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Satya Prakash Gupta
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

PK Singh
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Vivek
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

RK Naresh
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

M Sharath Chandra
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Sandeep Kumar Verma
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Anand Kumar
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Durgesh Kumar Maurya
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Siddhant Gupta
Acharya Narendra Dev University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Satya Prakash Gupta
Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Effect of micronutrients application on productivity and profitability of moong bean (*Vigna radiata* L.)

Satya Prakash Gupta, PK Singh, Vivek, RK Naresh, M Sharath Chandra, Sandeep Kumar Verma, Anand Kumar, Durgesh Kumar Maurya and Siddhant Gupta

Abstract
A field experiment was conducted at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, with a view to compare the production potential under different micronutrients application and also to find out the economic viability of this cultivar for soil quality. The treatments comprised of consistent application of *Rhizobium* inoculation *viz*., Control**,** RDF (20:40:20) kg ha^{-1}**,** RDF + Zn @ 5 kg ha^{-1}**,** RDF + B @ 2.5 kg ha^{-1}**,** RDF + Mo @ 1 kg ha^{-1}**,** RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}**,** RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}, RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} and RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} were tested in RBD with three replications. SML-1827 was grown as a test variety. The results indicated that with the application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} exhibited significant influence on yield attributes and yields of moong bean as compared to over rest of the micronutrients treatments. The maximum gross return was obtained in T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) followed by T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). The highest net return was obtained in T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) followed by T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}), while minimum gross return and net return was obtained in T_1 (control plot). Higher values of B: C ratio (2.35) was obtained in T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). Thus the application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} was found better for sustainability of moong bean.

Keywords: Moong bean, micronutrients, production potential, profitability

Introduction
The pulses are an excellent source of dietary proteins and play an important role in fulfilling requirements of rapidly increasing population. Pulse production is very low and has become a challenging problem against the requirement of increasing population of our country (Choudhay *et al*., 2016) [8]. Its shortage in human diet leads to manifold problems, *viz.*, poor growth and development particularly of growing child. In India, the protein status of common man's diet is far less than the minimum recommendations (80 g day^{-1}) of Indian Council of Medical Research (ICMR) (Aftab *et al*., 2018) [1]. Green gram locally called as moong (*Vigna radiate* L.) belongs to the family leguminaceae. Being a short duration crop and having wider adaptability, it can be grown in kharif as well as in summer season. It is an important ruling crop in summer season. The yield of summer green gram are comparatively more than that of kharif crop mainly because of controlled moisture conditions through irrigation, abundant sunshine and less pest and disease infestation (Balai *et al*., 2017) [5]. Moong bean is an excellent source of protein (25%) with good amount of lysine content (460 mg g^{-1}) and tryptophan (60 mg g^{-1}). It also has remarkable quantity of ascorbic acid when sprouted and also bear riboflavin (0.21 mg 100 g^{-1}) and minerals (3.84 g 100 g^{-1}). Moong bean sprouts are a rich source of vitamin C (8 mg 100 g^{-1}). The total area covered under moong bean in India during 2017-18 was 4.1 m ha with a total production of 1.9 m tonnes and a productivity of 463 kg ha^{-1} (Anonymous 2019) [3]. This necessitates a holistic approach for balanced and integrated nutrient management Farmyard manure and vermin compost have been advocated as good organic manure for use in integrated nutrient management programme in field crop. they supply nitrogen, phosphorus, potassium and micronutrient like Zn, S, Mo, B etc. in available form to the plants through biological decomposition and improve physical-chemical properties of soil, slow release of nutrients, increase in cation exchange capacity and enhance the microbial, crop growth and yield (Bhamare *et al*., 2018; Chaurasiya *et al*., 2020) [6, 7].

The purpose of the current field experiment to evaluate the performance of moong bean (*Vigna radiata* L.) on productivity and profitability under different application of micronutrients of western Uttar Pradesh.

