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RESPONSE OF CHICKPEA (*CICER ARIETINUM* L.) TO BORON AND MOLYBDENUM FERTILIZATION

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Abstract

An experiment was conducted to study the effect of micronutrients on the growth and yield performance of chickpea. The experiment was consisted using two factors- variety and treatments. Two local cultivars *viz*. BARI Chola-5 and BARI Chola-9 and five treatments e.g. T_0 = control, T_1 = 2 kg B/ha, T_2 = 2 kg Mo/ha, T_3= seed priming with Mo (1g/l water), T_4 = foliar spray of B (0.5 g/l water) + seed priming with Mo (1g/l water), and T_5 = 2 kg B/ha + seed priming with Mo (1g/l water) were considered for this study. A randomized complete block design (RCBD) was adopted with three replications. Significant variation was observed between the varieties and here the BARI Chola-9 produced the higher seed yield (2.47 ton/ ha). Treatment showed significant effect on the yield attributes and yield of chickpea. The highest plant height, number of branches/ plant, number of pods/ plant, nodule/ plant, number of effective pod/ plant, length of the pod, 1000-grain weight, seed yield, straw yield, biological yield was obtained from T_4. The highest seed yield (2.68 ton/ ha) was recorded from BARI Chola-9 with foliar spray of boron and seed priming with Mo. The results indicated that foliar spray of B and seed priming with molybdenum can be beneficial in improving growth and yield of chickpea variety BARI Chola-9.

Key words: Boron, Chickpea, Foliar spray, Molybdenum, Yield components and yield

Introduction

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop, after dry bean and peas, produced in the world. It accounts for 20% of the world pulses production. Globally, it is grown over an area of 13.98 million hectares with a production of 13.73 million tones and productivity of 982 kg/ha (FAOSTAT 2016). The major chickpea producing countries are India, Australia, Pakistan, Turkey, Myanmar and Ethiopia account for about 90% of world chickpea production. Chickpea has the ability to fix atmospheric nitrogen and can also tolerate high temperatures during and after flowering (Cumming and Jenkins 2011). It is one of the earliest cultivated legumes: 7,500 year old remains have been found in the Middle East (Bell 2014). Chickpea is a good source of energy, protein, minerals, vitamins, fiber and also contains potentially health beneficial minerals and vitamins.

Chickpea is one of the major pulse corps in Bangladesh. It contributes about 1.64% of total pulses production in Bangladesh (BBS 2016). In (2015-16), 2.44% area was cultivated pulse crop in Bangladesh under the total cultivated area (BBS 2016). Total production of chickpea in Bangladesh 6382 metric ton and the total cultivated area is about 15026 acre in 2015-16 (BBS 2016). In Rajshahi region the total chickpea production is about 3023 metric ton and total area under cultivated is about 6836 acres during the year 2015-2016 (BBS 2016). The average yield of chickpea is very low compared to other countries of the world. It is very difficult to meet the total demand of the countries as a result; more than one half of the total demand of chickpea has

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to be imported in every year. Major constrains in increasing production of chickpea are poor soils, inadequate moisture, adverse climatic conditions, weeds and inadequate or even no fertilizer supply (Aslam et al. 2000).

Micronutrients play an important role in increasing yield of pulses legumes through their effects on the plant itself and on the nitrogen fixing symbiotic process. The soils of different parts of Bangladesh are more or less deficient in boron and molybdenum, which causes poor yield of chickpea (Bhuiyan et al. 1997). Boron (B) is very important in cell division and in pod and seed formation. Boron ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc (Shil et al. 2007). Boron is an important micronutrient, plays role in carbohydrate metabolism, translocation of sugars from source to sink, flower retention, pollen fertility and germination, pod setting, seed development, yield and its components. Thus, the requirement of boron appears more essential for reproductive development than vegetative (Nalini and Bhavana 2013).

