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Effect of micronutrient foliar application on seed yield and storability of pea cv. Master B

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Abstract

Two field trials were carried out during the winter seasons of 2015-16 and 2016-17 at Sakha Horticultural Research Station Farm, Kafr El-Sheikh University, Egypt to examine the response of pea cv. Master B as foliar nutrients application with boron, manganese, and zinc at shooting, flowering, and podding stages. The results showed that foliar application of micronutrient (boron, manganese, and zinc) at all three stages enhanced most vegetative growth characters, shelling ratio, seed yield and its components, seed germination percentage, chlorophyll leaf contents and seed protein content. It was found that the foliar application of boron, manganese, and zinc at three stages of growth seemed to be the best effective treatment for more robust vegetative growth and seed yield and quality enhancement.

Keywords: pea (*Pisum sativum* L.), foliar micronutrients (B, Mn and Zn), growth.

Introduction

Peas (*Pisum sativum* L.), a winter season crop, is one of the most important pulse crops in Egypt, due to high contents of protein, carbohydrates, vitamins, and minerals. It can grow throughout different soil types extending from the light sandy loam to the heavy clay soil. Most pea cultivars are grown for fresh and/or dry seeds yield. Foliar application is an excellent method for amending soil nutrient deficiencies and overcoming the soil's inability to supply nutrients to the plant (Marchener 1995 and Stigler et al. 2010). Nutrition of crops with micro-nutrients is mostly performed either through soil or foliar application. High pH level and calcium carbonate content are known to render the micro-nutrients added to the soil into unavailable from. Therefore, the required small quantities from micro-nutrients are preferably supplied in the form of a dilute spray to enhance plant response to the added micro-nutrients. Also, foliar nutrition is a practiced when nutrient shortages cannot be fixed by nutrient applications to the soil (Sarkar et al. 2007). Another advantage of foliar application is direct application of micronutrient on target plant, so weeds are not benefited (Chaubey et al. 2016). Boron is one of the micro-nutrients that have important roles in the physiological and metabolic processes of plants. Boron, also, facilitates transport of carbohydrates through cell membranes. Apart from boron, manganese plays crucial roles in the metabolism of isoprenoids, chlorophylls, carotenoids, and phenolics. External application of Mn^{2+} increases photosynthesis, net assimilation and relative growth and yield (Lidon and Teixerira 2000, Sultana et al. 2001). Manganese plays a vital role in nitrogen metabolism, photosynthesis, and forms several other compounds required for plant metabolism. Manganese acts as an activating factor in a plant that almost activates 35 various enzymes in the plant (Mengel and Kirkby 2001). Zinc is one of the trace elements which are needed for the regular healthy growth and reproduction of crop plants (Alloway 2004). In addition, the deficiency of zinc is one of the highly significant and prevalent deficiencies of micronutrients in the world which cause the decrease of crop's products (Brown et al. 1993). Zinc is required for chlorophyll production, pollen function, fertilization and germination (Kaya and Higgs 2002, Pandey et al. 2006). Zinc can become inactivated within cells by the formation of complexes with organic legends or by complexes with phosphorus (Brown et al. 1993). Zinc has high phloem movement from leaves to roots, stems and maturing grain and from one root to another (Rengel 2001). Keeping in the view of above mentioned benefits of micronutrient like B, Mn and Zn the present investigation was carried out to examine the influences of time of foliar application of boron, manganese, and zinc on growth, seed yield and seed quality of the pea plants.

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Materials and Methods

This study was carried out at the experimental farm of Sakha Horticultural Research Station Farm, Kafr El-Sheikh University, for two seasons of 2015-16 and 2016-17. The main goals of these trials were to study the influence of stages of micronutrient application (shooting, flowering, and podding stages) and foliar nutrition with boron, manganese and zinc and their interactions on vegetative growth, dry seed yield and their components of pea cv Master B which is an early maturing, determinate and fertilizer responsive cultivar widely grown in Egypt. The soil of the experimental site is clayey in texture (Table 1).