Material and Methods

The field experiment was conducted at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to study the influence of different micronutrients on productivity and profitability of Moong bean in Randomized Block Design with 09 treatments *viz*., *viz*., *Control*, RDF (20:40:20) kg ha^{-1}, RDF + Zn @ 5 kg ha^{-1}, RDF + B @ 2.5 kg ha^{-1}, RDF + Mo @ 1 kg ha^{-1}, RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}, RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}, RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} and RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} respectively were replicated three times. The maximum and minimum temperatures recorded were 35.9 ºC and 18.5 ºC during the crop growth period. Maximum temperature ranged from 18.5 ºC to 35.9 ºC during maturity phase of the crop. Relative humidity varied from 46.5% to 95.7% during crop growth period. The area receives mean annual rainfall of 845mm. The soil of the experimental field was sandy loam in texture, low in available nitrogen (180.5 kg ha^{-1}) and organic carbon (0.47%), medium in available phosphorous (13.5 kg ha^{-1}) and potassium (180.0 kg ha^{-1}), available zinc (16.1 ppm), available boron (0.6 ppm), available molybdenum (0.26 ppm) and slightly alkaline (pH 8.0) in reaction with electrical conductivity of 0.16 dS m^{-1}. The gross and net plot size were 5 m X 3.6 m and 4.0 m X 2.4 m respectively. The crop variety SML-1827 was sown on 01 August 2020 and harvested on 06 October 2020. The seed rate was 20 kg ha^{-1}. Seeding was done in the row to row spacing of 30 cm and plant to plant spacing of 10 cm. The recommended dose of nitrogen (120 kg ha^{-1}) was applied in two equal split, the half as basal and the remaining half was top dressed 2 times at the time of first and second irrigation. The whole quantity of potassium (40 kg ha^{-1}) was applied as basal dose through Murate of Potash at 8-10 cm depth along with half dose of nitrogen prior to sowing. Phosphorous was applied as basal dose (60 kg ha^{-1}) through DAP. Vermicompost (2t ha^{-1}) and FYM (6t ha^{-1}) were applied in the field as per treatments and was thoroughly mixed at the time of sowing. The sulphur was applied through Gypsum in the field as per treatments. Boron was applied through borax at the time of sowing. Zinc was applied at the time of sowing in the form of Zinc sulphate. The seed was treated with Azotobacter @200g / 10 kg seed which was applied as per treatments before the sowing. One thinning was done after 30 days of sowing to maintain a plant to plant distance of about 10 cm.

Weeding and hoeing operation were performed manually after first and second irrigation at proper soil moisture condition of the soil. At the harvest, number of grains per pod, 1000 grains weight, grain yield and straw yield were calculated. Economics of treatments were computed on the basis of prevailing market price of inputs and outputs under each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and materials used for raising the crop including the cost of fertilizers and seeds. The cost of labour incurred in performing different operation was also included. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at $P<0.05$ level of probability using t-test and calculating CD values.

Result and Discussion

Effect of micronutrient on yield attributes moong bean

Yield attributes *viz*., Number of pods plant^{-1}, Pod length (cm), Number of grains pod^{-1}, Grain yield plant^{-1} and weight of 1000 grains of moong bean were affected significantly by various treatments involving different micronutrients treatments (Table 1 and Fig 1).

Table 1: Effect of micronutrient on yield attributes characters of moong bean crop

