International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2019; 2(2): 23-28
Received: 12-07-2019
Accepted: 15-08-2019

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Effect of micronutrients (Zn, B and Mo) foliar application at different growth stages of chickpea (*Cicer arietinum* L.) on yield and yield components

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Abstract
Two field experiments were conducted during 2015/16 and 2016/17 seasons, at Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, Egypt, to study the effects of zinc (Zn), Boron (B) and molybdenum (Mo) in combination at three growth stages; V_3: vegetative stage (30 DAS), R_1: stage of flowering (45 DAS) and R_6: pod formation (60 DAS) on yield and yield components of chickpea cultivar (Giza 531). The treatments of micronutrients foliar application were T_1 (application with water), T_2 (Zn 0.5 g/L + B 0.5 g/L), T_3 (Zn 0.5 g/L + Mo 0.5 g/L), T_4(B 0.5 g/L + Mo 0.5 g/L), T_5(Zn 0.5 g/L + B 0.5 g/L + Mo 0.5 g/L). A split plot design in randomized complete blocks arrangement with three replications was used. Foliar application treatments were randomly assigned for the main plots while, times of foliar application were randomly arranged for the sub plots. Spraying treatments had a significant effect on yield and its components in both seasons. The T_5 treatment (Zn + B + Mo) produced significantly the highest plant height (72.2 and 74.2 cm), number branches plant^{-1}(4.30 and 4.37), number of pods plant^{-1} (70.4 and 70.8), 100-seed weight (26.6 and 28.6 g), seed yield plant^{-1} (15.6 and 16.9 g), seed yield feddan^{-1} (702 and 727 kg), straw yield feddan^{-1} (2275 and 2276 kg),biological yield feddan^{-1} (2977 and 2999 kg), harvest index (23.6 and 24.1%) and seed protein content (19.7 and 19.9%), respectively, in both seasons. However, the lowest value of all studied traits was recorded from T_1 treatment (control).The results indicated that the spraying time of micronutrients did not have a significant effect on all studied traits in both seasons. The interaction between micronutrients foliar application and times of application was significant for all characters under study in both seasons. The highest seed yield (705 and 732 kg feddan^{-1}) in both seasons, respectively was recorded by combined application of zinc (0.5 g/l) + Boron (0.5 g/l) + molybdenum (0.5 g/l) as foliar spray at start of flowering stage (R_1) compared with other tested treatments. It was concluded that combined application of zinc, boron and molybdenum significantly produced greater crop yields. These results suggested that combined application of zinc @ 0.5 g/l, boron @ 0.5 g/l and molybdenum @ 0.5 g /l as foliar spray at 45 DAS (R_1 growth stage: start of flowering) significantly enhanced the crop yields and protein content in seed of chickpea.

Keywords: Chickpea, seed yield, zinc, boron, molybdenum

1. Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important legume crops in world and Egypt as it offers human nutrition with vegetable protein. Chickpea seeds contain about 20.6% protein, 61.2% carbohydrates and 2.2 % fats as well as amino acids like, lysine, leucine, isoleucine, valine and phenylalanine (Bejandi *et al.* 2012) [3]. Despite its uses, the area cultivated with chickpeas is continuously decreasing. The world's total production of chickpea was12, 092,950 tons annually, harvested area was 12,650,078 ha and the average yield was 956 kg/ha in the world (Anonymous, 2019) [1]. In Egypt, the amount of chickpea production was 3271 tons, harvested area and yield was 1503 hectare and 2176.2 kg/ha, respectively (Anonymous, 2019) [1]. The gap between consumption and production was filled by imports. Molybdenum (MO) plays an important role in increasing growth and yield of chickpea through its effects on the plant itself and on the nitrogen-fixing symbiotic process because Mo is directly involved in N fixation by pulses (Valenciano *et al.*2010) [27]. Foliar application of molybdenum (Mo) at 30 DAS improved chickpea yield and total dry matter (Valenciano *et al.* 2010 and 2011) [27, 28]. According to Bejandi *et al.* (2012) [3] increasing in flower numbers, pod set improvement, and reduction in days to flowering is affected by molybdenum.