Total chlorophyll content of leaves measured by the SPAD-501, a portable leaf chlorophyll meter (Minolta crop) was used for greenness measurements (Marquard and Timpton 1987) on fully expanded leaves (the fifth from the shoot tip) leaves without destroying them. Vegetative traits such as plant height, leaves number plant^{-1}, leaf area plant^{-1} and plant fresh weight were recorded. Shelling ratio was measured by dividing the fresh weight of the green seeds extracted from 30 pods on the total weight of these pods. After harvesting, the yield of dry seed and its components, and germination percentage were determined, the plants of the three middle rows allocated to evaluate the subsequent data, i.e., dry seed yield plant^{-1} and dry seed yield ha.$^{-1}$, weight of seeds pod^{-1}, seed index (weight of 100 seeds), dry seeds protein which measured by a random sample of 100 seeds from each treatment. Store ability of pea crop expressed as seed germination (%), which was recorded from old dry seeds that were stored for one year at room temperature as suggested by Anitha et al. (2001). For seed germination, seeds collected from middle position of pods were placed on filter paper (Whatman No. 1) moistened with distilled water in 155 mm glass Petri dishes. Three replicates of 50 seeds from each treatment were kept in germinator at 25±2 °C. Germinated seeds were counted daily starting from 5th day to till 14th days. Germination percentage, thereafter, was calculated according to ISTA (2012).

Table-1: Structural, textural, chemical and mineral profile of experimental site.

Season	Mechanical analysis			Texture	pH*	EC** dSm^{-1}	OM (%)	Available elements (ppm)			Soluble cations (meq/L)				Soluble anions (meq/L)		
	Sand (%)	Silt (%)	Clay (%)					N	P	K	Na^+	Ca^{++}	Mg^{+++}	K^+	HCO_3	Cl^-	SO_4^{--}
1st	10.0	40	50.0	Clayey	8.42	4.03	1.68	46	10	250	22.5	5.86	10.75	0.35	4.7	12.0	22.75
2nd	9.5	39.5	51.0	Clayey	8.15	4.01	1.70	48	12	250	23.5	5.90	10.85	0.35	4.7	11.8	22.60

* 1: 2.5 soil: water suspension.

** Soil past extract

Foliar treatment of micronutrients was performed at specific stages only at once at shooting stage, at flowering stage, at podding stage and at all three stages i.e. shooting, flowering and podding stages. Seven foliar treatments of micronutrient consist of only boron, manganese, zinc and in combination of B+Mn, B+Zn, Mn+Zn, and B+Mn+Zn, in addition to the control only with water. The manure sources involved Boron ethanol amen 10% B, manganese EDTA 13% Mn and zinc EDTA 13% Zn. The foliar concentration of boron, manganese, and zinc were 10, 200 and 100 ppm respectively. Few drops of salient film were added to the spraying (480 l/ha.) as a wetting agent. Plants of the control treatment were sprayed with water. In all treatments, pea seeds were inoculated by an effective Rhizobium strain just before sowing. The sowing was done during 1st week of November in both years. The experiments were performed using the split-plot design in a randomized complete blocks design with four replications. The main plots were devoted for the stages of micronutrient application; whereas, the sub-plots were allocated for boron, manganese and zinc treatments. Each sub-plot contained 5 rows, 5m in long and 0.6 m in wide, comprising an area of 15 m^2. Spacing between plants within rows was 15 cm, and sowing was done on one side of the row.

After the completion of the spraying of nutrients about 60 days from sowing, the following data were recorded:

Seed samples were oven dried, crashed and digested using sulphoric and salicylic acid and a catalyst mixture method according to Cottenie et al. (1982). Nitrogen in the digested seeds was determined by micro-Kjeldahl method according to Jackson (1958), the nitrogen content of pea seeds was multiplied by a factor of 6.25 to calculate the crude protein content. Soil samples were collected, air dried and finely ground for chemical and mechanical analysis according to Jackson 1958 and Black et al. (1965). The statistical analysis of mean data for the design (RBD) was worked out by using M-stat-C software; and treatment means were compared by Duncan's multiple range test (Duncan 1955).

Results and Discussion

I. Vegetative characters:

a. Effect of growth stages: Data shown in Table-2 indicated that growth parameters viz, plant height, leaves number plant^{-1}, leaf area plant^{-1}, chlorophyll content, plant fresh weight and shelling percentage were significantly affected by micronutrient foliar application at all stages in both the growing seasons. However, there were no considerable variations between application times of foliar application in the first season for chlorophyll content. This attributed to the role of B, Mn, Zn in CO_2 flowing out, vitamin A enhancement and resistant system performances through different stages of growth (Malakoti and Keshavarz 2003, Mahbobeh et al. 2011).

