Influence of Boron and Molybdenum on growth, yield and economics of Kabuli chickpea (*Cicer kabulium* L.)

ABSTRACT

A Field experiment titled "Influence of Boron and Molybdenum on growth and yield of Kabuli Chickpea (*Cicer kabulium* L.*)"* was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.4), low in organic carbon (0.58%), available N (225 kg/ha), available P (32.30 kg/ha) and available K (350 kg/ha). The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The result showed that growth parameters of Kabuli Chickpea viz., Higher plant height (68.49 cm), dry weight (24.34 g), number of nodules per plant (41.03) and the yield attributes namely pods per plant (14.29), seeds per pod (2.00), seed yield (3.29 t/ha), stover yield (3.36 t/ha) and harvest index (43.80%) were recorded significantly higher with application of treatment 9 Boron 2 kg/ha + Molybdenum 1.5 kg/ha. The higher net returns (122,782 INR/ha), gross return (165,977 INR/ha) and B:C ratio (2.84) was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

Key words: *Kabuli Chickpea, Boron, Molybdenum, Growth and Yield*.

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INTRODUCTION

Chickpea, scientifically known as Cicer arietinum, is a versatile legume cultivated worldwide. India holds a prominent position in chickpea production and consumption. The country has a rich history of cultivating chickpeas, with major production areas in states like Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, and Andhra Pradesh. These regions provide favorable agro-climatic conditions for chickpea cultivation, such as well-drained soils and moderate temperatures. Chickpea contains 18-22 per cent protein, 52-70 per cent carbohydrate, 4-10 per cent fat and sufficient quantity of minerals, calcium, phosphorus, iron and vitamins **(Pujitha *et al*. 2022).** Its deep roots also open the soil, which ensure better aeration and heavy leaf drop increases the organic matter in the soil. It can fix about 25-30 kg N/ha through symbiosis and these minimize dependency on chemical fertilizers. Thus,chickpea plays a vital role in improving the soil health.

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)**. Mo is the key to nitrogen fixation by legumes **(Meagher *et al*. 1991)**. 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).**

Boron deficiency and surplus leads to physiological and morphological disorder in crop plants **(Kastori *et al.,* 2008).** Boron deficiency symptoms are poor root proliferation, inferior development of apical meristem, weak leaves growth, lower chlorophyll and photosynthetic rate, disturbance in ion channel; higher phenolic and lignin concentrations, and lower crop production (**Wang *et al.,* 2015)**. Boron application is reported to have significant improvement in chickpea development and its scarcity cause destructive effects on chickpea production.

By combining B and Mo sources and applying them at appropriate times, farmers can enhance improve crop performance, and contribute to sustainable chickpea production systems.

MATERIALS AND METHODS

The experiment was conducted at during rabi 2022, at Crop Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj. The experimental site of the study is geographically located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level (MSL). The soil of the experimental field constituting a part of central Gangetic alluvium is neutral and deep. The soil was sandy loam in texture, organic carbon (0.58%) and available nitrogen (225 kg/ha), phosphorous (32.30 kg/ha) and low in potassium (350 kg/ha). The experiment was laid out in randomized block design with three replications comprising ten treatment *viz*., T_1: Boron 1 kg/ha + Molybdenum 0.5 kg/ha, T_2: Boron 1 kg/ha + Molybdenum 1 kg/ha, T_3: Boron 1 kg/ha + Molybdenum 1.5 kg/ha, T_4: Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha, T_5: Boron 1.5 kg/ha + Molybdenum 1 kg/ha, T_6: Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha, T_7: Boron 2 kg/ha + Molybdenum 0.5 kg/ha, T_8: Boron 2 kg/ha + Molybdenum 1 kg/ha, T_9: Boron 2 kg/ha + Molybdenum 1.5 kg/ha and T_{10}: Control (RDF 20:60:60 NPK kg /ha). Dollar variety chickpea was used for sowing. Recommended nutrient dose 20:60:60 NPK kg/ha were applied in the plot through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively at the time of sowing. All other recommended agronomic practices were followed and plant protection measures were adopted as per need. The plots were prepared with dimension of 3m × 3m and seeds were sown with a spacing of 30cm × 10cm. Irrigations were given uniformly and regularly to all plots as per requirement so as to prevent the crop from water stress at any stage. The crop was completely harvested at physiological maturity stage and their post-harvest observations such as number of pods per plant, number of seeds per pod, test weight (g), seed yield (t/ha), stover yield (t/ha) and harvest index (%) were recorded. The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by **Gomez (1984).**

RESULTS AND DISCUSSIONS

Growth parameters

Table.1 Pertaining the details of Influence of Boron and Molybdenum on growth attributes of Kabuli Chickpea.

