Effect of Zinc and Thiourea levels on Growth, Yield and Quality of Mungbean [*Vigna radiata* (L.) Wilczek]

Abstract

A field experiment was conducted during Kharif season 2024 at the Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur to evaluate their effects on growth, yield and economics of mungbean. The results revealed that growth parameters such as plant height, dry matter accumulation, number of branches and nodulation were significantly improved by both zinc and thiourea. Zinc @ 6 kg ha^{-1} (Z_3) recorded maximum plant height, dry matter accumulation, and branches per plant, while zinc @ 4 kg ha^{-1} (Z_2) proved most effective for effective nodules. Yield attributes including number of pods per plant, seeds per pod, seed yield and straw yield were significantly enhanced by zinc and thiourea. Economic analysis indicated that zinc @ 6 kg ha^{-1} and thiourea @ 500 ppm at branching and flowering initiation produced the highest gross return, net return, and benefit–cost ratio. Overall, the study concludes that application of zinc @ 6 kg ha^{-1} along with foliar spray of thiourea @ 500 ppm at branching and flowering initiation is an effective and economically viable strategy for enhancing growth, productivity and profitability of mungbean under Kharif conditions.

Key words: Thiourea, Zinc, Interaction, Semi-arid region, Yield

1. Introduction

The country grows a wide range of pulse crops, including mungbean, chickpea, pigeon pea, lentil, and kidney bean. Chickpea and pigeon pea together contribute nearly 60% of the total pulse production in India. Mungbean (*Vigna radiata* L.) also known as green gram is cultivated across various regions and is considered the third most important pulse crop after pigeon pea and chickpea, occupying about 12–13% of the total pulse cultivation area. In India, Mungbean is grown on approximately 40.38 lakh hectares, producing 3.39 million tonnes in 2022–2023 (DES, 2024). Rajasthan overtook Maharashtra and Karnataka in both production and cultivation area in 2022–23. In Rajasthan alone, 21.40 lakh hectares are under mungbean cultivation contributing to 46% of area under mungbean cultivation of India, with an estimated output of 10.97 lakh tonnes during 2022-2023, contributing to 45% of mungbean production of India. The productivity of mungbean of Rajasthan in country is also highest with 513 kg/ha (IIPR, 2024).

Micronutrient elements like Zinc (Zn) are required in small amounts, plays a crucial role in enhancing the health, growth, and various physiological functions of plants (Ahmed *et al.*, 2024). Micronutrients are commonly utilized as fertilizers in agricultural practices to boost yields for both commercial and subsistence farming. The availability of Zn in the soil can assist plants in improving their protein synthesis, cell division, and hormonal regulation, including auxin, which promotes nutrient absorption in plants (Umair *et al.*, 2020). Zinc is essential for the carbonic enzyme that generates chlorophyll (Tavallali *et al.*, 2009). Soil factors affect zinc availability for growing plants by controlling the sorption and desorption of zinc in the soil solution, which impacts the zinc levels. Seeds with higher zinc content serve multiple functions during germination and the early stages of establishment (Ozturk *et al.*, 2006).

Thiourea comprises 42.1 percent sulphur and 36.8 percent nitrogen, and its application as a plant growth regulator may prove beneficial in this context. The soaking of seeds and the foliar application of thiourea have been shown to enhance not only the growth and development of plants but also the dry matter distribution, leading to increased grain yield. Given the limited potential for horizontal expansion in acreage, the remaining option is to pursue vertical growth by boosting the current production levels. This highlights the need to consider the use of thiourea, bioregulators, and micronutrients such as zinc to overcome the stagnation in mungbean production (Singh and Sharma, 2005).