Table-2: Effect of growth stages and foliar nutrients on vegetative characters on pea plants in 2015-16 and 2016-17

Treatments	Plant height (CM)		Number of leaves/plant		Leaf area/plant (cm2)		Chlorophyll Content SPAD unit		Plant fresh weight (g)		Shelling ratio (%)	
	1^{st}	2^{nd}	1^{st}	2^{nd}	1^{st}	2^{nd}	1^{st}	2^{nd}	1^{st}	2^{nd}	1^{s}	2^{nd}
Shooting stage	49.2 a	53.9 b	23.9 ab	28.0 ab	832.2 b	1058.3 b	40.02	42.82 ab	94.90 b	106.2 b	70.1 d	71.4 d
Flowering stage	43.8 b	47.3 c	21.3 bc	25.8 b	790.2 c	975.2 c	38.95	41.51 ab	90.61 c	98.90 c	70.3 cd	71.6 cd
Podding stage	41.0 b	44.4 d	19.8 c	23.5 c	755.2 d	931.1 d	38.37	40.67 b	88.60 c	92.60 d	71.2 b	72.1 b
S. + F. + P. stages*	52.2 a	58.0 a	25.2 a	29.6 a	861.0 a	1113.9 a	40.67	43.50 a	98.58 a	110.8 a	71.7 a	72.4 a
F. test	**	**	**	**	**	**	n.s	*	**	**	*	*
Control	36.9 d	40.6 d	18.1 c	20.8 b	720.5 h	871.3 h	37.43 b	39.65 b	84.60 d	87.50 d	68.8 d	0.3 d
B	39.6 c	42.6 d	18.9 bc	21.8 b	731.6 g	897.5 g	37.93 b	40.24 ab	86.38 d	89.30 d	71.8 a	72.6 a
Mn	46.4 b	50.8 c	22.5 ab	27.1 ab	808.1 f	1010.9 f	39.54 ab	42.24 ab	92.83 c	102.20 c	70.0 c	71.3 c
Zn	47.1 b	51.8 c	23.0 a	27.5 ab	816.2 e	1024.7 e	39.71 ab	42.40 ab	93.45 c	103.30 bc	70.1 c	71.4 bc
B + Mn	48.2 b	52.8 c	23.4 a	27.9 ab	826.0 d	1044.1 d	39.86 ab	42.59 ab	94.40 c	104.7 bc	72.0 a	72.7 a
B +Zn	49.0 b	53.6 bc	23.9 a	28.3 ab	835.7 c	1059.9 c	40.01 ab	42.75 ab	95.15 bc	106.50 b	72.1 a	72.7 a
Mn + Zn	52.2 a	57.1 ab	25.3 a	28.9 ab	868.2 b	1115.3 b	40.64 ab	43.41 a	98.50 ab	110.90 a	70.3 bc	71.4 bc
B + Mn + Zn	52.9 a	58.1 a	25.6 a	30.6 a	874.9 a	1133.6 a	40.90 a	43.72 a	99.80 a	112.60 a	72.3 a	72.8 a
F. test	**	**	**	**	**	**	**	**	**	**	*	*

Means designated by the equal letter at each column are not considerably different at the 0.05 level of probability, according to Duncan's Multiple Range Test.
S. + F. + P. stages = Shotting, flowering and podding stages.
B = Boron, Mn = Manganese, Zn = Zinc.

b. Effect of foliar nutrients: Foliar application of (B+Mn+Zn) gave the tallest plants, the highest leaves number, leaf area, chlorophyll content as well as the largest plant fresh weight and shelling percentage in both the seasons, followed by the treatment of (Mn+Zn), whereas the untreated plants produced the lowest value of each character (Table 2). The improving effects of boron may be attributed to the direct action of boron on the development of N-fixing root nodules (Bolanos et al. 1994) and translocation of sugars through cellular membranes (Dugger and Palmer 1983). Manganese acts as an activating factor in a plant that almost activates 35 various enzymes in the plant. In addition, zinc has high phloem mobility from leaves to roots, stems and developing grain and from one root to another (Mengel and Kirkby 2001, Rengel 2001, Texeira et al. 2004). In the same line, Bin Ishage (2002) and El-Waraky et al. (2013) stated that spring pea plants with various concentrations of boron resulted in more vigorous vegetative growth compared with the untreated ones.