Symbol	Treatment	Yield attributes				
		No. of Pods plant^{-1}	Pod length (cm)	No. of Grains pod^{-1}	Grain yield (g plant^{-1})	1000 grains weight(g)
T_1	Control	5.65	5.3	3.75	1.12	31.65
T_2	RDF (20:40:20) kg ha^{-1}	8.35	6.1	6.00	2.09	33.45
T_3	RDF + Zn @ 5 kg ha^{-1}	10.05	7.2	6.58	2.35	33.98
T_4	RDF + B @ 2.5 kg ha^{-1}	9.45	6.8	6.06	2.25	32.85
T_5	RDF + Mo @ 1 kg ha^{-1}	9.15	6.6	4.89	2.18	32.65
T_6	RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}	10.65	8.1	6.80	2.75	34.75
T_7	RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	11.49	8.6	6.99	2.90	34.95
T_8	RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	10.97	7.6	6.25	2.74	34.25
T_9	RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	12.35	8.8	7.30	3.17	35.25
	S.Em (±)	0.62	0.34	0.10	0.09	0.76
	C.D. (P=0.05)	1.86	0.81	0.31	0.28	NS

From the given data (Table 1) it can be inferred that the maximum number of pod plant^{-1} (12) were produced in the treatment T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) which was found to be on par with T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}), T_8 (RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) and T_6 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}). However, the lowest number of pods plant^{-1} (5) were recorded in treatment T_1 (Control) which was significantly lower than rest of the other treatments. The results were in accordance with those reported by Anjum, M. S *et al.* (2006) [2] and Deva, A *et al.* (2018) [9].

Significantly higher pod length (8.8) was recorded in treatment T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) which was statistically found to be on par with, T_6 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}) and T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). Treatment T_1 (Control) recorded the lowest pod length (5.3 cm) and next in order was treatment T_2 (RDF (20:40:20) kg ha^{-1}). It might be due to increased and prolonged availability of nutrients from integrated use of micronutrients, which ultimately resulted in rapid cell multiplication and cell elongation under sufficient nutrient supply. The results were in accordance with those reported by Malik *et al.* (2015) [16] and Habib, A.S. *et al.* (2018) [11]. It is evident from the data that the significantly higher number of grains pod^{-1} (7.30) were produced in treatment T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) which remained on par with, T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). Treatment T_1 recorded lowest number of grains pod^{-1} (3.75) followed by T_2 (RDF (20:40:20) kg ha^{-1}). Adequate nutrients availability to the crop as a result of increment in photosynthesis as well as growth led to increase in the number of grains pod^{-1}. These findings were almost similar to the results reported by Monu *et al.* (2015) [17]. Maximum grain yield plant^{-1} (3.17) were produced in treatment T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) which remained on par with, T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). Treatment T_1 recorded lowest grain yield plant^{-1} (1.12) followed by T_2 (RDF (20:40:20) kg ha^{-1}). These findings were almost similar to the results reported by Pandey (2013) [18] and Patra *et al.* (2009) [19].

Micronutrients treatments did not bring any significant variation in test weight maximum 1000 grains weight (35.25 g) was recorded in T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}), whereas the lowest test weight (31.65) was recorded in T_1 (Control). Micronutrients might increase availability of plant nutrients which result into better nourishment of plants and the formation of bold seeds, ultimately increased weight of seeds.

Influence of different micronutrients on Productivity

Data with regard to the effect of different micronutrients on grain yield, straw yield, biological yield and harvest index of moong bean crop are mentioned in Table 2 and depicted in fig 2.

Table 2: Effect of micronutrient on yield (kg ha^{-1}) of moong bean crop

Symbol	Treatment	Yields (kg ha^{-1})			Harvest index (%)
		Grain	Straw	Biological	
T_1	Control	5.83	14.13	19.96	29.02
T_2	RDF (20:40:20) kg ha^{-1}	7.15	15.36	22.51	29.70
T_3	RDF + Zn @ 5 kg ha^{-1}	10.76	24.34	35.09	30.65
T_4	RDF + B @ 2.5 kg ha^{-1}	9.90	22.62	33.25	29.82
T_5	RDF + Mo @ 1 kg ha^{-1}	7.96	19.59	27.55	28.91
T_6	RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}	11.90	26.63	38.53	30.91
T_7	RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	12.50	27.75	40.25	31.09
T_8	RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	11.06	25.06	36.12	30.65
T_9	RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	13.91	30.74	44.65	31.25
	S.Em (±)	0.40	1.12	1.52	0.90
	C.D. (P=0.05)	1.11	3.23	4.31	2.62

