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RESEARCH ARTICLE Agricultural Science Digest

Assessment of the Economic Impact of Boron and Molybdenum on Cowpea (*Vigna unguiculata* L.) in South Gujarat

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10.18805/ag.D-6373

ABSTRACT

Background: Cowpea production has been noticeably increased during the last few decades due to its wider adaptability to withstand against adverse climatic conditions. It's numerous dietary, agronomical and climate resilient property has imparted significant contribution to the population across the globe. The current study aim to study the economic impacts of boron and molybdenum on cowpea (*Vigna unguiculata* L.) in South Gujarat region in order to manage and control cowpea production related problems.

Methods: The experiment was conducted for three years, from 2019 to 2021 at Navsari, Gujarat. The experiment was arranged in a two- factor randomized block design with three replications. The factor-A comprised of seed treatments with molybdenum at 2 mg/l (M_1), 4 mg/l (M_2), 6 mg/l (M_3) for 24 hours prior to sowing including control (M_0), where as the factor- B comprised of boron (B) spray at 2 mg/l (B_1), 4 mg/l (B_2), 6 mg/l (B_3) and control at 30 DAS, 45 DAS and 60 DAS. The experiment was conducted on Anand Vegetable Cowpea-1 (AVCP-1) variety of cowpea.

Result: The cowpea seed treated with molybdenum at 2 mg/l (M_1) provides the highest net realization (Rs. 1,20,345.94). Similarly, in case of individual effect of boron foliar spray at 4 mg/l (B_2) at 30 DAS, 45 DAS and 60 DAS gave the highest net realization (Rs. 1,36,576.61) as compared to other levels including control. Furthermore, the treatment combination of molybdenum seed treatment @ 2 mg/ l with foliar spray of boron @ 4 mg/ l at 30, 45 and 60 DAS (M_1B_2) resulted in the highest gross return (Rs. 2,45,400), net return (Rs. 1,73,589.51) and benefit cost ratio (3.42) compared to all other treatment combinations. These findings suggest that seed treatment with molybdenum prior to sowing followed by foliar application of boron at 30, 45 and 60 DAS would be economically profitable for the farmers of South Gujarat.

Key words: B:C ratio, Boron, Cowpea, Gross return, Molybdenum, Net return.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] belongs to family *Leguminaceae,* has significant ability to withstand against adverse climatic conditions like high temperatures and drought, which has boost up its production noticeably during the last few decades. Its ability to restore soil fertility for succeeding cereal crops in crop rotation, making this crop a valuable component of farming systems throughout the world (Kumar *et al*., 2015). Beside this, it is being used as food *viz*., fresh-shelled cowpea seeds are cooked as a vegetable and dry mature seeds are utilized as pulse for boiling and canning. Looking to its nutritional value, cowpea contains 23-32% protein which is 2 to 4 times higher than cereal, 50-60% carbohydrates and 1% fat. Also, contains reasonable amount of dietary fiber, phytochemicals, minerals and vitamins. Thus, due to its multiple nutritional, agronomical and climate resilient qualities it makes greater contribution in food and nutritional security as well as economic to the population across the globe.

Molybdenum plays a key role in proper functioning of nitrogenase enzyme. Rhizobium bacteria require molybdenum for the fixation process as it acts as a cofactor for the nitrate reductase enzyme which is responsible for nitrogen assimilation in the soil (Nadia Gad and Abd El-Moez, 2013). Thus, in leguminous crops molybdenum have greater influence on nodulation and nitrogen fixation process (Rathod *et al*., 2024).

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How to cite this article: Rathod, H.R., Kaswala, A.R., Intwala, C.G. and Patel, P. (2025). Assessment of the Economic Impact of Boron and Molybdenum on Cowpea (*Vigna unguiculata* L.) in South Gujarat. *Agricultural Science Digest.* 1-5. doi: 10.18805/ag.D-6373.

Submitted: 17-05-2025 **Accepted:** 26-11-2025 **Online:** 25-12-2025

Boron being an important micro nutrient for development of reproductive organs, its deficiency during reproductive phase may create negative impact on pollen germination, fertilization and pod setting (Chatterjee and Bandyopadhyay, 2017). Beside this, cowpea being a short duration crop, could not receive full amount of the fertilizer applied in soil before maturity (Naik *et al*., 2018). Foliar spray efficiently provides the applied quantity of boron to the plant. Therefore, this study was undertaken to assess the economic impact of

boron foliar spray and molybdenum seed treatment on cowpea (*Vigna unguiculata* L.) in South Gujarat.