Moreover, using zinc foliar application increase grain yield and seed protein content up to 25 and 40%, respectively (Bejandi *et al*. 2012 and Pathak *et al.* 2012) [3, 19]. Ganga *et al.* (2014) [7] mentioned that foliar application with 0.25% multiplex at pre-flowering stage gave the highest growth, seed yield and monetary advantage in chickpea under late sown condition. Also, Sarbandi and Madani (2014) [21] found that foliar application of micro-nutrients special Zn could have significant role in improving the yield and dependent characteristics in chickpea that helped in enhancing yield and yield components of chickpea. Nasar and Shah (2017) [18] concluded that combined application of iron and molybdenum significantly produced greater crop yields and more nodulation than sole application of iron or molybdenum. Rahman *et al.* (2017) [20] reported that foliar application of micronutrients mixtures (Zn, Fe, Mg, Cu, B and Mn) in combination with nitrogen improved the plant growth, yield and yield components were number of pods plant^{-1}, number of seed plant^{-1}, and seed weight plant^{-1}. The same application also produced maximum seed yield ha^{-1} harvest index and 100-seed weight. Kachave *et al*. (2018) [12] indicated that foliar application by multi micronutrients gave the maximum seed yield and seed protein content of chickpea. Also, Menaka *et al.* (2018) [15] found that spray of boron resulted in an increase of 24.7 and 12.6% in pod number plant^{-1} ad 100 seed weight respectively. The main objectives of this study were to investigate the effect of combination of zinc (Zn), boron (B) and molybdenum (Mo) at different times of application on yield and their attributes of chickpea.

2. Materials and Methods

Two field experiments were carried out at the Agricultural Experimental Research Station, Faculty of Agriculture, Cairo University during the seasons 2015/2016 and 2016/2017 to study effects of zinc (Zn), boron (B) and molybdenum (Mo), in combination at three growth stages of application; V_3: vegetative stage (30 DAS), R_1: start of flowering (45 DAS) and R_6: pod formation (60 DAS) on yield and its components of chickpea Giza 531 cultivar. Foliar application treatments were adopted as follows: T_1: Control (spray water), T_2: zinc 0.5 g/L + boron 0.5 g/L, T_3: zinc 0.5 g/L + molybdenum 0.5 g/L, T_4:boron 0.5 g/L + molybdenum 0.5 g/L, T_5: zinc 0.5 g/L + boron 0.5 g/L + molybdenum 0.5 g/L.

The plant received three sprays of solutions contained 0.5 g/L from each treatment at 30, 45 and 60 days after sowing (DAS), zinc chelate (14% Zn), molybdenum chelate (5% Mo) and Boraxe ($Na_2B_4O_7$, $10H_2O$) 5% boron.The experimental design was a split plot in randomized complete blocks arrangement with three replications in both seasons. The experimental plot consisted of 5 ridges spaced 60 cm apart with 4 meters long (12 m^2). The main plots were allocated to the five micronutrients foliar application. While, foliar application times were assigned to subplots. An alley of one meter apart was left between plots to prevent overlapping. The preceding summer crop was maize (*Zea mays* L.) in both seasons of study. Fertilizers were applied at the rate of 30 kg P_2O_5 and 15 kg N feddan^{-1}. Sowing date was on 24th and 21th November in the first and second seasons, respectively. Chickpea seeds were inoculated immediately before sowing with a culture broth containing *Rhizobium ciceri*. All other agronomic practices were applied as recommended.

Table 1: Physical and chemical analysis of soil at experimental site in 2015/16 and 2016/17 seasons

Season	Clay %	Silt %	Sand %	Organic %	pH -	Salinity ds.m^{-1}	N ppm	P ppm	K ppm	Zn ppm	Fe ppm	Mo ppm	Cu ppm
2015/16	38.9	23.1	38.0	1.9	7.8	0.87	39	16.7	220	0.67	13.1	3.4	0.59
2016/17	38.2	24.3	37.5	1.8	7.9	0.78	38	15.4	211	0.53	12.8	3.2	0.56

2.1 Yield and its components

At harvest, ten individual guarded plants were randomly taken from the central three ridges to determine seed yield and its components. The following traits were estimated: plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}, pods weight plant^{-1}, number of seeds pod^{-1}, 100-seed weight (g) and seed yield plant^{-1}(g). Seed, straw and biological yield in kg plot^{-1} were determined at harvest from plants of the central three ridges of each plot and then converted to kg feddan^{-1}.Harvest index percentage was estimated as the ratio of seed weight to biological yield without dropped leaves at harvest multiplied by 100.