Among the various micronutrients, the treatment T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}r) exhibited significantly higher grain yield (13.91 q ha^{-1}) followed by T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}), T_6 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}) and T_8 (RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). Treatment T_1 (Control) with no application of any fertilizer recorded lowest grain yield of 5.83 q ha^{-1}. About 138.59%, 114.40%, 104.11%, 89.70% and 84.56% increase in grain yield was recorded by T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}), T_7 (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}), T_6 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}), T_8 (RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) and T_3 (RDF + Zn @ 5 kg ha^{-1}), respectively over control treatment T_1.

This might be due to slow release of nutrient and efficient use of micronutrients. In the same way, straw yield of moong bean (Table 2) was significantly influenced by different micronutrients treatments. Results revealed that the differences in straw yield were found significant due to different treatments. Though significantly higher straw yield 30.74 q ha^{-1} was recorded under T_9, it was statistically on par with T_7, (RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}). The lowest straw yield (14.13 q ha^{-1}) was recorded in T_1 (control). Similar trend was observed in Biological yield, whereas maximum harvest index (31.25%) was recorded in T_9 (RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}) which was on par with T_7, T_6, T_8, T_3, T_4 and T_2. The increase in straw yield was mainly due to increased growth attributing characters like plant height and number of pod plant^{-1}. The use of micronutrients had profound effect on vegetative growth due to improved nutrients availability in the soil. These findings are in conformity with the results of Badiyala *et al.* (2011) [4], Divyashree, K.S. *et al.* (2018) [10], Khan, K. *et al.* (2014) [14], Dhruw *et al.* (2017) and Malik *et al.* (2015) [16].

Economics

From Table 3 it can be seen that among the various micronutrients levels, the cost of cultivation (Rs. ha^{-1}) varied from 19119 to 32571 Rs. ha^{-1}. The highest cost of cultivation was registered with the application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_9) followed by RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_7) and RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} (T_6) while the application of no fertilizer (Control) registered the lowest cost of cultivation. Maximum gross returns (76675 Rs. ha^{-1}) was obtained by the application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_9) followed by RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_7) and RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} (T_6). The lowest Gross return of 29574 Rs. ha^{-1} was obtained in treatment T_1 (Control). Maximum net return of 44104 Rs ha^{-1} was recorded by the application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_9) followed by RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_7) and RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} (T_6). However, the maximum Benefit cost ratio of 2.35 was obtained by the application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} (T_9) followed by T_6 and T_7. The higher net returns and BCR was mainly due to increase in grain yield. Similar results recorded by Jat, S. L. *et al.* (2012) [13], M.P. and Patil, H.Y. (2013) [15] and Jat, S. L. *et al.* (2015) [12].

Table 3: Effect of micronutrient on profitability of moong bean crop

Symbol	Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B: C ratio
T_1	Control	19119	29574	10455	1.55
T_2	RDF (20:40:20) kg ha^{-1}	27161	48020	20859	1.77
T_3	RDF + Zn @ 5 kg ha^{-1}	28190	60136	31946	2.13
T_4	RDF + B @ 2.5 kg ha^{-1}	27490	56503	28813	2.06
T_5	RDF + Mo @ 1 kg ha^{-1}	27625	51851	24226	1.88
T_6	RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1}	29771	65261	35390	2.19
T_7	RDF + Zn @ 5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	30150	67641	37645	2.24
T_8	RDF + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	28385	58379	29994	2.06
T_9	RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1}	32571	76675	44104	2.35
	S.Em (±)	-	2197	1156	0.08
	C.D. (P=0.05)	-	6275	3302	0.22