c. Effect of growth stages and foliar nutrients interaction: Data tabulated in Table-3 show that foliar nutrient (B, Mn and Zn) at shooting, flowering and podding stages had the high values of plant height, leaf area, chlorophyll content, plant fresh weight and shelling percentage, followed by foliar nutrients with (Mn and Zn) at the same (shooting, flowering and podding stages) and foliar nutrients with (B, Mn and Zn) and /or foliar nutrients with (Mn and Zn) at shooting stage. Thus, compared with those of the foliar nutrients and flowering and/or podding stages. These outcomes were in harmony with Mahbobeh et al. (2011).

II. Dry seed yield and its components

a. Effect of growth stages: Foliar nutrients application at (shooting, flowering and podding stages) significantly increased average seed yield plant^{-1}, total seed yield ha.$^{-1}$, weight of seeds pod^{-1}, seed index (weight of 100-seeds), dry seed protein content and seed germination percentage in both the seasons (Table-4). The positive effects of micronutrient application on quantity and quality of pea yield might be related to its beneficial effects on enzymes system activities and vegetative growth characters (Table 2), which probably supplied more photosynthesis and hence might help in increasing yield potential, as mentioned by Mahbobeh et al. (2011). Days to first flowering, single pod weight, weight of seeds per pod, pod length, number of seeds per pod and number of branches per plant also had positive and direct effect on pod and seed yield per plant (Gautam et al. 2017)

b. Effect of foliar nutrients: Data in Table (4) clearly shown that foliar application with boron, manganese, and zinc, gave the highest values for yield components, where they increased average seed yield plant^{-1}, total seed yield ha.$^{-1}$, weight of seeds pod^{-1}, seed index, dry seeds protein and seed germination percentage over the control. However, there were insignificant differences between the foliar application with B and /or (B+Mn) and /or (B+Zn), in both seasons. Similar results were reported by Bin Ishaq (2002), El-Waraky et al. (2013) who found that boron applied at 10 ppm of boron as a foliar spray to pea plants caused a significant increment in pea seed yield and its components.

c. Effect of growth stages and foliar nutrients interaction: The comparisons between the mean values of each character indicated that foliar application with (B, Mn, and Zn) at (shooting, flowering and podding stages) resulted in significant increases in average seed yield plant^{-1}, total seed yield ha.$^{-1}$, weight of seeds pod^{-1}, seed index (weight of 100-seeds), dry seeds protein and seed germination percentage compared with those of all treatment combinations which were treated with only one factor (Table-5) and the control treatment

Table-3: Effect of the interaction between growth stages and foliar nutrients on vegetative characters on pea plants in 2015-16 and 2016-17