2. Materials and methods

A field experiment was conducted during the Kharif season of 2024-25 at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, to assess the effect of zinc and thiourea application on the growth, yield and quality of mungbean. The experimental site is located in a semi-arid, subtropical climate characterized by extreme temperature variations, with hot and dry summers (maximum temperature up to 45°C) and cold winters (minimum temperature as low as 2.8°C). The collected data were statistically analysed using analysis of variance (ANOVA) appropriate for the FRBD design to determine the significance of treatment effects in two factors. Factor-I- zinc levels- Z_0- (Zinc 0 kg), Z_1- (Zinc 2 kg), Z_2- (Zinc 4 kg), Z_3- (Zinc 6 kg) and factor-II, T_0- (Control), T_1- (Foliar spray at branching @ 500 ppm), T_2 - (Foliar spray at flowering initiation @ 500 ppm) and T_3- (Foliar spray at branching and flowering initiation @ 500 ppm). Total 16 treatments combination and number of total plots is 48. The area receives an average annual rainfall of 500–800 mm, mostly concentrated during the monsoon season. The soil of the experimental field was sandy loam in texture, saline in reaction, with the following initial characteristics: Soil of the experimental field was sandy loam intexture, saline in reaction with a pH value of 7.62, EC (0.48 dSm^{-1}), poor in organic carbon (0.34%), low in available nitrogen (134.25 kg/ha), phosphorus (13.25kg/ha) and (178.15 kg/ha) but medium in available potassium (320 kg/ha). The chickpea variety 'DSM-25' was used in the experiment

3. Results and Discussion

3.1 Growth attributes

The perusal of data further revealed that plant height was also significantly affected by zinc levels. The highest plant height (24.74, 42.70 and 65.30 cm) was recorded with Z_3-(Zinc 6 kg). (46.78 cm), it was found at par with the treatment Z_2-(Zinc 4 kg) (24.47, 42.20 and 63.72 cm). The lowest plant height (17.92, 30.45 and 46.84 cm) was recorded with Z_0-(Zinc 0 kg) at 25, 50 DAS and at harvest, respectively. The highest plant height (23.83, 39.89 and 61.56 cm) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), it was found at par with the treatment T_2-(Foliar spray at flowering initiation @ 500 ppm) (23.20, 39.80 and 58.41 cm). The lowest plant height (18.79, 33.79 and 54.10 cm) was recorded with T_0-(Control) at 25, 50 DAS and at harvest, respectively. Aslam *et al.* (2021) reported that foliar application of Zn-lysine chelate produced the greatest plant height (60.83 cm) in mungbean. Amin *et al.* (2014) observed that thiourea at 1000 ppm markedly improved plant growth parameters including plant height in faba bean.

The perusal of data further revealed that dry matter accumulation was also significantly affected by zinc levels. The maximum dry matter accumulation (8.65, 54.74 and 122.95 g/m^2) was recorded with Z_3-(Zinc 6 kg). (46.78 g/m^2), it was found at par with the treatment Z_2-(Zinc 4 kg) (8.34, 53.65 and 122.95 g/m^2). The minimum dry matter accumulation (5.88, 37.24 and 95.91 g/m^2) was recorded with Z_0-(Zinc 0 kg) at 25, 50 DAS and at harvest, respectively. The maximum dry matter accumulation (8.25, 50.21 and 114.78 g/m^2) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), it was found at par with the treatment

T_2-(Foliar spray at flowering initiation @ 500 ppm). The minimum dry matter accumulation (6.61, 44.28 and 106.35 g/m^2) was recorded with T_0-(Control) at 25, 50 DAS and at harvest, respectively. Premaradhya *et al.* (2018) observed that foliar spraying thiourea at 1000 ppm during pre-flowering and pod initiation produced the maximum total dry matter accumulation. Bhadru *et al.* (2019) found that zinc at 4.0 kg ha^{-1} significantly improved dry matter accumulation at various growth stages in greengram, and thiourea at 500 ppm further enhanced growth traits.

The perusal of data further revealed that number of branches per plant was also significantly affected by zinc levels. The maximum number of branches per plant (11.09) was recorded with Z_3-(Zinc 6 kg). (46.78 cm), followed by treatment Z_2-(Zinc 4 kg) (9.80). The minimum number of branches per plant 7.64) was recorded with Z_0-(Zinc 0 kg). The maximum number of branches per plant (10.10) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), it was found at par treatment with the T_2-(Foliar spray at flowering initiation @ 500 ppm) (9.66). The minimum number of branches per plant (8.59) was recorded with T_0-(Control). The perusal of data further revealed that number of effective root nodules per plant was also significantly affected by zinc levels. The maximum number of effective root nodules per plant (14.88) was recorded with Z_2-(Zinc 4 kg), it was found at par with the treatment Z_3-(Zinc 6 kg) (13.53). The minimum number of effective root nodules per plant (8.33) was recorded with Z_0-(Zinc 0 kg). The maximum number of effective root nodules per plant (13.18) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), it was found at par with the treatment T_2-(Foliar spray at flowering initiation @ 500 ppm) (12.85). The minimum number of effective root nodules per plant (11.38) was recorded with T_0-(Control). The interaction between zinc and thiourea was non-significant for all three parameters, indicating that although both inputs improved vegetative and nodulation traits, their effects were additive rather than synergistic. This suggests that branching and nodulation are driven primarily by the physiological requirements for micronutrients and growth enhancers independently rather than through their combination, which is typical for early vegetative attributes in legumes. Barla *et al.* (2022) found that foliar application of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ significantly increased number of branches per plant (8.00) and nodule formation (16.00 nodules per plant). Meena *et al.* (2018) observed that the application of 2 kg Zn ha^{-1} with 1 kg B ha^{-1} recorded the highest number of nodules (41.33) and effective nodules.