2.2 Seed protein%

Total nitrogen content in seed was determined according the micro-kjeldahl method of AOAC (1990) [2]. Protein content (%) was calculated by multiplying N content by 6.25 according to Chapman and Pratt (1978) [6].

Data were subjected to analysis of variance of the split plot design according to the procedure outlined by Steel and Torrie (1997) [24]. The combined analysis was conducted for the data of the two seasons after testing the error variance homogeneity of both seasons according to Snedecor and Cochran (1990) [25]. Treatment means were compared based on least significant differences (LSD) at probability level of 5%. Finally, all statistical analysis was carried out using "MSTAT-C" program.

3. Results and Discussion

3.1. Effect of foliar application treatments

3.1.1 Yield and its components

Perusal of data presented in Table (2) revealed that foliar application treatment was significantly increased plant height in 2015/2016 and 2016/2017 seasons. The highest plant height (72.2 and 74.2 cm) was recorded by the T_5 treatment which was statistically similar to T_4 and T_3 treatments and the lowest (54.7 and 55.2 cm) was recorded by the T_1 treatment (control) in both seasons. Similar finding was also reported by Yadav *et al.* (2010) [29], Nandaniya *et al*. (2016) [17] Islam *et al*. (2018) [10] and Jadhav *et al.* (2019) Jadhav. The increase in plant height might be attributed to the role of foliar application in the synthesis of IAA, metabolism of auxins, biological activity, stimulating effect on enzyme activity and photosynthetic pigments which in turn encourage vegetative growth of plants (Michail *et al.* 2004). On the other hand, micronutrient foliar application was not only effective on plant height (Thalooth *et al*., 2006, Hu *et al*., 2008 and Kobraee 2019) [26, 9, 14].

Table 2: Effect of micronutrients foliar application on yield and yield components of chickpea in 2015/2016 and 2016/2017 seasons.

Characters	Foliar application treatments*					$LSD_{0.05}$
	T_1	T_2	T_3	T_4	T_5	
	2015/2016 Season					
Plant height (cm)	54.70	64.7	65.7	67.3	72.2	6.62
Branches No./plant	2.47	3.53	3.63	3.90	4.30	2.70
Pods No./plant	55.7	65.8	67.3	69.2	70.4	1.40
Seed index (g)	18.5	23.1	24.4	25.6	26.6	1.73
Seed yield /plant (g)	10.2	11.4	12.4	14.6	15.6	1.34
Seed yield (Kg/fed.)	568	626	667	685	702	21.8
Straw yield (kg/fed.)	2033	2157	2192	2217	2275	34.8
Biological yield (kg/fed.)	2601	2783	2858	2902	2977	29.3
Harvest index (%)	21.8	22.5	23.3	23.6	23.6	0.81
Protein content (%)	17.4	18.4	18.4	19.2	19.7	0.74
	2016/2017 Season					
Plant height (cm)	55.2	65.5	66.3	68.5	74.2	1.87
Branches No./plant	2.50	3.73	3.93	4.20	4.37	0.21
Pods No./plant	55.9	66.6	68.4	69.6	70.8	1.29
Seed index (g)	18.9	22.8	23.6	25.9	28.6	2.24
Seed yield /plant (g)	11.2	12.4	14.4	15.6	16.9	0.95
Seed yield (Kg/fed.)	574	633	676	696	727	27.8
Straw yield (kg/fed.)	2034	2157	2192	2217	2276	31.7
Biological yield (kg/fed.)	2614	2789	2867	2912	2999	27.4
Harvest index (%)	22.2	22.7	23.6	23.9	24.1	0.71
Protein content (%)	17.6	18.8	19.3	19.7	19.9	0.31