The lack of a nutritional element in a cultivated plant inevitably leads to a decrease in yield. Molybdenum (Mo) plays an important role in increasing chickpea yield through its effects on the plant itself and on the nitrogen fixing symbiotic process because Mo is directly involved in N fixation by legumes (Roy et al. 2006). The efficiency of N_2 fixation can be increased by seed dressing with molybdenum (Mo) because Mo is an essential component of nitrate reductase and nitrogenase, which control the reduction of inorganic nitrate and helps in fixing N_2 to NH_3. Generally Mo is an essential micronutrient for plants and bacteria (Williams and Silva 2002). Meagher et al. (1991) reported that Mo is the key to nitrogen fixation by legumes. Total Mo content of soil varies from 0.2 to 5.0 mg/ kg (Sims 2000). In Mo deficient chickpeas, the flowers produced are fewer in number, smaller in size and many of them fail to open or mature, leading to lower seed yield (Ahlawat et al. 2007). Therefore, the present study was undertaken to study the response of chickpea to molybdenum and boron fertilization.

Materials and Methods

The present research work was carried out at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, during the period from November 2018 to April 2019 to study the modes of application of micronutrients on the yield performance of chickpea. The experimental site was located under AEZ-11. Two major factors were selected for the experiment. Factor A- variety, *viz*. BARI Chola-5, BARI Chola-9 respectively and factor B- treatments, *viz*. T_0 = control, T_1 = 2 kg B/ha, T_2 = 2 kg Mo/ha, T_3 = seed priming with Mo (1g/l water) T_4 = foliar spray of B (0.5 g/l water) + seed priming with Mo (1g/l water), T_5 = 2 kg B/ha + seed priming with Mo (1g/l water) respectively. The experiment was laid out in a RCBD with three replications. The experimental field was fertilized with Urea, TSP, MoP @ 45, 85, 35 kg/ha. Boron and molybdenum were applied as per experimental specifications. Seeds were sown in line on 22 November, 2018 by hand in rows. Agronomic practices were given properly to ensure a healthy growth of the crop. The crop was harvested at full maturity. At maturity, five plants were selected randomly from each unit plot and uprooted before harvesting for recording of necessary data on yield contributing characters. Recorded data were compiled and tabulated for statistically analysis. The collected data were analyzed statistically and the values of the means differences were adjusted by Duncan's New Multiple Range Test (DMRT) with the help of MSTAT-C program.

Results and Discussion

Plant height

The plant height was significantly influenced by different chickpea varieties. The tallest plant (57.42 cm) was found in BARI Chola-9 and the shortest one (51.14 cm) was noted from BARI Chola-5 (Table 1). This is the inherent features of the variety as a result BARI Chola-9 gave the tallest plant. Plant height is an important determinant for better crop growth. It can have a good influence on biological yield. Seed priming with molybdenum and foliar spray of boron had a significant effect on the plant height of chickpea. The tallest plant (56.14 cm) was observed in T_4 (foliar spray of B + seed priming with Mo) and the shortest one (52.15 cm) was found in control (Table 2). This might be due to the accessibility of nitrogen fixed by molybdenum which in result increases vegetative growth and plant height. On the other hand boron plays a vital role in cell division, distinction and generative growth of plants. Our outcomes are also sustained by Singh et al. (2012) who resulted that successive plant growth was carried out by application of boron and molybdenum. The interaction between variety and treatment on plant height was statistically significant. The tallest plant (59.20 cm) was obtained from BARI Chola-9 with foliar spray of B and seed priming with Mo and the shortest one (49.00 cm) was noted from BARI Chola-5 in-control (Table 3).