Plant height (cm)

Significantly higher plant height (68.49 cm) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha at 120 DAS. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (67.77cm) and Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (67.22 cm) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

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 reported that successive plant growth was carried out by application of boron and molybdenum. Mo fertilization at 1.5 kg/ha equivalently promotes plant height, nodulation, number of pods, dry matter production and seed yield **(Meera *et. al.* 2019)**

Dry weight (g)

Significantly higher dry weight (24.34 g) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha at 120 DAS. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (23.40 g), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (23.39 g) and Boron 1.5 kg/ha + Molybdenum 1 kg/ha (23.12 g) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

The result obtained on dry weight per plant exhibited on increasing trend upto harvest stages. Plants fertilized with B had greater total dry matter production (30.36 g), plant growth increased with application of B 3kg/ha **(Kumar 2022)**. Plant growth was affected by the Mo application; at maturity plants fertilized with Mo had greater total dry matter production, because the Mo foliar application caused an increase in plant growth **(Bhanavase and Patil 1994)** and **(Johansen *et al*. 2007)**. The dry matter production increase, with increased Mo supply, was mostly due to the increase in the number of pods (including seeds) per plant and also because, according to **(Ahlawat *et al*. 2007)**, there were more flowers produced.

Number of nodules/plant

At 120 DAS, significantly higher number of nodules/plant (2.80) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (2.44) was found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

The improvement in crop growth and nodulation due to Mo and B could be ascribed to itspivotal role in nodule synthesis and fixing of nitrogen **(Hoque *et al.* 2021).** Similar investigation was also observed by **(Chakraborty 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).**

Crop growth rate (g/m^2/day)

During 100-120 DAS, significantly higher crop growth rate (8.26 g/m^2/day) was recorded in Boron 1.5 kg/ha + Molybdenum 1 kg/ha. However, Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (8.22 g/m^2/day), Boron 2 kg/ha + Molybdenum 1 kg/ha (6.50 g/m^2/day) and Boron 2 kg/ha + Molybdenum 1.5 kg/ha (6.04 g/m^2/day) were found statistically at par with Boron 1.5 kg/ha + Molybdenum 1 kg/ha.

The maximum CGR was registered with B (10 kg/ha) + Mo (0.2%) treatment (0.25 g/plant/day). Increased CGR in the treatments inclusive of B and Mo is indicative of enhanced physiological growth condition of a crop which enables to produce higher seed yield **(Karim and Fattah, 2007)**.

Yield attributes

Table. 2 and 3 Pertaining the details of Influence of Boron and Molybdenum on growth and yield of Kabuli chickpea.

Number of pods/plant:

Significantly higher number of pods/plant (14.29) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (14.12), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (13.63), Boron 1 kg/ha + Molybdenum 1.5 kg/ha (13.80) and Boron 1 kg/ha + Molybdenum 1 kg/ha (13.60) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

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)**, who reported that application of molybdenum improved numbers 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 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.

Number of seeds/pod

Significantly higher number of seed/pod (2.00) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (1.80), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (1.87) and Boron 1.5 kg/ha + Molybdenum 1 kg/ha (1.67) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

Data analysis presented that molybdenum and boron affected seeds per pod significantly. Number of pods were maximum when molybdenum was used in amount of 0.6 kg/ha while lowest were observed in non-Mo treated plants. Our outcomes are in similarity with **(Tahir *et al*. 2011)**, they described that fertilization of molybdenum enhanced seeds per pod. In case of boron higher seeds per pod were noted with the use of 3.6 kg/ha and less were recorded in no boron treated plants. This is because that boron play role in seed setting which can increase seeds per pod which might be the cause of more seed yield. This outcome is in conformity with the conclusions of **(Kushwaha 1999)** and **(Hossain *et al*. 2016)**, who declared that treating boron expressively increases seeds per pod.

Seed index (g)

Significantly higher seed index (41.28 g) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (40.83 g), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (41.12 g), Boron 1.5 kg/ha + Molybdenum 1 kg/ha (41.10 g), Boron 1 kg/ha + Molybdenum 1.5 kg/ha (40.89) and Boron 1 kg/ha + Molybdenum 1 kg/ha (40.58) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

It possibly could 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).**

Seed yield (t/ ha)

Significantly higher seed yield (3.29 t/ha) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (3.18 t/ha), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (3.16 t/ha) and Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (2.94 t/ha) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

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).**

Stover yield (t/ha)

Significantly higher haulm yield (3.36 t/ha) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (3.30 t/ha) was found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

(Sarker *et al*. 2000) noted the positive effect of straw yield due to application of B and Mo. **(Hoque et al. 2021)** reported that variation of stover yield was observed to be significant due to application of boron and molybdenum. The maximum stover 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.

Harvest Index (%)

Significantly higher harvest index (43.80 %) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (43.12 %), Boron 2 kg/ha + Molybdenum 0.5 kg/ha (39.27 %), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (43.92 %), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (42.60 %) and Boron 1 kg/ha + Molybdenum 0.5 kg/ha (38.92 %) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

(Mekkei 2019) reported increase in harvest index by 8.2% in B+Mo treatment as compared to control treatment. The reason of this is increasing of seed yield more than biological yield. The greatest value of harvest index (23.6 and 24.1%) was recorded in treatment (B+Mo) in both seasons. Thus, increasing of seed yield could improve harvest index. These results are in agreement with those of **(Sarbandi and Madani 2014), (Ganga *et al*. 2014), (Rahman *et al*. 2017), (Nasar and Shah 2017)** and **(Kobaraee 2019)** who reported that application of molybdenum significantly increased harvest index (%) of chickpea and lentil.