Treatments		Plant height (cm)		Number of leaves/plant		Leaf area/plant (cm2)		Chlorophyll Content SPAD unit		Plant fresh weight (g)		Shelling ratio (%)	
growth Stages	Foliar nutrients**	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Shooting stage	Control	36.9 d	40.6 e	18.1	20.8	720.5 e	871.3 f	37.43 f	39.65 f	84.6 f	87.5 f	68.0 e	70.3 f
	B	40.0 cd	43.0 e	19.1	22.1	732.6 e	900.4 f	38.00 e	40.30 ef	87.0 ef	89.5 ef	70.9 cd	72.1 cd
	Mn	48.7 bc	52.5 cd	23.5	28.7	830.4 cd	1040.6 de	40.05 cd	42.86 cd	94.1 de	107.0 cd	68.0 c	70.7 ef
	Zn	49.2 bc	53.6 cd	24.2	29	835.7 cd	1052.5 de	40.20 d	43.05 cd	94.6 de	107.2 cd	68.0 e	70.7 ef
	B + Mn	50.3 bc	55.4 cd	24.6	29.2	847.5 cd	1075.3 cd	40.36 cd	43.30 cd	95.2 d	108.3 cd	70.9 cd	72.3 c
	B +Zn	51.2 bc	56.3 c	25.1	29.5	855.4 bc	1090.7 cd	40.55 cd	43.58 bc	95.6 d	110.5 c	70.9 cd	72.3 c
	Mn + Zn	58.1 ab	64.5 ab	28.2	32.2	909.5 b	1205.3 b	41.65 bc	44.75 abc	103.2 bc	118.4 b	69.5 e	70.7 ef
	B + Mn + Zn	59.0 ab	65.2 ab	28.6	32.8	925.7 ab	1230.4 ab	41.90 ab	45.06 ab	105.4 b	120.8 ab	70.9 cd	72.3 c
Flowering stage	B	39.2 cd	42.1 e	18.9	21.8	730.1e	893.5 f	37.85 e	40.15 ef	86.5 f	89.1 ef	71.4 f	72.3 c
	Mn	43.5 cd	47.9 de	21.3	26.3	795.4d	982.3 de	39.05d e	41.65 de	91.2 de	98.7 de	70.0 d	71.2 de
	Zn	44.3 cd	48.4 de	21.7	26.7	805.2 cd	990.5 de	39.10 de	41.84 de	91.5 de	100.3 de	70.0 d	71.2 de
	B + Mn	45.4 bc	49.1 de	22.1	27.1	811.6 cd	997.6 de	39.25 de	42.00 de	92.1 de	101.4 de	71.4 c	72.3 c
	B +Zn	46.0 bc	49.5 d	22.5	27.5	815.3 cd	1008.4 de	39.40 de	42.05 de	92.5 de	103.6 cd	71.9 bc	72.3 c
	Mn + Zn	47.2 bc	50.2 cd	22.8	28	820.5 cd	1025.7 de	39.65 de	42.20 de	93.0 de	105.0 cd	70.4 d	71.2 de
	B + Mn + Zn	48.1 bc	50.9 cd	23.1	28.3	822.6 cd	1032.5 de	39.86 cd	42.55 cd	93.5 de	105.8 cd	71.9 bc	72.3 c
Podding stage	B	38.5 cd	41.5 e	18.5	21.2	725.4 e	885.2 f	37.70 f	40.05 ef	86.1 f	88.7 ef	71.9 bc	72.9 b
	Mn	41.1 cd	44.2 de	19.6	23.1	746.2 de	920.5 ef	38.25 e	40.60 ef	88.6 ef	90.5 ef	70.4 d	71.7 d
	Zn	41.5 cd	45.1 de	19.8	23.5	751.5 de	935.3 ef	38.45 e	40.72 ef	89.1 ef	91.6 ef	70.4 d	71.7 d
	B + Mn	42.0 cd	45.3 de	20.1	24.2	760.3 de	942.6 ef	38.62 e	40.90 e	89.5 ef	93.4 ef	72.4 b	72.9 b
	B +Zn	42.2 cd	45.6 de	20.5	24.7	771.4 de	950.4 ef	38.70 e	41.00 e	90.0 ef	95.2 ef	72.4 b	72.9 b
	Mn + Zn	42.7 cd	46.1 de	20.8	25.1	780.1 de	967.5 ef	38.85 de	41.10 e	90.3 ef	96.5 de	70.4 d	71.7 d
	B + Mn + Zn	43.0 cd	46.7 de	21.1	25.4	786.5 de	975.7 ef	39.00 de	41.32 de	90.6 ef	97.1 de	72.9 ab	72.9 b
S. + F. + P. stages*	B	40.8 cd	43.9 de	19.1	22.1	738.4 e	910.7 ef	38.15 e	40.45 ef	87.5 ef	90.0 ef	72.9 ab	73.1 ab
	Mn	52.4 b	58.4 bc	25.5	30.4	860.3b c	1100.4 cd	40.80 c	43.86 bc	97.4 cd	112.7 bc	70.4 d	71.7 d
	Zn	53.5 ab	60.1 bc	26.1	30.8	872.5 bc	1120.5cd	41.10 bc	44.00 bc	98.6 cd	114.2 bc	70.4 d	72.1 cd
	B + Mn	55.1 ab	61.2 bc	26.8	31.1	884.6 bc	1160.7 bc	41.20 bc	44.15 bc	100.8 c	115.5 bc	73.3 a	73.1 ab
	B +Zn	56.4 ab	62.8 b	27.3	31.5	900.8 bc	1190.2 bc	41.40 bc	44.37 bc	102.5 b	116.7 bc	73.3 a	73.1 ab
	Mn + Zn	60.8 a	67.4 ab	29.1	34.2	946.5 ab	1262.5 ab	42.40 ab	45.57 a	107.5 ab	123.6 ab	70.9 cd	72.1 cd
	B + Mn + Zn	61.5 a	69.7 a	29.5	35.7	964.7a	1295.6 a	42.85 a	45.94 a	109.7 a	126.5 a	73.3 a	73.5 a
F. test		**	**	n.s	n.s	**	**	**	**	**	**	**	**

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.