Table 1. Effect of variety on yield and yield components of chickpea

Variety	Plant height (cm)	Nodules/ plant (No.)	Branches/ plant (No.)	Total pods/ plant (No.)	Effective pods/ plant (No.)	Non-effective pods/ plant (No.)	Pod length (cm)	1000 seed weight (g)	Seed yield (ton/ha)	Straw yield (ton/ ha)
V_1	51.14b	18.41b	24.43b	46.86b	41.51b	5.35b	1.51b	115.95b	1.56b	1.92b
V_2	57.41a	22.10a	25.66a	57.76a	54.35a	3.41a	1.73a	215.68a	2.46a	3.18a
LS	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0..05
CV (%)	4.43	4.70	3.17	5.72	5.21	6.53	5.93	4.11	8.14	5.14

V_1 = BARI Chola-5, V_2 = BARI Chola-9, LS = Level of significance, CV = Co- efficient of variation. In a column the figures bearing similar letter (S) or without letter (S) are identical and those having dissimilar letter(s) differed significantly as per DMRT.

Nodules per plant

The data on total number of nodules/plant was influenced by the variety. Significantly higher number of nodules/plant (22.10) was recorded from the variety BARI Chola-9. Lower number of nodule/plant (18.41) was observed in BARI Chola-5 (Table 1). Molybdenum and boron had significant effect on nodules/plant. The number of nodules/plant (22.9) was highest in T_4 whereas the lowest number of nodules/plant (17.78) was obtained from the control (Table 2). Bhuiyan et al. (1997) observed that application of B and Mo increases the number and weight of nodule over control. This was because that molybdenum plays an active part in nodule synthesis and fixing of nitrogen. Similar investigation was also observed by Chakraboty (2009) who reported application of Mo responds well in enhancing nodules number in legumes. In case of boron, an increase in nodule numbers was noted with an increase in boron levels. Foliar spray of boron increased nodules numbers as compared to control. These findings are substantiated with that of Hasnain et al. (2011). The data on number of nodules/plant was influenced by the interaction of variety and the treatments. The highest number of nodules/plant (24.82) was recorded from BARI Chola-9 when foliar spray and seed priming was done by B and Mo respectively whereas BARI Chola-5 produced lowest (16.21) when Mo and B was not applied (Table 3).

Table 2. Effect of treatment on the yield & yield components of chickpea

Treat. (T)	Plant height (cm)	Nodules/ plant (No.)	Branches/ plant (No.)	Total pods/ plant (No.)	Effective pods/ plant (No.)	Non-effective pods plant (No.)	Pod length (cm)	1000 seed weight (g)	Seed yield (ton/ha)	Straw yield (ton/ ha)
T_0	52.15f	17.78f	22.55f	49.85f	44.40f	5.45a	1.52c	161.15e	1.82d	2.34f
T_1	54.05d	18.55e	24.50d	51.60d	47.00d	4.60c	1.58 bc	165.20cd	2.08 a-c	2.48d
T_2	53.20e	19.59d	23.85e	50.60e	45.65e	4.95b	1.55c	163.70d	1.89cd	2.42e
T_3	54.65c	20.64c	25.60c	52.75c	48.60c	4.15d	1.63a-c	166.85bc	1.98bcd	2.55c
T_4	56.16a	22.90a	27.30a	55.20a	51.85a	3.35f	1.74a	169.55a	2.20a	2.82a
T_5	55.46b	21.85b	26.50b	53.90b	50.10b	3.80e	1.69ab	168.45ab	2.13ab	2.69b
LS	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	4.43	4.70	3.17	5.72	5.21	6.53	5.93	4.11	8.14	5.14

T_0 = control, T_1 = 2 kg B/ ha, T_2 = 2 kg Mo/ ha, T_3 = seed priming with Mo (1g/l water), T_4 = foliar spray of B (0.5 g/l water) + seed priming with Mo (1 g/l water), T_5 = 2 kg B/ ha + seed priming with Mo (1 g/l water), LS = level of significance, CV = co-efficient of variation. In a column the figures bearing similar letter (S) or without letter (S) are identical and those having dissimilar letter (S) differed significantly as per DMRT.