Gross return (INR/ha)

The higher gross return was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha (165,977 INR/ha).

Net returns (INR/ha)

The higher net return was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha (122,782 INR/ha).

Benefit cost ratio (B:C)

Higher B:C was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha (2.84), as compared to rest of the treatments.

Thus, Boron 2 kg/ha + Molybdenum 1.5 kg/ha is economically profitable. There was considerable increase in the net return and B:C ratio with foliar application of Mo and B.

CONCLUSION

From the observations, it was concluded that with the combination of Boron 2 kg/ha + Molybdenum 1.5 kg/ha in treatment no. 9 significantly recorded higher in all the growth and yield attributes namely, plant height, dry weight, pods per plant, seeds per pod, seed index, seed yield, pod yield and haulm yield. Also recorded higher net return and B.C ratio and therefore is a fitting practice for augmenting higher Kabuli chickpea yields for farmer.

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Table 1: Influence of Boron and Molybdenum on growth attributes of Kabuli Chickpea.

S. No.	Treatments	Plant height (cm)	Dry weight (g)	Nodules/plant	CGR (g/m^2/day)	RGR (g/g/day)
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	61.70	18.40	1.40	6.58	0.01206
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	65.40	18.87	1.80	4.48	0.00770
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	66.01	20.08	1.93	4.35	0.00696
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	62.80	18.34	1.40	4.63	0.00823
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	66.59	23.12	2.13	8.26	0.01210
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	67.22	23.39	2.30	8.22	0.01184
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	64.15	18.31	1.40	4.43	0.00786
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	67.77	23.40	2.44	6.50	0.00911
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	68.49	24.34	2.80	6.04	0.00806
10.	Control (RDF 20:60:60 NPK kg/ha)	61.11	17.68	0.80	4.41	0.00805
	F Tab (5%)	S	S	S	S	NS
	SEm (±)	0.50	0.47	0.13	0.81	0.001
	CD (p=0.05%)	1.40	1.33	0.37	2.26	-

Table 2:Influence of Boron and Molybdenum on yield attributes of Kabuli Chickpea.

S.No.	Treatments	Pods/plant	Seeds/pod	Seed index
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	12.20	1.20	39.38
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	13.60	1.33	40.58
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	13.80	1.33	40.89
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	12.33	1.13	39.56
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	13.44	1.67	41.10
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	13.63	1.87	41.12
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	12.67	1.40	39.72
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	14.12	1.80	40.83
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	14.29	2.00	41.28
10.	Control (RDF 20:60:60 NPK kg/ha)	11.68	1.00	37.46
	F-Test	S	S	S
	SEm (±)	0.28	0.16	0.40
	CD (p = 0.05)	0.80	0.47	1.11

Table 3: Influence of Boron and Molybdenum on yield attributes of Kabuli Chickpea.

S.No.	Treatments	Seed yield (t/ha)	Haulm yield (t/ha)	Harvest Index (%)
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	1.52	2.16	38.92
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	2.24	2.91	34.00
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	2.46	2.98	36.61
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	1.88	2.24	35.74
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	2.94	3.06	42.60
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	3.16	3.21	43.92
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	2.19	2.41	39.27
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	3.18	3.30	43.12
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	3.29	3.36	43.80
10.	Control (RDF 20:60:60 NPK kg/ha)	1.26	2.01	26.30
	F-Test	S	S	S
	SEm (±)	0.112	0.03	2.52
	CD (p = 0.05)	0.313	0.09	7.04

Table 4. Influence of Boron and Molybdenum on economics of Kabuli Chickpea

		Economics(INR)			
S.No.	**Treatments**	**Cost of Cultivation (INR/ha)**	**Gross return (INR/ha)**	**Net return (INR/ha)**	**B C ratio (%)**
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	41,645.00	76,760.00	35,115.00	0.84
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	42,295.00	113,120.00	70,825.00	1.67
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	42,945.00	124,230.00	81,285.00	1.89
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	41,770.00	94,940.00	53,170.00	1.27
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	42,420.00	148,470.00	106,050.00	2.50
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	43,070.00	159,580.00	116,510.00	2.70
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	41,894.00	110,595.00	68,701.00	1.63
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	42,545.00	160,759.00	118,213.00	2.77
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	43,195.00	**165,977**.00	**122,782**.00	**2.84**
10.	Control (RDF 20:60:60 NPK kg/ha)	40,745.00	63,630.00	22,885.00	0.56

*MSP (minimum support price) for chickpea= 5050 per quintal