3.2 Yield attributes and yield

The perusal of data further revealed that number of pods per plant was also significantly affected by zinc levels. The maximum number of pods per plant (16.54) was recorded with Z_3-(Zinc 6 kg), followed by treatment Z_2-(Zinc 4 kg) (12.48). The minimum number of pods per plant (9.45) was recorded with Z_0-(Zinc 0 kg). The perusal of data further revealed that number of pods per plant was also significantly affected by thiourea levels. The maximum number of pods per plant (13.58) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), followed by treatment T_2-(Foliar spray at flowering initiation @ 500 ppm) (12.75). The minimum number of pods per plant (10.81) was recorded with T_0-(Control). Bhadru *et al.* (2019) reported that zinc at 4.0 kg ha^{-1} significantly increased pods per plant and seeds per pod in greengram, while thiourea at 500 ppm further enhanced these yield attributes. Sarita *et al.* (2019) noted that thiourea at 500 ppm applied at flower initiation significantly increased pods per plant, seeds per pod, and pod length.

The perusal of data further revealed that number of seeds per plant was also significantly affected by zinc levels. The maximum number of seeds per plant (8.99) was recorded with Z_3-(Zinc 6 kg), followed by treatment Z_2-(Zinc 4 kg) (8.04). The minimum number of seeds per plant (6.24) was recorded with Z_0-(Zinc 0 kg). The perusal of data further revealed that number of seeds per plant was also significantly affected by thiourea levels. The maximum number of seeds per plant (7.99) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), it was found at par with the treatment T_2-(Foliar spray at flowering initiation @ 500 ppm) (7.62). The minimum number of seeds per plant (6.97) was recorded with T_0-(Control). Jeengar (2012) reported that seed soaking + foliar spray of thiourea at 500 ppm produced significantly more pods per plant and seeds per pod along with higher 1000-seed weight in mungbean. Priyanka (2017) found that thiourea at 500 ppm at branching and flowering initiation produced significantly superior yield traits including pods per plant and pod length in greengram.

The perusal of data further revealed that seed yield was also significantly affected by zinc levels. The maximum seed yield (1273.75 kg/ha) was recorded with Z_3-(Zinc 6 kg), followed by treatment Z_2-(Zinc 4 kg) (1081.17 kg/ha). The minimum seed yield (902.92 kg/ha) was recorded with Z_0-(Zinc 0 kg). The perusal of data further revealed that seed yield was also significantly affected by thiourea levels. The maximum seed yield (1133.25 kg/ha) was recorded with T_3-(Foliar spray at branching and flowering initiation @ 500 ppm), followed by treatment T_2-(Foliar spray at flowering initiation @ 500 ppm) (1073.42 kg/ha). The minimum seed yield (974.25 kg/ha) was recorded with T_0-(Control). The perusal of data further revealed that straw yield was also significantly affected by zinc levels. The maximum straw yield (3509.69 kg/ha) was recorded with Z_3-(Zinc 6 kg), followed by treatment Z_2-(Zinc 4 kg) (3306.73 kg/ha). The minimum straw yield (1846.28 kg/ha) was recorded with Z_0-(Zinc 0 kg). In the case of straw yield, T_3 also recorded the highest value (3281.41 kg/ha), at par with T_1 (3233.46 kg/ha) ranking next. Both treatments produced substantially higher biomass compared to T_0 (2220.70 kg/ha). The best treatment, T_3, improved straw yield by around 48%, confirming the growth-promoting effect of thiourea on vegetative and structural biomass. Bamniya (2009) found that seed soaking and foliar spray of thiourea at 500 ppm significantly increased test weight in mungbean. Balai and Keshwa (2011) noted that foliar application of thiourea at 1000 ppm significantly increased seed and straw yield in coriander. Kumawat (2011) observed that soaking seeds in 1000 ppm thiourea combined with a 1000 ppm foliar spray resulted in the highest seed yield, straw yield, and biological yield in moth bean.

