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Effect of boron and molybdenum application methods on growth and growth indices of chickpea in Bihar region

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Abstract
A field experiment entitled "Effect of boron and molybdenum application methods on growth and growth indices of chickpea in Bihar" was conducted at Rajendra Prasad Central Agricultural University, Pusa, Bihar, India, during *Rabi* 2019-2020. The combinations of treatments were used for two tillage practices, two irrigation methods and six boron and molybdenum application methods *viz.*, Boron basal (M_1), Boron foliar (M_2), Molybdenum seed treatment (M_3), Molybdenum foliar (M_4), Boron basal + Molybdenum seed treatment (M_5) and Boron basal + Molybdenum foliar (M_6) applications with split-split-plot design and replicated thrice. The results revealed that among the different application methods of Boron and Molybdenum, Boron basal + Molybdenum seed treatment (M_5) significantly influenced higher growth and growth indices at all the phenological phases and on par with Boron basal + Molybdenum foliar (M_6). In contrast, the boron foliar application recorded lower chickpea growth indices in the Bihar region.

Keywords: Chickpea, micronutrients, application methods, growth parameters and growth indices

1. Introduction

Chickpea (*Cicer arietinum*.), also called Bengal gram or Garbanzo bean, comes under the Fabaceae family and is widely grown for its nutritious seeds. It is considered the fourth most important grain legume crop grown worldwide (Arvind *et al.,* 2023) [4]. India is the foremost chickpea-growing country, accounting for 77 percent of the total area and production in the world, with an area of 10.74 Mha and production of 13.54 Mt with a productivity of 1261 kg/ha (Anonymous, 2022) [3]. Chickpea also significantly maintains the soil's fertility and productivity by improving chemical, physical and biological properties and fixing atmospheric nitrogen inside the root nodules (Ali and Kumar, 2005) [2]. Due to its nutritional advantages, the cultivation of chickpeas is becoming more popular in India and across the globe. Chickpea play an important role in confirming nutritional security and environmental security as they have an integral mechanism to fix atmospheric nitrogen in the soil. In legume crops, Rhizobium symbiosis is a significant facet of symbiotic nitrogen fixation, which is exploited to advantage agriculture and its sustainability (Reddy and Singh, 2021) [18].

The biggest problem with chickpea cultivation in India is the lowest productivity compared to other countries due to a need for more management practices on nutrients, irrigation, weeds, and other intercultural practices. Hence, more focus should be given to improving chickpea productivity by adopting proper nutrient management practices. Presently, nutrient depletion in the soil is increasing predominantly, especially micronutrients. Micronutrients play a crucial part in increasing the growth and yields of pulses through their effects on the plant itself and the nitrogen-fixing mutual process (Kumari *et al.,* 2019) [10]. Micronutrient deficiency problems are also exacerbated due to the intensive use of high-yielding crop cultivars (Reddy and Singh, 2021) [18]. The deficiency of micronutrients reduces crop productivity and the quality of produce (Welch and Graham., 2004) [21]. Majorly, zinc, boron and molybdenum micronutrients have been well-documented to involve photosynthesis, nitrogen fixation, respiration, and other biochemical pathways in chickpea (Rawat *et al*., 2021) [17].

Boron influences plant hormone levels, photosynthetic activity, and plant generative growth, influencing chickpea growth and seed yield. Boron is important in synthesizing amino acids and proteins (Ahlawat *et al.,* 2007) [1]. It also maintains carbohydrate metabolism, the mechanism of root and is crucial for the translocation of sugar, phosphorus, calcium and helps in the fixation of nitrogen and establishment of nodules (Singh *et al*., 2015) [19]. Legume crops require more quantity of boron compared to field crops to help in the proper development of reproductive organs. Its deficiency causes plant sterility by malformation of reproductive tissues affecting pollen germination, resulting in increased flower drop and reduced fruit set (Subasinghe *et al*., 2003) [20]. Molybdenum is an important element required by microorganisms for nitrogen fixation. Molybdenum is a structural component of the nitrogenase enzyme, which is dynamically involved in nitrogen fixation by Rhizobium bacteria in the root nodules of leguminous crops and is concurrently essential for the absorption and translocation of iron in plants as well as seeds (Rahman *et al.*, 2008) [15]. It also acts as an activator of some dehydrogenase and phosphatase and a co-factor in the synthesis of ascorbic acid (Welch and Graham, 2004) [21]. Nevertheless, Farmers are unaware of micronutrients and their management and application methods on chickpea.

Considering the above facts, the present investigation entitled "Effect of boron and molybdenum application methods on growth parameters and growth indices of chickpea in Bihar" was conducted to identify the suitable micronutrient application methods for increasing growth and yield of chickpea in Bihar region.