S. + F. + P. stages = Shotting, flowering and podding stages; B = Boron, Mn = Manganese, Zn = Zinc.

Table-4: Effect of growth stages and foliar nutrients on dry seed yield and its components of pea plants in 2015-16 and 2016-17

Treatments	**Dry seed yield**				**Weight of seeds per pod (g)**		**Seed index (g)**		**Dry seeds protein (%)**		**Seed germination (%)**	
	Per plant (g)		**Per hectare (ton)**									
	1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Growth Stages												
Shooting stage	26.42 c	32.40 c	2.114 c	2.592 c	1.65 b	1.81 c	18.41 c	19.13 d	21.79 c	22.86 c	79.7 c	80.6 b
Flowering stage	28.04 bc	34.46 bc	2.258 bc	2.758 bc	1.70 b	1.87 bc	18.90 b	19.72 c	22.04 bc	23.07 bc	80.3 c	81.4 ab
Podding stage	29.71 ab	36.58 b	2.378 ab	2.926 b	1.76 ab	1.92 ab	19.17 ab	20.40 b	22.44 ab	23.42 a	81.3 b	82.5 ab
S. + F. + P. stages*	31.45 a	39.40 a	2.806 a	3.122 a	1.93 a	2.01 a	19.56 a	21.14 a	22.82 a	23.65 a	82.4 a	83.3 a
F. test	**	**	**	**	*	*	*	*	*	*	*	**
Foliar nutrients**												
Control	21.40 c	26.57 c	1.716 c	2.126 c	1.45 c	1.61 c	17.36 c	17.73 c	20.87 c	22.08 c	78.1 d	78.6 c
B	32.36 a	40.46 a	2.590 a	3.238 a	1.85 ab	2.05 a	19.88 a	21.37 ab	22.88 ab	23.77 ab	82.6 abc	83.7 ab
Mn	25.51 b	30.84 b	2.042 b	2.467 b	1.87 a	1.77 bc	18.07 c	18.53 bc	21.66 bc	22.72 bc	78.9 d	79.8 c
Zn	25.60 b	31.46 b	2.047 b	2.518 b	1.62 bc	1.79 bc	18.21 c	18.63 bc	21.78 bc	22.81 bc	79.1 cd	80.0 c
B + Mn	33.14 a	40.66 a	2.652 a	3.252 a	1.87 a	2.05 a	20.01 a	21.64 ab	22.95 ab	23.82 a	82.9 ab	84.1 a
B +Zn	33.37 a	41.32 a	2.669 a	3.307 a	1.88 a	2.06 a	20.09 a	21.90 ab	23.03 a	23.90 a	83.1 a	84.4 a
Mn + Zn	26.23 b	32.12 b	2.098 b	2.570 b	1.67 b	1.81 b	18.31 bc	18.81 abc	21.88 bc	22.87 bc	79.3 bcd	80.3 bc
B + Mn + Zn	33.65 a	42.25 a	2.693 a	3.378 a	1.88 a	2.09 a	20.15 a	22.17 a	23.14 a	24.02 a	83.4 a	84.7 a
F. test	**	**	**	**	*	*	*	**	*	*	**	**

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.
S. + F. + P. stages = Shotting, flowering and podding stages; B = Boron, Mn = Manganese, Zn = Zinc

Table-5: Effect of the interaction among growth stages and foliar nutrients on yield of dry seed and its components of pea plants in 2015-16 and 2016-17