MATERIALS AND METHODS

The research trial was conducted for three years from 2019 to 2021 at Vegetable Research Farm, RHRS, Navsari Agricultural University, Navsari, Gujarat. The experimental field was geographically situated at 72°54′ East longitude and 20°57′ North latitude at an altitude of 11.89 m above mean sea level and about 12 km away from the Arabian sea coast. Traditionally, the South Gujarat region receives average rainfall of about 1500 mm which starts from second fortnight of June and ceases by September end. The experimental site has heavy black soil which is rich in organic matter, potash and clay content ranges from 60 to 68% predominated by montmorillomitic clay minerals along with pH 6.8 and EC 0.53 dS/m.

The experiment was implemented in randomized block design with factorial concept and was replicated thrice. There were two factors under study. Factor one consisted of four levels of seed treatments with molybdenum (M) at 2 mg/l (M_1), 4 mg/l (M_2), 6 mg/l (M_3) for 24 hours prior to sowing and control (M_0), where as the second factor was consisted of four levels of boron (B) spray at 2 mg/l (B_1), 4 mg/l (B_2), 6 mg/l (B_3) at 30 DAS, 45 DAS and 60 DAS including control (B_0). Thus, overall there were sixteen treatment combinations were under study in this experiment. Boron was applied in the form of boric acid and molybdenum as ammonium molybdate.

Economics

The input cost of cultivation includes all the operational cost from land preparation to harvesting of crop. The cost that varies between treatments were; cost of agrochemicals which were used for seed treatment and exogenous application, labour charge for spray, market price of produce and transportation cost of different treatments under study. The gross return was calculated based on the green pod yield and its market price for the studied treatments. Net realization was calculated by subtracting the total cost of cultivation from gross realization for all the possible treatment combinations under study and was recorded in rupees per hectare. The benefit cost ratio was also calculated for each the studied treatment combinations.

RESULTS AND DISCUSSION

Yield parameter

The green pod yield of cowpea showed significant influence of different levels of molybdenum seed treatment and foliar application of boron and its combinations. The treatment combination of molybdenum seed treatment at 2 mg/ l followed by foliar spray of boron at 4 mg/l) registered maximum green pod yield per hectare (12.88, 11.62, 12.31 and 12.27 t/ha, respectively) during all the individual years of experimentation as well as in pooled analysis (Table 1 and Fig 1). These results are in accordance with Velmurugan and Mahendran (2015). The increase in green pod yield per hectare is the result of increased plant vegetative as well as reproductive growth due to better nutritional environment present in the rhizosphere, induced by nitrogen fixation coupled with foliar application of boron might have increased the yield attributes and ultimately the yield. These results are consistent with the conclusions drawn by Kalyani and Math (2021) and Katara *et al.* (2025).

Economic parameter

After completion of three consecutive years of experimentation, the economics was worked out to find the best and economical combination of boron and molybdenum. Result regarding economic analysis for different treatment combinations are presented in Table 1 and depicted in Fig 2 and 3. The data presented in Table 1 gives the detailed overview of the economic parameters of the experiment which were calculated based on average green pod yield of three years. It has revealed nuanced variations