2. Materials and Methods

The experiment was conducted at *the Diara* Research farm of Dr RPCAU, Pusa, Bihar, during the winter season of 2019-2020. The soil of the experimental unit was sandy loam in texture with a slight alkali pH of 7.6, EC of 0.18 dSm^{-1}, medium in organic carbon (0.69%), medium in available nitrogen (268.32 kg/ha), low in phosphorus (20.47 kg/ha) and low in potassium (112.51 kg/ha). The experiment was arranged in a split-split-plot design and replicated thrice. The combination treatments were used for two tillage practices and two irrigation methods with six boron and molybdenum application methods *viz*., 1. Boron basal 2. Boron foliar 3. Molybdenum seed treatment, 4. Molybdenum foliar, 5. Molybdenum seed treatment and 6. Molybdenum foliar applications. Sabour Chana-1 variety was used for the research experimental plot and sown in line at 30 x 10 cm spacing manually in the respective treatment plots. Before sowing, seeds were treated with rhizobium biofertilizer and dried in the shade. For fertilizer application, N, P, and K were given as a basal dose at the time of sowing, and foliar applications were given before flowering. All the recommended practices of chickpea crops were adopted during the study period. The biometric observations at various growth phases, *viz*., Seedling vegetative, reproductive and maturity phase, and the yield parameters were recorded at harvest time. The data recorded during the experimentation were statistically analyzed as per the procedure given by Panse and Sukhatme (1989) [14]. The treatment effect significance was tested using the 'F' test (Fisher, 1958) [7]; wherever the results were significant, the critical difference was worked out at a five percent level and represented as"*." When the treatment differences were non-significant, they were denoted as "NS" (Gomez and Gomez, 1984) [8].

3. Result and Discussion

3.1. Effect of Boron and Molybdenum application methods on growth parameters of chickpea

Micronutrient application methods significantly affected the plant height during the cropping season of 2019-20. The combined application of micronutrients significantly enhanced the plant height than the application alone. The maximum plant height was recorded in the basal application of boron with a molybdenum seed treatment. However, it was found at par with boron basal + molybdenum foliar application and significantly superior over boron foliar and foliar molybdenum at all growth stages (Table 1). This might be due to molybdenum being an essential element for nitrogen assimilation and nitrogen-fixing enzyme; on the other hand, boron is essential for cell wall formation and strengthening of fast-growing tissues. The combined application of molybdenum and boron showed synergistic and significant impacts on plant growth and development than the applied alone, which helped the plants to grow more vigorously. It agrees with the findings of Chatterjee and Bandyopadhyay (2017) [5] and Noor and Hossain (2007) [13]. Molybdenum and boron application methods significantly influenced the number of branches per plant. More branches were recorded in the boron + molybdenum seed treatment, which was at par with the boron basal + molybdenum foliar application. In contrast, fewer branches were observed in the boron foliar application (Table 2). This might be due to boron involved cell division and new cell formation, and molybdenum assimilates the nitrogen in the plant system, which increases plant growth. The combined application of boron and molybdenum significantly produced more branches. Similar findings have been reported by Johansen *et al.* (2007) [9] and Ahalwat *et al.* (2007) [1]. Regarding the dry matter production, the basal application of boron + molybdenum seed treatment significantly produced maximum dry matter, which was on par with the boron basal + molybdenum foliar application. At the same time, the foliar application of boron produced the lowest dry matter of the other application methods (Table 3.). Soil application of boron and seed treatment with molybdenum significantly increased the crop establishment and growth of the plant compared to foliar application as well as late application (Chatterjee and Bandyopadhyay, 2017) [5]. Combining boron and molybdenum increases plant growth and dry matter accumulation by synthesizing plant hormones, enzyme translocation, carbohydrate, and nitrogen fixation, contributing to a higher dry matter accumulation of chickpea. Similar findings have also been reported by Das *et al.* (2012) [6] and Nahardani *et al*. (2013) [12].

3.2 Effect of Boron and Molybdenum application methods on growth indices of chickpea

Concerning the growth indices, basal application of boron + molybdenum treatment was recorded to have a much higher value of CGR, RGR and NAR; it was at par with boron basal + molybdenum foliar, which significantly surpassed the other application methods (Table 4 and 5). Combined application of boron and molybdenum increases the physiological indices of chickpea because boron and molybdenum are directly involved in the plant metabolism as structural, functional elements of the enzyme, also promote the plant water potential, chlorophyll synthesis, translocation of photosynthetic assimilates, which is leads to increase the growth rate of organs and accumulation of dry matter. These results corroborate those that Raju *et al.* (2019) [16] and Mahilane and Singh (2018) [11] reported. The chlorophyll SPAD value does not vary much in the pulse crop like other cereal crops. The Micronutrient application methods showed a significant impact of chlorophyll SPAD value between the treatments at 30 DAS but not in the remaining stages. Among the micronutrient application methods, the boron basal and seed treatment method showed greatly higher than those used by the foliar method at 30 DAS (Table 6). Based on the treatment plan, the foliar application was given at 50 DAS, so foliar application methods recorded a lower chlorophyll SPAD value than the basal and seed treatment application at 30 DAS. It might be due to boron basal and molybdenum seed treatment accumulating more nitrogen content in the leaf initially, resulting in increased chlorophyll content than foliar application at 30 DAS.