Treatments		Dry seed yield				Weight of seeds/ pod (g)		Seed index (g)		Dry seeds protein (%)		Seed germination (%)	
growth Stages	Foliar nutrients**	Per plant (g)		Per hectare (ton)									
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Shooting stage	Control	21.40 g	26.57 g	1.716 g	0.886 g	1.45 c	1.61 d	17.36 f	17.73 g	20.87 e	22.08 e	78.1 g	78.6 g
	B	29.90 cd	36.27 de	2.393 d	1.209 de	1.78 b	1.95 bc	19.10 cd	19.87 de	22.35 c	23.31 cd	80.8d e	81.7 de
	Mn	22.50 fg	27.89 g	1.800 g	0.930 g	1.50 c	1.68 cd	17.55 ef	17.95 fg	21.05 de	22.35 de	78.2 g	78.9 fg
	Zn	22.50 fg	28.56 g	1.800 g	0.952 g	1.50 c	1.70 cd	17.67 ef	18.02 fg	21.25 de	22.42 de	78.2 g	79.0 fg
	B + Mn	30.26 cd	36.66 de	2.422 d	1.222 de	1.78 b	1.95 bc	19.15 cd	20.18 de	22.40 c	23.35 c	81.1d e	82.2 de
	B +Zn	30.44 cd	37.05 de	2.436 cd	1.235 de	1.78 b	1.95 bc	19.29 cd	20.80 de	22.50 bc	23.39 bc	81.4d e	82.5 d
	Mn + Zn	23.56 fg	28.73 fg	1.884 fg	0.958 g	1.55 c	1.70 cd	17.75 ef	18.08 fg	21.36 de	22.45 de	78.3f g	79.1 fg
	B + Mn + Zn	30.79 cd	37.44 de	2.462 cd	1.248 de	1.79 ab	1.95 bc	19.46 bc	20.72 d	22.53 bc	23.50 bc	81.6d e	82.8 cd
Flowering stage	B	31.14 cd	38.80 cd	2.491 cd	3.103 cd	1.80 ab	2.00b c	19.65 bc	20.93 cd	22.57 bc	23.55 bc	81.8 d	83.1 cd
	Mn	24.80 ef	29.93 fg	1.985 fg	2.395 fg	1.60b c	1.75 cd	17.88 ef	18.17 fg	21.42 de	22.51 de	78.4 fg	79.3 fg
	Zn	24.80 ef	30.28 fg	1.985 fg	2.422 fg	1.60b c	1.75 cd	18.05 e	18.35 fg	21.56 de	22.57 de	78.5 fg	79.5 fg
	B + Mn	32.20 bc	38.80 cd	2.575 cd	3.103 cd	1.84 ab	2.00 bc	20.00 b	21.15 cd	22.60 bc	23.60 bc	82.1 cd	83.4 cd
	B +Zn	32.20 bc	39.20 cd	2.575 cd	3.137 cd	1.84 ab	2.00 bc	20.05 b	21.30 cd	22.68 bc	23.65 bc	82.4 cd	83.6 cd
	Mn + Zn	25.43 ef	31.50 fg	2.035 ef	2.518 f	1.63 bc	1.80 cd	18.10 de	18.56 fg	21.75 cd	22.73 d	78.7 fg	79.8 fg
	B + Mn + Zn	32.38 bc	40.59 c	2.590 cd	3.247 c	1.84 ab	2.05 b	20.05 b	21.54 cd	22.87 bc	23.87 bc	82.6 cd	84.1 bc
Podding stage	B	33.46 bc	41.00 c	2.676 bc	3.281 c	1.88 ab	2.05 b	20.15 ab	21.83 c	23.02 bc	24.01 ab	83.0 c	84.3 bc
	Mn	26.54 e	31.86 ef	2.124 ef	2.549 f	1.68 bc	1.80 cd	18.20 de	18.74 f	22.02 cd	22.86 cd	79.0 fg	80.3 ef
	Zn	26.88 de	32.40 ef	2.150 ef	2.592 f	1.68 bc	1.80 cd	18.25 de	18.86 ef	22.05 cd	23.02 cd	79.3 fg	80.5 ef
	B + Mn	33.65 b	41.41 c	2.693 bc	3.312 c	1.88 ab	2.05 b	20.25 ab	22.05 bc	23.09 bc	24.06 ab	83.5 bc	84.7 bc
	B +Zn	34.20 b	42.84 bc	2.736 bc	3.427 bc	1.90 ab	2.10 ab	20.35 ab	22.35 bc	23.15 b	24.11 ab	83.6 bc	85.1 b
	Mn + Zn	27.37 de	33.30 ef	2.189 de	2.664 ef	1.70 bc	1.85 c	18.42 de	19.07 ef	22.10 cd	23.05 cd	79.7 ef	80.7 ef
	B + Mn + Zn	34.20 b	43.26 bc	2.736 bc	3.461 bc	1.90 ab	2.10 ab	20.40 ab	22.57 bc	23.25 ab	24.16 ab	84.0 bc	85.4 ab
S. + F. + P. stages*	B	34.94 b	45.76 ab	2.796 ab	3.660 ab	1.92 ab	2.20 ab	20.60 ab	22.83 bc	23.58 ab	24.22 ab	84.7 ab	85.7 ab
	Mn	28.21 de	33.67 ef	2.256 de	2.693 ef	1.72 bc	1.85 c	18.65 de	19.24 ef	22.15 cd	23.18 cd	80.0 ef	80.8 ef
	Zn	28.21 de	34.58 e	2.256 de	2.767 ef	1.72 bc	1.90 bc	18.86 cd	19.31 ef	22.25 cd	23.22 cd	80.3 ef	81.1 ef
	B + Mn	36.43 ab	45.76 ab	2.914 ab	3.660 ab	1.98 a	2.20 ab	20.65 ab	23.18 ab	23.70 ab	24.28 ab	84.7 ab	86.0 ab
	B +Zn	36.63 ab	46.20 ab	2.903 a	3.696 ab	1.98 a	2.20 ab	20.70 a	23.46 ab	23.78 ab	24.43 ab	85.1 ab	86.2 ab
	Mn + Zn	28.55 de	34.96 e	2.285de	2.796 e	1.72 bc	1.90 bc	18.95 cd	19.53 ef	22.30 cd	23.26 cd	80.5 e	81.5 de
	B + Mn + Zn	37.22 a	47.70 a	2.978 a	3.816 a	1.98 a	2.25 a	20.70 a	23.85 a	23.90 a	24.56 a	85.4 a	86.5 a
F. test		**	**	**	**	**	**	**	**	**	**	**	**

