضر، كلية الزراعة، جامعة المنصورة، مصر خلال الموسمين الشتويين لعامي 2016/2015 و 2017/2016 تحت ظروف تربة طمية سلتية طينية باستخدام نظام ري سطحي لدراسة تأثير حامض الأسكوربيك، والتسميد النيتروجيني الغير عضوي وتفاعلاتهما على نمو وإنتاجية وجودة البسلة. لذلك، تم دراسة أربع تركيزات من حامض الأسكوربيك، أي بدون، 100، 200 و 400 ملجم/لتر (جزء في المليون) كإضافة ورقية بالتداخل مع ثلاث مستويات تسميد نيتروجيني أرضي هى 60، 80 و 100 كجم نيتروجين/فدان. لقد صممت التجربة كقطع منشقة في تصميم قطاعات كاملة العشوائية ذو ثلاثة مكررات. هذا ولقد أظهرت النتائج المتحصل عليها أن تسميد نباتات البسلة بـ 100 كجم نيتروجين/فدان بالتداخل مع الرش الورقي بحامض الأسكوربيك بتركيز 400 ملجم/لتر متبوعة بـ 80 كجم نيتروجين/فدان مع 400 ملجم/لتر من حامض الأسكوربيك أعطت زيادات معنوية لصفات النمو الخضري النباتي (إرتفاع النبات والوزن الطازج للنبات، وعدد الأفرع والأوراق لكل نبات، الوزن الطازج للأوراق، والمساحة الورقية للنبات وبصورة جزئية للنسبة المئوية للمادة الجافة بالأوراق)، والتركيب الكيماوي للأوراق (النسب المئوية للنيتروجين، الفوسفور والبوتاسيوم، ومحتويات كلوروفيل أ، كلوروفيل ب والكاروتينيدات)، ومكونات محصول القرون والبذور (العدد والوزن الطازج للقرون الخضراء لكل نبات، محصول القرون الخضراء للفدان، الوزن الطازج لـ 100 بذرة ومحصول البذور الخضراء للفدان)، وجودة البذور (محتويات فيتامين ج، والمواد الصلبة الكلية الذائبة، والكربوهيدرات الكلية، والبروتين الخام، والنيتروجين، والفوسفور والبوتاسيوم) وقيم معتدلة للنسب المئوية لكل من النترات والمادة الجافة ببذور البسلة مقارنة بمعاملة الكنترول (60 كجم نيتروجين فقط للفدان)، بدون إختلافات معنوية بين معاملتي التفاعل خلال الموسمين. وفيما يتعلق بتأثير مستويات التسميد النيتروجيني، فإن جميع الصفات السابقة الذكر قد زادت معنوياً بزيادة مستوى التسميد النيتروجيني من 60 كجم نيتروجين للفدان إلى 100 كجم نيتروجين للفدان، والعكس بالعكس بالنسبة للنسب المئوية للمادة الجافة بالأوراق والبذور ومحتوى البذور من النترات في كلا الموسمين. وفيما يتعلق بتأثير حامض الأسكوربيك، فإن معدل الرش الورقي بـ 400 جزء في المليون قد سجل زيادات معنوية لجميع الصفات سابقة الذكر مع أقل محتوى للنترات ببذور البسلة الجافة مقارنة بمعاملة الكنترول (النباتات الغير معاملة)، بدون وجود إختلافات معنوية بين تركيزات حامض الأسكوربيك في هذا الشأن خلال موسمي النمو. لذلك، فإن إضافة 100 كجم نيتروجين للفدان بالتداخل مع حامض الأسكوربيك بتركيز 400ملجم/لتر كإضافة ورقية تعتبر المعاملة الأفضل التي توصي هذه الدراسة باستخدامها، متبوعة بالمعاملة 80 كجم نيتروجين للفدان + حامض الأسكوربيك بتركيز 400ملجم/لتر لتقليل تكاليف الإنتاج، والتلوث البيئي وإنتاج غذاء آمن لصحة الإنسان.