Table 1: Effect of boron and molybdenum application on Plant height (cm) of chickpea

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At Harvest
C. Micro nutrient applications				
Boron basal	15.3	26.1	41.3	50.5
Boron foliar	13.5	23.6	40.2	50.1
Molybdenum seed treatment	16.6	27.9	44.2	52.9
Molybdenum foliar	13.4	23.7	41.6	51.8
Boron basal + Molybdenum seed treatment	17.1	31.0	48.7	55.7
Boron basal + Molybdenum foliar	15.7	28.7	47.4	53.8
S. Em±	0.85	0.82	0.96	0.84
CD (P = 0.05)	2.42	2.34	2.74	2.41

Table 2: Effect of boron and molybdenum application on number of branches of chickpea

Treatments	No. of branches/plant			
	30 DAS	60 DAS	90 DAS	At Harvest
C. Micro nutrient applications				
Boron basal	3.1	5.4	9.7	7.6
Boron foliar	2.9	5.2	8.9	6.8
Molybdenum seed treatment	3.4	5.8	11.1	8.3
Molybdenum foliar	2.9	4.9	9.7	7.1
Boron basal + Molybdenum seed treatment	3.5	6.1	13.2	9.9
Boron basal + Molybdenum foliar	3.1	5.9	12.3	8.8
S. Em±	0.22	0.11	0.43	0.44
CD (P = 0.05)	NS	0.31	1.22	1.25

Table 3: Effect of boron and molybdenum application on dry matter production (g/plant) of chickpea

Treatments	Dry matter production (DMP) (g/plant)			
	30 DAS	60 DAS	90 DAS	At Harvest
C. Micro nutrient applications				
Boron basal	1.0	4.0	13.6	20.2
Boron foliar	0.7	3.1	13.4	21.3
Molybdenum seed treatment	1.3	4.6	14.6	23.2
Molybdenum foliar	0.9	2.9	13.7	22.3
Boron basal + Molybdenum seed treatment	1.7	6.0	18.7	26.9
Boron basal + Molybdenum foliar	1.5	5.3	17.4	25.0
S. Em±	0.05	0.25	0.43	0.55
CD (P = 0.05)	0.14	0.71	1.23	1.56

Table 4: Effect of boron and molybdenum application on CGR ($g/m^2/day$) of chickpea

Treatments	CGR ($g/m^2/day$)			
	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS
C. Micro nutrient applications				
Boron basal	0.03	0.10	0.32	0.15
Boron foliar	0.02	0.08	0.34	0.16
Molybdenum seed treatment	0.04	0.11	0.33	0.19
Molybdenum foliar	0.03	0.07	0.33	0.19
Boron basal + Molybdenum seed treatment	0.06	0.15	0.43	0.27
Boron basal + Molybdenum foliar	0.05	0.13	0.41	0.24
S. Em±	0.002	0.009	0.013	0.011
CD (P = 0.05)	0.005	0.026	0.038	0.032

Table 5: Effect of boron and molybdenum application on RGR (g/g/day) and NAR (mg/cm^2/day) of chickpea

Treatments	RGR (g/g/day)			NAR (mg/cm^2/day)		
	30-60 DAS	60-90 DAS	90-120 DAS	30-60 DAS	60-90 DAS	90-120 DAS
C. Micro nutrient applications						
Boron basal	0.05	0.04	0.01	0.36	0.53	0.17
Boron foliar	0.05	0.05	0.01	0.33	0.59	0.14
Molybdenum seed treatment	0.04	0.04	0.01	0.37	0.54	0.21
Molybdenum foliar	0.04	0.05	0.01	0.28	0.59	0.16
Boron basal + Molybdenum seed treatment	0.05	0.05	0.01	0.46	0.69	0.33
Boron basal + Molybdenum foliar	0.04	0.04	0.01	0.41	0.63	0.18
S. Em±	0.003	0.002	0.001	0.032	0.020	0.021
CD (P = 0.05)	NS	0.006	NS	0.093	0.057	0.059

Table 6: Effect of boron and molybdenum application on Chlorophyll content (SPAD value) of chickpea

Treatments	Chlorophyll content (SPAD value)		
	30-60 DAS	60-90 DAS	90-120 DAS
C. Micro nutrient applications			
Boron basal	33.0	44.8	48.5
Boron foliar	31.0	45.8	49.7
Molybdenum seed treatment	35.0	44.9	49.5
Molybdenum foliar	31.8	46.7	50.7
Boron basal + Molybdenum seed treatment	36.9	46.1	50.3
Boron basal + Molybdenum foliar	35.7	47.3	50.9
S. Em±	1.53	0.40	1.47
CD (P = 0.05)	3.63	NS	NS

4. Conclusion
The present investigation revealed that the application method of boron basal + molybdenum seed treatment and Boron basal + molybdenum foliar increased chickpea growth parameters and growth indices. It also increases chickpea grain yield and yield attributes by source-sink relationship in Bihar.

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