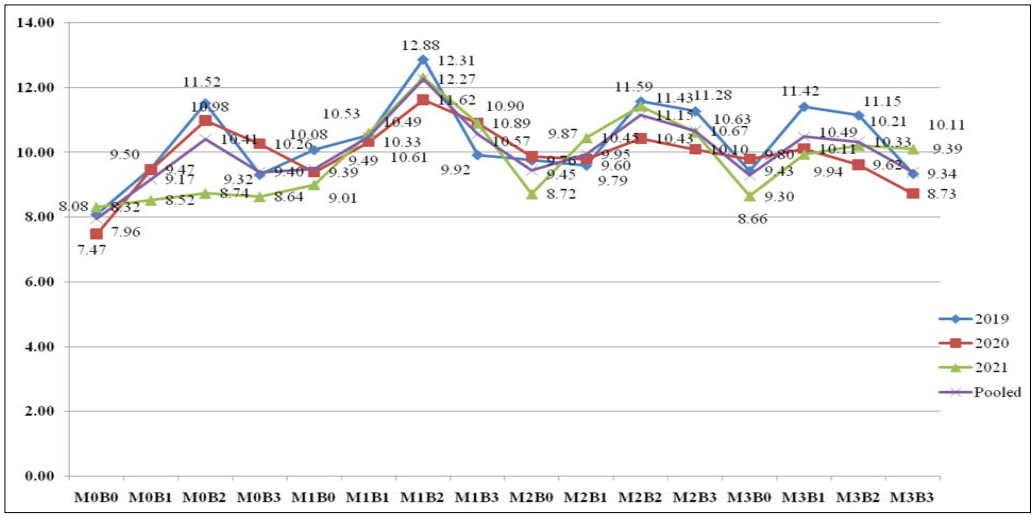

Fig 1: Impact of boron and molybdenum on green pod yield per hectare (t/ha).

Table 1: Economic impact of boron and molybdenum on cowpea.

Treatment	Green pod yield (t ha^{-1})	Fixed cost (Rs.)	Variable cost (Rs.)	Total cost (Rs.)	Gross realization (Rs.)	Net Realization (Rs.)	B:C ratio
T_1- M_0B_0 (Control)	7.96	68503.96	796.00	69299.96	159200.00	89900.04	2.30
T_2 - M_0B_1 (Boron foliar spray 2 mg/ l (At 30,45 and 60 DAS)	9.17	68503.96	2976.22	71480.18	183400.00	111919.82	2.57
T_3 - M_0B_2 (Boron foliar spray 4 mg/ l (At 30,45 and 60 DAS)	10.41	68503.96	3119.43	71623.39	208200.00	136576.61	2.91
T_4 - M_0B_3 (Boron foliar spray 6 mg/ l (At 30,45 and 60 DAS)	9.40	68503.96	3037.66	71541.62	188000.00	116458.38	2.63
T_5- M_1B_0 (Molybdenum seed treatment 2 mg/ l)	9.49	68503.96	950.10	69454.06	189800.00	120345.94	2.73
T_6- M_1B_1 (Molybdenum seed treatment 2 mg/ l + (Boron foliar spray 2 mg/ l (At 30, 45 and 60 DAS)	10.49	68503.96	3109.32	71613.28	209800.00	138186.72	2.93
T_7- M_1B_2 (Molybdenum seed treatment 2 mg/ l + (Boron foliar spray 4 mg/ l (At 30, 45 and 60 DAS)	12.27	68503.96	3306.53	71810.49	245400.00	173589.51	3.42
T_8- M_1B_3 (Molybdenum seed treatment 2 mg/ l + (Boron foliar spray 6 mg/ l (At 30, 45 and 60 DAS)	10.57	68503.96	3155.76	71659.72	211400.00	139740.28	2.95
T_9 -M_2B_0 (Molybdenum seed treatment 4 mg/ l)	9.45	68503.96	947.20	69451.16	189000.00	119548.84	2.72
T_{10} - M_2B_1 (Molybdenum seed treatment 4 mg/ l + (Boron foliar spray 2 mg/ l (At 30, 45 and 60 DAS)	9.95	68503.96	3056.42	71560.38	199000.00	127439.62	2.78
T_{11} - M_2B_2 (Molybdenum seed treatment 4 mg/ l + (Boron foliar spray 4 mg/ l (At 30, 45 and 60 DAS)	11.15	68503.96	3195.63	71699.59	223000.00	151300.41	3.11
T_{12} - M_2B_3 (Molybdenum seed treatment 4 mg/ l + (Boron foliar spray 6 mg/ l (At 30, 45 and 60 DAS)	10.67	68503.96	3166.86	71670.82	213400.00	141729.18	2.98
T_{13}-M_3B_0 (Molybdenum seed treatment 6 mg/ l)	9.30	68503.96	933.32	69437.28	186000.00	116562.72	2.68
T_{14}- M_3B_1 (Molybdenum seed treatment 6 mg/ l + (Boron foliar spray 2 mg/ l (At 30, 45 and 60 DAS)	10.49	68503.96	3111.54	71615.5	209800.00	138184.5	2.93
T_{15}- M_3B_2 (Molybdenum seed treatment 6 mg/ l + (Boron foliar spray 4 mg/ l (At 30, 45 and 60 DAS)	10.33	68503.96	3114.75	71618.71	206600.00	134981.29	2.88
T_{16} -M_3B_3 (Molybdenum seed treatment 6 mg/ l + (Boron foliar spray 6 mg/ l (At 30, 45 and 60 DAS)	9.39	68503.96	3039.98	71543.94	187800.00	116256.06	2.62