*Foliar application treatments: (T_1: application with water (control), T_2 : Zn+ B,T_3:Zn+Mo,T_4 : B +Mo and T_5 : Zn+B+Mo)

Results depicted in Table (2) confirm that micronutrients' foliar application treatments have significant effect on the number of branches plant^{-1} in 2015/2016 and 2016/2017 seasons. The maximum number of branches plant^{-1} (4.30 and 4.37) was recorded by the T_5 treatment in both seasons, respectively. The minimum number of branches plant^{-1} (2.47 and 2.50) was recorded from the T_1 (control) treatment in both seasons, respectively. A significant increase in number of branches plant^{-1} has been reported following the foliar application of different micronutrients in chickpea Yadav *et al.* 2010 [29], Ganga *et al.* 2014 [7], Nandaniya *et al*., 2016 [17] and Jadhav *et al.*, 2019) [11].

Data regarding number of pods plant^{-1} of chickpea as influenced by different micronutrient applications in 2015/2016 and 2016/2017 seasons are presented in Table (2). Statistical analysis of the data revealed that the effect of treatments was significant on the number of pods plant^{-1}. Among all of the foliar application treatments, the highest number of pods plant^{-1} (70.4 and 70.8) was recorded from T_5 treatment, while the lowest (55.7 and 55.9) was recorded from T_1 (control) treatment. The previous results indicate that micronutrients have a positive effect on the pod set of chickpea. The pod set was increased by 26.4% in T_5 over the control (Table 2). This could be attributed to the greater role of Zn, B and Mo in the production of indole acetic acid (IAA), which may have resulted in more pods plant^{-1}. Similar results are in close conformity with the findings of Ganga *et al.* (2014) [7], Rahman *et al.* (2017) [20] and Islam *et al*. (2018) [10]. However, Bozoglu *et al*. (2007) obtained contrary results, in their work the number of pods plant^{-1}decreased with the application of Mo.

Seed index of chickpea (100-seed weight) was significantly affected by various foliar application treatments in 2015/2016 and 2016/2017 seasons (Table 2). The greatest seed index (26.6 and 28.6 g) was obtained from the T_5 treatment and the lowest (18.5 and 18.9 g) was recorded from the T_1 (control) treatment. These results are in conformity with the work of Valenciano *et al.* (2010) [27], Karan *et al.* (2014), Nasar and Shah (2017) [18], Rahman *et al.* (2017) [20] Islam *et al*. (2018) [10] and Kobraee (2019) [14] who reported that maximum 1000-seed weight of chickpea (*Cicer arietinum* L.) was obtained from those treatment plots where plots where Mo and Fe were applied.

Analysis of variance (Table 2) for seed yield plant^{-1} of chickpea in 2015/2016 and 2016/2017 seasons, showed significant differences in T_5 application with highest seed yield plant^{-1}(15.6 and 16.9 g), while minimum seed yield plant^{-1}(10.2 and 11.2 g) was recorded in T_1appication in both seasons, respectively. The present findings are corroborating with the reports of Hafiz *et al.* (2004), Siavashi *et al.* (2004), Burman *et al.* (2007) [5] Solanki and Sahu (2007), Yadav *et al.* (2010) [29], Pathak *et al.* (2012) [19], and Nandaniya *et al.* (2016) [17].

The results from Table (2) showed that the application of micronutrients (Zn, B and Mo) in combination had a significant effect on the seed yield (kg feddan^{-1}) of chickpea in 2015/2016 and 2016/2017. However, the maximum increase in seed yield (kg feddan^{-1}) was observed following the combined application of Zn, B and Mo. It was observed that the maximum seed yield (702 and 724 kg feddan^{-1}) was recorded with treatment T_5 which was similar statistically with T_4 and significantly superior over the rest of the treatments. The minimum seed yield (568 and 574 kg feddan^{-1}) was recorded by the control treatment (T_1). The increase in seed yield (kg feddan^{-1}) varied from 10.2 to 23.6% at various foliar application treatments compared with the control treatment (T_1). The higher seed yield of chickpea (kg feddan^{-1})was observed with foliar application with (Zn, B and Mo) due to their positive influence on pod set, number of pods plant^{-1}, pod weight, 100-seed weight and mobilization of assimilate reserves to the sink. Similar findings were also reported by Valenciano *et al.* (2010) [27], Valenciano *et al.* (2011) [28], Ganga *et al.* (2014) [7], Sarbandi and Madani (2014) [21], Nandaniya *et al.* (2017) Nasar and Shah (2017) [18], Menaka *et al.* (2018) [15], Jadhav *et al.* (2019) [11] and Kobraee (2019) [14].