Table 3. Interaction effect of variety and treatment on the yield & yield components of chickpea

Variety × Treatment	Plant height (cm)	Nodules/ plant (No.)	Branches/ plant (No.)	Total pods/ plant (No.)	Effective pods/ plant (No.)	Non-effective pods plant (No.)	Pod length (cm)	1000 seed weight (g)	Seed yield (ton/ha)	Straw yield (ton/ha)
V_1T_0	49.00k	16.21i	22.00g	44.20k	37.40j	6.80a	1.43g	112.10h	1.32e	1.78k
V_1T_1	51.10i	17.01h	24.00e	46.10i	40.50h	5.60b	1.48fg	115.30fgh	1.75 c	1.85ij
V_1T_2	50.20j	17.98g	23.50f	45.00j	39.00i	6.00b	1.46fg	114.10gh	1.40de	1.80jk
V_1T_3	51.30i	18.50g	25.00d	47.00h	42.00g	5.00c	1.51f	116.50efg	1.51cde	1.90i
V_1T_4	53.12g	20.98de	26.20c	50.20f	46.10e	4.10e	1.60de	119.30e	1.72c	2.20g
V_1T_5	52.13h	19.78f	25.90c	48.70g	44.10f	4.60cd	1.58e	118.40ef	1.69cd	2.00h
V_2T_0	55.30f	19.36f	23.10f	55.5e	51.40d	4.10de	1.61de	210.20d	2.32b	2.91f
V_2T_1	57.00d	20.50e	25.00d	57.10c	53.50c	3.60ef	1.69c	215.10bc	2.41ab	3.12d
V_2T_2	56.20e	21.21d	24.20e	56.20d	52.30d	3.90e	1.65cd	213.30cd	2.38ab	3.05e
V_2T_3	58.00c	22.78c	26.20c	58.50b	55.20b	3.30fg	1.76b	217.21ab	2.45ab	3.21c
V_2T_4	59.20a	24.82a	28.40a	60.20a	57.60a	2.60h	1.88a	219.80a	2.68a	3.45a
V_2T_5	58.80b	23.93b	27.10b	59.10b	56.10b	3.00gh	1.81b	218.50a	2.57ab	3.38b
LS	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	4.43	4.70	3.17	5.72	4.70	5.21	6.53	5.93	4.11	8.14

V_1 = BARI Chola-5, V_2 = BARI Chola-9, T_0 = control, T_1 = 2 kg B/ ha, T_2 = 2 kg Mo/ ha, T_3 = seed priming with Mo (1 g/l water), T_4 = foliar spray of B (0.5 g/l water) + seed priming with Mo (1 g/l water), T_5 = 2 kg B/ ha + seed priming with Mo (1 g/l water), LS = level of significance, CV = co-efficient of variation. In a column the figures bearing similar letter (S) or without letter (S) are identical and those having dissimilar letter (S) differed significantly as per DMRT.

Branches per plant

The data on number of branches/plant was influenced by the variety are presented in Table 1. Significantly higher number of branches/plant (25.67) was recorded from BARI Chola-9. Lower number of branches/plant (24.43) was obtained from BARI Chola-5. Number of branches/plant was significantly influenced by the treatment combination. Significantly higher number of branches/plant (27.30) was recorded from the treatment combination of foliar spray of B and seed priming with Mo. Lower number of branches/plant (22.55) was found in control (Table 2). Similar findings were also reported by Jadhav et al. (2019). They reported a significant increase in number of branches/plant following the foliar application of different micronutrients in chickpea. Significantly higher number of branches/plant (28.40) was noted from BARI Chola-9 when foliar spray of B was applied at Mo seed primed plot. Significantly lower number of branches/plant (22.00) was found in BARI Chola-5 in control (Table 3).