among different treatment combinations for the economic parameters *viz*., total cost of cultivation, gross realization, net realization, benefit-cost ratio.

The total cost of cultivation ranged from 69,299.96 Rs. ha^{-1}(M_0B_0) to 71,810.49 Rs. ha^{-1}(M_1B_2), demonstrated the significant variation in expenses of all the treatment combinations under study based on all cultivation practices, treatment application cost as well as labour cost. Among all the treatments, the treatment combination of M_1B_2 *i.e.* Molybdenum seed treatment 2 mg/l with boron foliar spray 4 mg/l at 30, 45 and 60 days after sowing has notably recorded the highest cost of cultivation at 71,810.49 Rs. ha^{-1}. This emphasizes the substantial economic implications of specific treatment application strategies on overall cultivation expenses of cowpea.

The considerable diversity was exhibited for gross realization across the treatment combinations. The treatment combination M_1B_2 *i.e.* Molybdenum seed treatment 2 mg/l with boron foliar spray 4 mg/l at 30, 45 and 60 days after sowing stands with the highest gross return of 2,45,400.00 Rs ha^{-1}, which was closely followed by M_2B_2 *i.e.* Molybdenum seed treatment 4 mg/l + Boron foliar spray 4 mg/ l at 30, 45 and 60 DAS with 2,23,000.00 Rs ha^{-1}. On contrary, M_0B_0 (Control) recorded the lowest gross return of 1,59,200.00 Rs. ha^{-1}. The significant variations among different treatment combinations highlights, impact of foliar application of boron and molybdenum seed treatments on productivity of cowpea and the subsequent financial returns.

In case of net realization, an indicator of profitability registered a similar trend with net returns. M_1B_2 *i.e.* Molybdenum seed treatment 2 mg/ l with boron foliar spray 4 mg/l at 30, 45 and 60 days after sowing exhibited the highest net return at 1,73,589.51 Rs. ha^{-1}, emphasizing the economic feasibility of the particular treatment combination. In opposition, M_0B_0 (Control) recorded the lowest net return

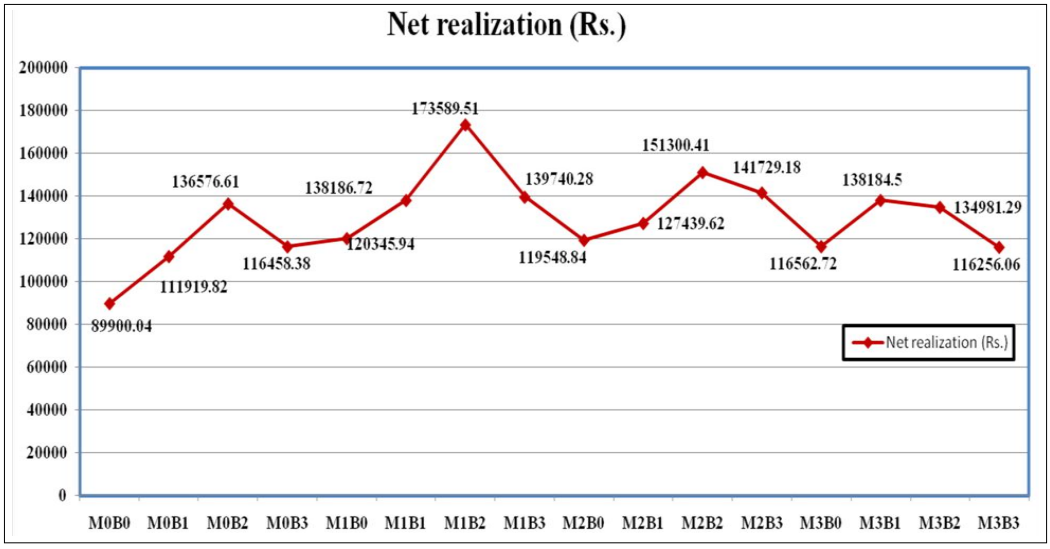

Fig 2: Impact of boron and molybdenum on Net realization (Rs.) of cowpea.