Data regarding straw yield (kg feddan^{-1}) of chickpea indicated that foliar application treatments significantly increased straw yield of chickpea over control treatment (Table 2) in 2015/2016 and 2016/2017 seasons. The maximum value of straw yield (2275 and 2276 kg feddan^{-1}) was recorded from T_5 treatment in both seasonse, respectively; this was somewhat statistically similar with other treatments (T_3 and T_4). This potential increase of straw yield of chickpea with foliar application micronutrients might be due to the contribution of growth and yield attributes. These results are in line with those obtained by Valenciano *et al.* (2011) [28], Sarbandi and Madani (2014) [21], Ganga *et al.* (2014) [7], Nandaniya *et al.* (2016) [17], Nasar and Shah (2017) [18], Rahman *et al.* (2017) [20] and Kobaraee (2019) [14] who stated that zinc, boron and molybdenum drastically improved straw yield of chickpea and lentil.

Biological yield (kg feddan^{-1}) was significantly affected by foliar application of micronutrients in 2015/2016 and 2016/2017 seasons (Table 2). The results indicated that the application of micronutrients in combination had a significant effect on the biological yield of chickpea. However, the maximum increase in biological yield was noticed following the combined application of Zn, B and Mo micronutrients. All other foliar application treatments gave low to moderate effects on enhancing the biological yield of chickpea. The increase in biological yield varied from 6 to 14.8% at different treatments compared to the control treatment (T_1) in both seasons, respectively. The increase in biological yield might be due to increase in growth and yield attributing characters of chickpea. Similar results are in close conformity with the findings of Valenciano *et al.* (2011) [28], Sarbandi and Madani (2014) [21], Ganga *et al.* (2014) [7], Nandaniya *et al.* (2016) [17], Nasar and Shah (2017) [18], Rahman *et al.* (2017) [20], Kachave *et al.* (2018) [12] and Kobaraee (2019) [14].

Results in Table (2) showed that foliar application treatments had a significant effect on harvest index of chickpea in 2015/2016 and 2016/2017 seasons. Adding of micronutrients could be increase harvest index by 8.2% in Zn+B+Mo treatment (T_5) as compared to control treatment (T_1). That reason of this is increasing of seed yield more than biological yield (Table 2). The greatest value of harvest index (23.6 and 24.1%) was recorded in treatment T_5 (Zn +B+Mo) in both seasons, repectively. Thus increasing of seed yield could improve harvest index. These results are in agreement with those of Sarbandi and Madani (2014) [21], Ganga *et al.* (2014) [7], Rahman *et al.* (2017) [20], Nasar and Shah (2017) [18] and Kobaraee (2019) [14] who reported that application of iron and molybdenum significantly increased harvest index (%) of chickpea and lentil.

Foliar application of Zn, B and Mo in combination had a significant effect on seed protein content of chickpea in 2015/2016 and 2016/2017 seasons (Table 2). The highest seed protein content (19.7 and 19.9%) was obtained from T_5 treatment in both seasons, respectively. However, the lowest value of seed protein content (17.4%) was obtained from the T_1 (control treatment). This might be due that an increase in micronutrient availability enhances N uptake by plants through nodule formation, which increases the protein content in seeds. The results of the present research are in agreement with the findings of Bejandi *et al.* (2012) [3], Islam *et al* (2018) [10], Kachave *et al.* (2018) [12] and Kobaraee (2019) [14] who reported that application of Mo, Zn, B K, and S enhanced the seed protein content of pulses.