Total pods per plant

The data on total number of pods/plant was significantly influenced by the variety. The higher number of pods per plant (57.77) was recorded from BARI Chola-9 and the lower number of pods/plant (46.87) was found in BARI Chola-5 (Table 1). It was observed that number of pods/plant was positively influenced by the treatments are presented in Table 2. Significantly higher number of pods/plant (55.2) was recorded in T_4. The lower number of pods/plant (49.85) was found in control (Table 2). It may be due to the efficient utilization of molybdenum which increased yield attributes (Awomi et al. 2011). These results are supported by Khan et al. (2014), they resulted that application of molybdenum improved number of pods/ plant. Rabbani et al. (2005) also witnessed a constructive role of Mo and stated that fertilization of Mo gave significant influence on the quantity of pods/plant plant. Application of molybdenum increased active nodules and nodules weight plant/plant in chickpea (Khan et al. 2020). Boron works in reproductive tissues and control flower drop which in result increases the amount of pods/ plant. Our findings are an agreement with Singh et al. (2014), who specified that molybdenum and boron enhanced pods/ plant. Deficiency of boron showed a noticeable decline in the amount of flowers and fail to fruit, causing decreases in grain and pod yield. These results are in agreement with the findings of Kaisher et al. (2010), Valenciano et al. (2010) and Ahlawat et al. (2007). Total number of pods/plant was varied due to interaction of variety and the treatment. The treatment V_2T_4 was found to be the best combination producing the highest number of pods/plant (60.20) while the treatment combination V_1T_0 generated the lowest (44.20) pods/plant (Table 3).

Effective pods per plant

The maximum number of effective pods per plant (54.35) was obtained from BARI Chola-9 and the minimum number (41.52) from BARI Chola-5 (Table 1). The number of effective of pods/plant was significantly influenced by the treatment. The experimental results indicated that molybdenum boosted number of nodules in chickpea which caused in an increase in effective pods/plant. The highest number of effective pods/plant (51.85) was recorded in T_4 and lowest one (44.4) was recorded from control (Table 2). The foliar sprays of boron resulted in an increase of number of effective pods/plant over control. Boron is important in cell division and helps in germination and growth of pollen grains, sugar translocation, and movement of growth regulators within the plant. Similar results were also reported by Menaka et al. (2018). The number of effective pods/plant was highest (57.6) in V_2T_4 over control (Table 3).

Non-effective pods per plant

Variety showed significant influence on the production of non-effective pods/plant. The higher number of non-effective pods/plant (5.35) was recorded from BARI Chola-5 while the lower number of non-effective pods/plant (3.417) was obtained from BARI Chola-9. The results revealed that seed priming with molybdenum as well as application of boron exhibited significance effect on the production of non-effective pods/plant (Table 2). Seed priming with molybdenum and foliar spray of boron exhibited the lowest value (3.35) for this trait over control (5.45). Control showed higher number of non-effective pods/plant (6.80) was recorded from BARI Chola-5. The lowest number of non-effective pods/plant (2.60) was recorded from BARI Chola-9 when foliar spray of B was done in Mo seed treated plot (Table 3).

Pod length

The pod length was significantly influenced by chickpea variety. The tallest pod (1.73) was observed in BARI Chola-9 and the shortest one (1.51) was found in BARI Chola-5 (Table 1). It was observed that the pod length varied significantly due to treatments. The longest pod (1.74) was observed in T_4 (foliar spray of B + seed priming with Mo) and the shortest pod (1.52) was found in control (Table 2). There were significant interaction between variety and treatment on pod length. The V_2T_4 treatment produced the longest pod (1.88) compared with V_1T_0 (Table 3).