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.
S. + F. + P. stages = Shotting, flowering and podding stages; B = Boron, Mn = Manganese, Zn = Zinc.

(without foliar nutrients application). However, there were insignificant differences between the foliar application with B and /or (B and Mn) and /or (B and Zn) at the three stages. Apparently, the stimulating effects of foliar (B, Mn, and Zn) application pea plants growth were returned on the improved total seed yield and its components. These outcomes are in the same line with those achieved by Mahbobeh et al. (2011). Manimurugan et al. (2017) found increased seed quality with foliar application of 0.1% $MgSO_4$ and increased seed yield and quality with foliar application of 0.1% borax at 30 and 60 days after transplanting in carrot.

Conclusion

The results of this study showed that foliar application at the three stages positively affected the plant height, number of leaves^{-1}, leaf area, chlorophyll content, plant fresh weigh, shelling percentage and seed yield and its components. Application of micronutrients B, Mn and Zn is essential for obtaining the good yield. Foliar application of these elements can be the best alternative to reduce fertilizer consumption and also full fill the plant energy requirement.

सारांश

सब्जी मटर के दो प्रक्षेत्र परीक्षण वर्ष 2015–16 एवं 2016–17 में साखा उद्यान शोध प्रक्षेत्र स्टेशन, इजिप्ट में मटर के प्रभेद मास्टर बी पर बोरान, मैग्नीज व जिंक के पर्णीय छिड़काव का प्रभाव पुष्पन एवं फल विकास पर जानने के लिये किया गया। परिणाम से पता चला कि सूक्ष्म ततवों (बोरान, मैग्नीज व जिंक) के तीन विभिन्न अवस्थाओं में छिड़काव करने से वर्धीय विकास गुणों, छिलका; बीज अनुपात, बीज उपज व उपज घटकों जैसे– बीज जमाव प्रतिशत, पत्तियों में हरित लवक की मात्रा एवं बीज में प्रोटीन की मात्रा को बढ़ाता है। इससे स्पष्ट होता है कि मटर में तीन अवस्था पर बोरान, मैग्नीज व जिंक के पर्णीय छिड़काव से वर्धीय विकास, बीज उपज एवं गुणवत्ता में सुधार लाया जा सकता है।

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