3.2. Effect of foliar application timing

3.2.1 Yield and its components

Data presented in Table (3) show the effect of three different times of foliar application (V_3: vegetative stage at 30 DAS, R_1: start of flowering at45 DAS and R_6: pod formation at 60 DAS) on plant height, number of branches plant^{-1}, number of pods plant^{-1}, 100-seed weight (seed index), seed weight plant^{-1}, seed yield feddan^{-1}, straw yield feddan^{-1}, biological yield feddan^{-1}, harvest index, seed protein content in 2015/2016 and 2016/2017 seasons.

The time of micronutrient application had no significant on plant height, number of branches plant^{-1}, number of pods plant^{-1}, 100-seed weight (seed index), seed weight plant^{-1}, seed yield feddan^{-1}, straw yield feddan^{-1}, biological yield feddan^{-1}, harvest index, seed protein content in 2015/2016 and 2016/2017 seasons (Table 3).

Table 3: Effect of different times of foliar application on yield and yield component of chickpea in 2015/2016 and 2016/2017 seasons.

Characters	**Growth stages***			**$LSD_{0.05}$**
	V_3	**R_1**	**R_6**	
2015/2016 Season				
Plant height (cm)	63.7	66.3	64.8	ns**
Branches No./plant	3.58	3.66	3.46	ns
Pods No./plant	63.2	66.7	67.0	ns
Seed index (g)	23.9	23.88	23.2	ns
Seed yield /plant (g)	12.9	13.0	12.6	ns
Seed yield (Kg/fed.)	641	655	651	ns
Straw yield (kg/fed.)	2164	2186	2175	ns
Biological yield (kg/fed.)	2805	2841	2826	ns
Harvest index (%)	22.8	23.0	23.0	ns
Protein content (%)	18.6	18.6	18.8	ns
2016/2017 Season				
Plant height (cm)	65.3	66.8	65.7	ns
Branches No./plant	3.80	3.70	3.74	ns
Pods No./plant	65.7	66.7	66.3	ns
Seed index (g)	24.5	23.5	23.9	ns
Seed yield /plant (g)	14.3	14.2	13.8	ns
Seed yield (Kg/feddan)	655	664	667	ns
Straw yield (kg/fed.)	2164	2186	2175	ns
Biological yield (kg/fed.)	2805	2842	2826	ns
Harvest index (%)	22.8	23.0	23.0	ns
Protein content (%)	19.1	19.0	19.0	ns

* V_3: vegetative stage at 30 days after sowing, R_1: start of flowering at 45 days after
sowing and R_6: pod formation at 60 days after sowing)
**ns= Not significant

3.3. Effect of interaction between foliar application × time of application

3.3.1 Yield and its components

There were significant interaction effect between foliar application treatments and time of application on yield and its components in 2015/2016 and 2016/2017 seasons (Table 4). The T_5 treatment gave the greatest values of plant height (74.5 and 76.5 cm), number of branches plant^{-1} (4.4 and 4.4), number of pods plant^{-1} (71.4 and 71.4), seed index (27.0 and 29.0 g), seed yield plant^{-1}(16.5 and 17.5 g), seed yield feddan^{-1}(705 and 725 kg), Straw yield feddan^{-1}(2287 ad 2297 kg), biological yield feddan^{-1} (2992 and 3022 kg), harvest index (23.8 and 24.0 %) and seed protein content (19.8 and 19.9%) at R_1 growth stage (45 days after sowing) in both seasons, respectively, compared with T_1 (control treatment).

Table 4: Effect of foliar application at different growth stages of chickpea on yield and yield components in 2015/ 2016 and 2016/2017 seasons.