1000 seed weight

1000 grain weight plays a vital role in final production. The data on 1000 seed weight was influenced by the variety are presented in Table 1. 1000 seed weight was significantly influenced by the varieties. The higher 1000 seed weight (215.68 g) was recorded BARI Chola-9 and lower (115.95 g) was obtained from BARI Chola-5. It was observed that 1000 seed weight was meaningfully influenced by molybdenum and boron application. Significantly higher 1000 seed weight (169.55 g) was recorded from T_4 which was followed by T_5 (168.45 g). Lower 1000 seed weight (161.15 g) was recorded from control (Table 2). Seed priming with Mo and foliar spray of B enhanced 1000 seed weight. It possibly will be due to molybdenum that improved nitrogen fixation which resulted in maximum utilization and improved thousand seed weight. Considering boron, a positive effect was observed by application of boron. Our outcomes are at par with Bellaloui et al. (2013) who testified that use of boron enhanced hundred seed weight. These results are also in agreement with the findings of Kaisher et al. (2010). Valenciano et al. (2010) and Ahlawat et al. (2007) earlier reported that 1000 seed weight was significantly affected due to various micronutrient treatments. The data on 1000 seed weight was influenced by the interaction of variety and treatment. The highest 1000 seed weight (219.80 g) was noted from BARI Chola-9 when foliar spray of B and seed priming Mo was done and the lowest one (112.10 g) was obtained from BARI Chola-5 in control (Table 3).

Seed yield

Seed yield is the last outcome of chickpea cultivation. The seed yield was maxim in BARI Chola-9 and minimum in BARI Chola-5. Analyzed data revealed that seed yield was positively impacted by molybdenum and boron application. The highest seed yield (2.20 ton/ha) was obtained fromT_4 which was followed by T_5 (2.13 ton/ha). The lowest seed yield (1.82 ton/ha) was recorded from control treatment (Table 2). Seed priming with molybdenum and foliar spray of boron enhanced seed production of chickpea. The rise in yield might be due to the rhizobium activity by molybdenum which increases vegetative growth and in result yield components increased. These results are in conformity with Khan et al. (2014). They reported that molybdenum enhanced grain yield as compared to control. Boron plays an important role on seed yield of chickpea as it regulates plant hormone level, photosynthetic activity and generative growth in plants which increase yield of chickpea. Our conclusions are also in similarity with Shil et al. (2007). Mekkei (2019) concluded that foliar application of zinc, boron and molybdenum significantly produced greater seed of chickpea. Similar findings were also reported by Kobraee (2019). The interaction of variety and treatments had the significant positive influence on the seed yield of chickpea. The higher seed yield (2.68 ton/ha) was noticed in V_2T_4 while the lowest one (1.32 ton/ha) was obtained from V_1T_0 (Table 3).

Straw yield

The data on straw yield was significantly affected by chickpea variety where BARI Chola-9 produced higher (3.18 ton/ha) straw yield (Table 1). Straw yield was significantly influenced due to treatment combinations. The highest straw yield varied from a lower value of 2.34 ton/ha in T_0 (control) to a higher value of 2.83 ton/ha in T_4 (Table 2). Sarker et al. (2000) noted the positive effect of straw yield due to application of B, Zn and Mo. Variation of straw yield was observed to be significant due to application of boron and molybdenum. The maximum straw yield (3.45 ton/ha) was found in BARI Chola-9 when the crop received B and Mo through foliar spray and seed priming respectively. The minimum straw yield (1.78 ton/ha) was noted from BARI Chola-5 in control (Table 3).

Conclusion

Mo deficiency and N fixation severely limit chickpea in acid soils of Bangladesh. It can be corrected by adding Mo in seed. Priming with molybdenum offers an effective, simple and low-cost technology within the scope of resource-poor farmers. Molybdenum is an essential nutrient for humans as a critical enzyme cofactor for metabolizing drugs, toxins and sulfur containing amino acids. In diets dominated by rice, molybdenum intakes may be inadequate. Thus seed priming with molybdenum can have a potential additional benefit for human health. Boron spray enhances the pod yield as evident from the study. This might be due to its positive influence on number of pods/plant and pod set and mobilization of assimilate reserves to the sink. As final conclusions, this study shows that both foliar application of boron and seed priming with Mo, under field conditions increase seed yield due to an increase in the number of pods/plant. The combined application of B and Mo provides a beneficial effect on seed yield; the boron application was more efficient when it was applied with Mo. Finally, the number of pods/plant is the most influential yield component and the yield component that is most closely correlated with seed yield.

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