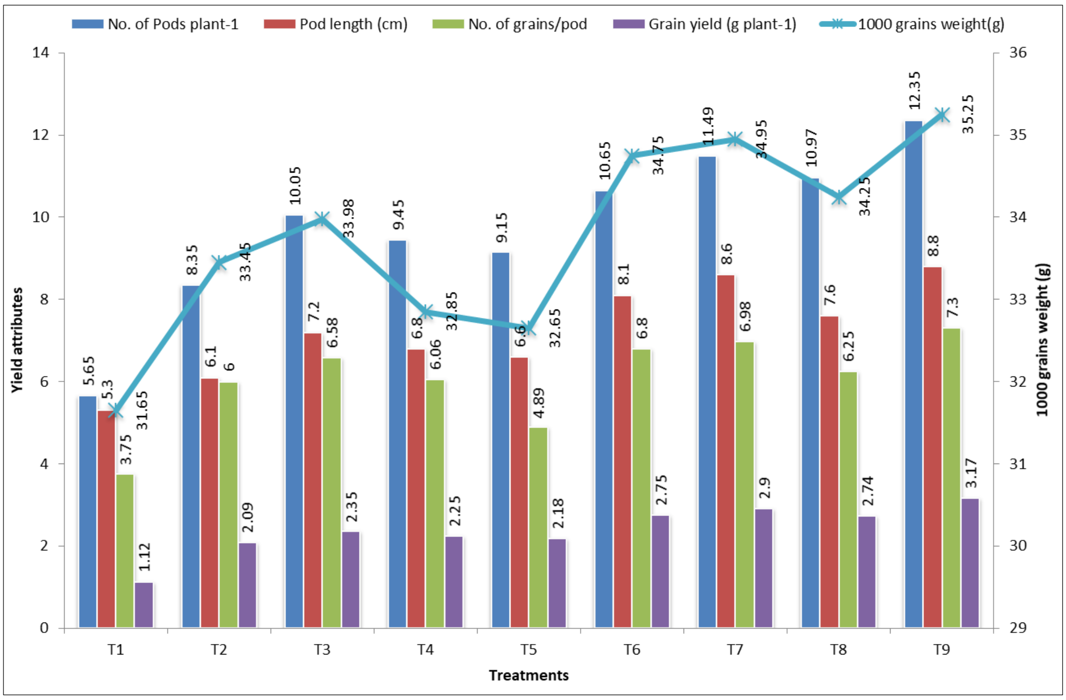

Fig 1: Effect of micronutrient on yield attributes characters of moong bean crop

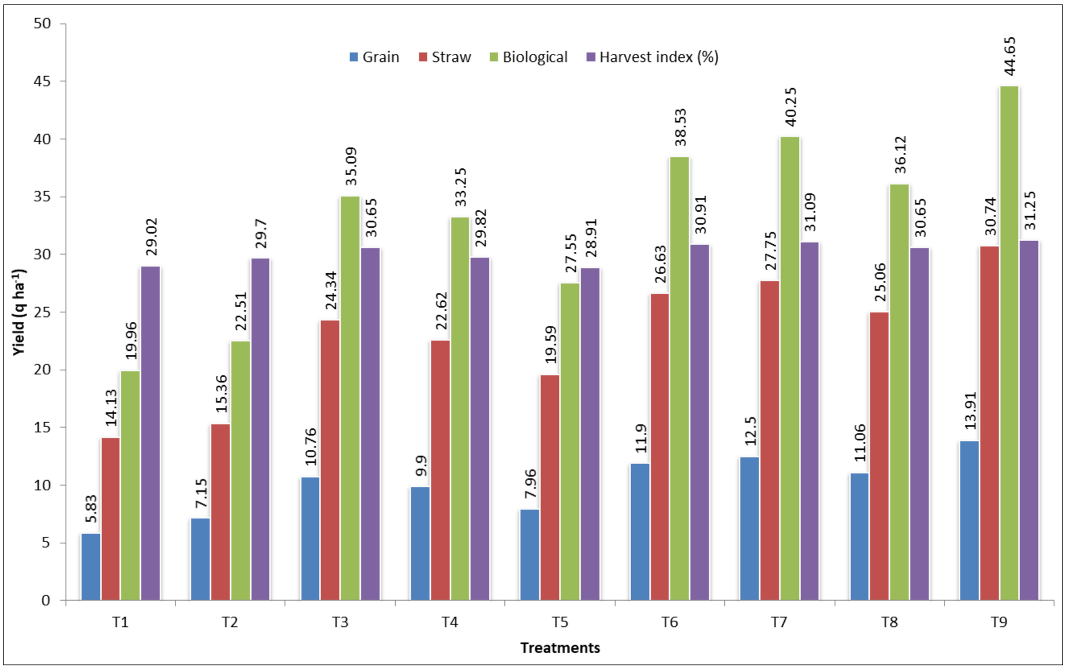

Fig 2: Effect of micronutrient on yield (kg ha^{-1}) of moong bean crop

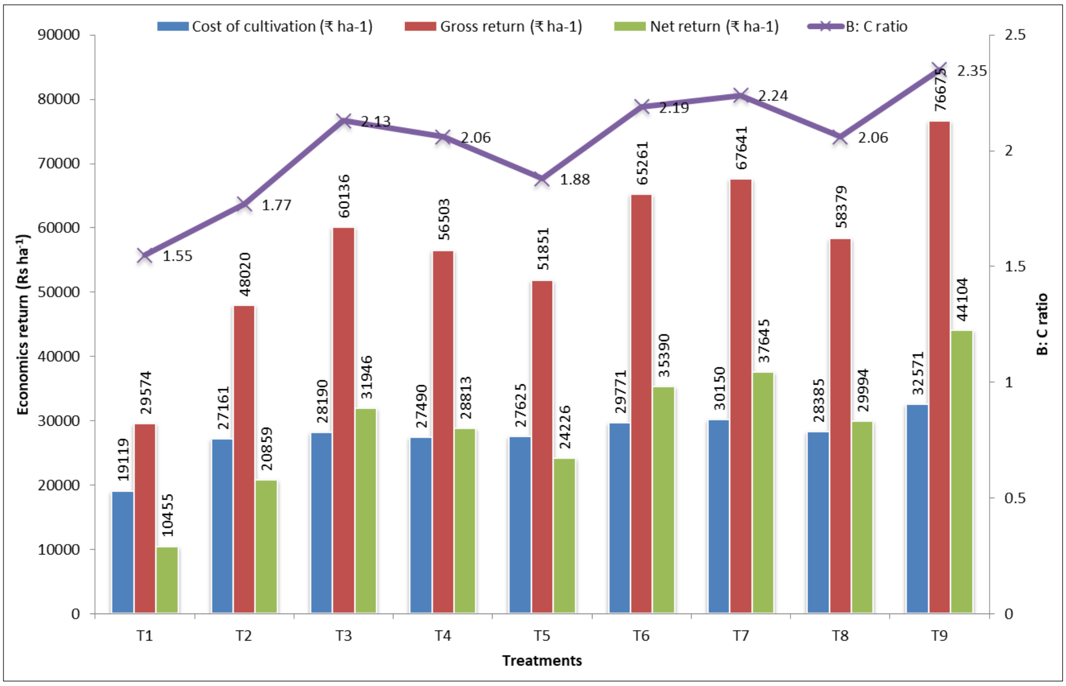

Table 3: Effect of micronutrient on profitability of moong bean crop

Conclusion

In the light of the results summarized as above, it may be concluded that for obtaining higher productivity of moong bean and maintaining soil health application of RDF + Zn @ 5 kg ha^{-1} + B @ 2.5 kg ha^{-1} + Mo @ 1 kg ha^{-1} should be applied in western U.P. Since the observations are based on one year experimental data, so it is advisable that the experiment should be repeated for few more years for recommendations.

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