Characters	Season*	Foliar application treatments															LSD$_{0.05}$
		T$_1$(Control)			T$_2$: (Zn+B)			T$_3$: (Zn+ Mo)			T$_4$: (B+ Mo)			T$_5$: (Zn+ B+ Mo)			
		Growth stages of foliar application**															
		V$_3$	R$_1$	R$_6$	V$_3$	R$_1$	R$_6$	V$_3$	R$_1$	R$_6$	V$_3$	R$_1$	R$_6$	V$_3$	R$_1$	R$_6$	
Plant height (cm)	1st	51.7	55.7	56.7	63.1	66.0	64.9	64.9	67.2	65.1	67.1	68.2	66.7	71.8	74.5	70.4	1.32
	2nd	53.7	55.4	56.5	64.1	66.4	65.9	65.9	66.9	66.1	69.1	68.8	67.7	73.8	76.5	72.4	2.32
Branches No. plant^{-1}	1st	2.20	2.50	2.70	3.80	3.50	3.3	3.70	3.80	3.40	4.0	4.1	3.6	4.2	4.4	4.3	0.32
	2nd	2.30	2.50	2.70	3.90	3.60	3.70	4.10	3.90	3.80	4.30	4.10	4.20	4.40	4.40	4.30	0.21
Pods No. Plant^{-1}	1st	56.7	54.9	55.6	60.6	67.2	89.9	63.0	69.2	69.8	66.9	70.8	69.8	69.0	71.4	70.9	1.81
	2nd	56.2	55.9	55.6	66.6	67.2	65.9	67.0	69.2	69.1	8.9	69.8	69.8	70.0	71.4	70.9	2.84
Seed index (g)	1st	18.0	18.1	19.5	23.5	23.5	22.3	25.0	24.5	23.7	26.3	26.3	24.2	26.5	27.0	26.3	1.01
	2nd	18.4	18.8	19.6	23.9	21.8	22.7	24.4	22.6	23.7	26.3	25.3	26.2	29.5	29.0	27.3	2.01
Seed yield plant^{-1}	1st	10.9	10.0	9.80	11.3	11.8	11.1	12.8	12.2	12.3	14.5	14.6	14.8	15.2	16.5	15.0	0.34
	2nd	11.9	11.0	10.8	12.3	12.8	12.1	14.8	14.2	14.3	15.5	15.6	15.8	17.2	17.5	16.0	1.10
Seed yield kg feddan^{-1}	1st	568	566	568	607	638	633	652	677	672	681	689	684	698	705	702	31.9
	2nd	578	576	588	627	638	632	661	684	682	691	697	698	714	725	733	33.1
Straw yield kg feddan^{-1}	1st	2025	2035	2041	2134	2184	2154	2187	2197	2192	2210	2230	2212	2264	2287	2276	34.8
	2nd	2035	2045	2048	2156	2192	2197	2205	2197	2194	2250	2260	2271	2294	2297	2286	48.2
Biological yield (kg feddan^{-1})	1st	2593	2601	2609	2741	2822	2786	2838	2874	2863	2891	2919	2896	2962	2992	2978	43.2
	2nd	2613	2613	2636	2783	2830	2829	2866	2881	2876	2941	2957	2969	3008	3022	3018	59.1
Harvest index (%)	1st	21.92	21.78	21.77	22.16	22.61	22.7	22.95	23.56	23.45	23.56	23.62	23.56	23.56	23.87	23.59	0.12
	2nd	21.13	21.99	23.31	22.55	22.54	22.36	23.08	23.74	23.73	23.50	23.58	23.51	23.74	24.0	24.27	0.18
Protein content (%)	1st	17.1	17.6	17.4	18.2	18.6	18.3	18.6	18.9	18.7	19.2	18.9	19.4	19.7	19.8	19.6	1.21
	2nd	17.4	17.6	17.8	18.9	18.8	18.8	19.6	19.2	19.1	19.9	19.7	19.5	19.9	19.9	19.8	0.21

*1st season 2015/2016, 2nd season 2016/2017.

** V$_3$: vegetative stage at 30 days after sowing, R$_1$: start of flowering at 45 days after sowing and R$_6$: pod formation at 60 days after sowing)

4. Conclusion

This study shows that the combined application of Zn, B and Mo provides a beneficial effect on seed yield of chickpea; the Zn application was more efficient when it was applied with B and Mo. As final conclusion, the number of pods plant^{-1} is the most influential yield component and the yield component that is most closely correlated with seed yield.

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