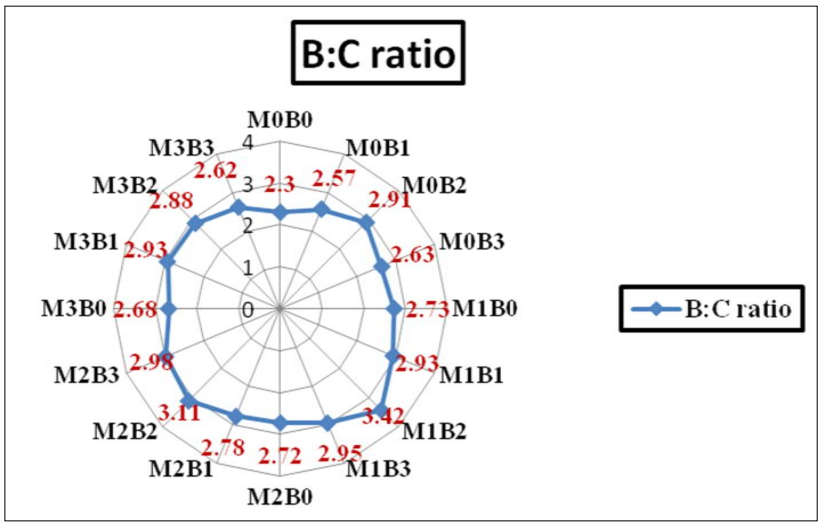

Fig 3: Impact of boron and molybdenum on B:C ratio of cowpea.

at 89,900.04 Rs. ha^{-1}, underscoring potential economic challenges associated with specific treatment combination.

The benefit-cost ratio (B:C Ratio), a key unit for assessing profitability, varied across treatment combinations. M_1B_2 (Molybdenum seed treatment 2 mg/l + Boron foliar spray 4 mg/l at 30, 45 and 60 DAS) and M_2B_2 (Molybdenum seed treatment 4 mg/l + Boron foliar spray 4 mg/l at 30, 45 and 60 DAS) consistently demonstrated higher B:C ratios at 3.42 and 3.11, respectively indicating favorable economic outcomes. Such significant increase in gross returns, net returns and B: C ratio with molybdenum seed treatment and boron foliar spray was also reported by Kumar *et al.* (2010) and Parry *et al.* (2016). On contrary, M_0B_0 (Control) registered the lowest B:C ratio at 2.30, suggesting unviability of the treatment combination.

CONCLUSION

From the foregoing results and discussion on assessment of the economic impact of boron and molybdenum treatment on cowpea (*Vigna unguiculata* L.) in South Gujarat region it was inferred that:

The treatment combination M_1B_2 *i.e.* Molybdenum seed treatment 2 mg/ l with foliar spray application of boron 4 mg/ l at 30, 45 and 60 days after sowing registered the higher cost of cultivation (71,810.49 $Rs.ha^{-1}$) as well as the highest gross return of 2,45,400.00 Rs. ha^{-1} as compared to other studied treatment combination.

Similar trend was observed in terms of net realization and the highest net return of 1,73,589.51 Rs. ha^{-1} was also recorded in the same treatment combination M_1B_2 (Molybdenum seed treatment 2 mg/ l + boron foliar spray 4 mg/ l at 30, 45 and 60 days after sowing).

With regards to B:C ratio, the highest value of benefit cost ratio (3.42) was obtained from treatment combination of M_1B_2 (Molybdenum seed treatment 2 mg/ l + boron foliar spray 4 mg/ l at 30, 45 and 60 days after sowing) followed by benefit cost ratio (3.11) obtained from treatment combination of M_2B_2 (Molybdenum seed treatment 4 mg/ l + Boron foliar spray 4 mg/ l at 30, 45 and 60 DAS).

ACKNOWLEDGEMENT

All the authors gratefully acknowledge the technical and financial support from the Navsari Agricultural University.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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