3.3 Economics

Zinc application significantly improved gross return, net return and B:C ratio of mungbean. The lowest gross return (₹ 81323 ha^{-1}) was recorded under Z_0 (no zinc application), whereas the highest gross return (₹ 116081 ha^{-1}) was obtained with Z_3 (zinc @ 6 kg ha^{-1}). Z_2 (₹ 77,844 ha^{-1}) ranked next-best and was significantly superior to the control. Thiourea application significantly influenced the economic returns of mungbean. The lowest gross return (₹ 88091 ha^{-1}) was recorded under T_0 (control), whereas the highest gross return (₹ 103515 ha^{-1}) was obtained under T_3 (foliar spray at branching and flowering initiation @ 500 ppm). A similar trend was observed for net return. The minimum net return (₹ 35823 ha^{-1}) was recorded under Z_0, while the maximum net return (₹ 67581 ha^{-1}) was achieved with Z_3, followed by Z_2 (₹ 51522 ha^{-1}). In terms of net return, T_0 recorded the lowest value (₹ 35823 ha^{-1}), while T_3 produced the highest net return (₹ 67581 ha^{-1}) closely followed by T_1 (₹ 51576 ha^{-1}). The benefit–cost ratio also increased progressively with increasing zinc levels. The lowest B:C ratio (1.79) was observed under Z_0 and Z_1, whereas the highest (2.39) was recorded under Z_3. Z_2 (2.08) was the next-best treatment, indicating improved profitability with higher zinc application. The B:C ratio followed a similar pattern, with the lowest value (2.18) under T_0 and the highest (2.81) under T_3 followed b treatments T_1 (2.11). Further support is drawn from the findings of Garg and Burman. (2007), who observed that combined application of zinc and thiourea at appropriate growth stages significantly increased gross return, net return and benefit–cost ratio in greengram. The superior economic performance under zinc fertilization coupled with thiourea spray reported by these authors corroborates the present results, highlighting the role of balanced nutrient management and physiological stimulation in maximizing crop profitability.

Conclusion

The present investigation conclusively demonstrated that zinc nutrition and thiourea application play decisive roles in improving the growth yield, and economic returns of mungbean. Overall, the study establishes that balanced zinc fertilization combined with judicious foliar application of thiourea at critical growth stages is an effective and economically viable strategy for enhancing productivity and profitability of mungbean under Kharif conditions.

Table 1 Effect of zinc and thiourea levels on plant height and dry matter accumulation

Treatments	Plant height (cm)			Dry matter accumulation (g/m^2)		
	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest
Levels of Zinc (Z)						
Z_0-(Zinc 0 kg)	17.92	30.45	46.84	5.88	37.24	95.91
Z_1-(Zinc 2 kg)	19.83	34.34	53.89	6.61	43.36	104.88
Z_2-(Zinc 4 kg)	24.47	42.20	63.72	8.34	53.65	120.72
Z_3-(Zinc 6 kg)	24.74	42.70	65.37	8.65	54.74	122.95
SE m (±)	0.48	0.77	1.22	0.14	1.04	2.07
CD (5%)	1.37	2.22	3.53	0.41	3.00	5.99
Levels of Thiourea (T)						
T_0-(Control)	18.79	33.79	54.10	6.61	44.28	106.35
T_1-(Foliar spray at branching @ 500 ppm)	23.20	39.80	58.41	7.65	48.00	112.62
T_2 -(Foliar spray at flowering initiation @ 500 ppm)	21.14	36.22	55.74	6.98	46.50	110.71
T_3-(Foliar spray at branching and flowering initiation @ 500 ppm)	23.83	39.89	61.56	8.25	50.21	114.78
SE m (±)	0.48	0.77	1.22	0.14	1.04	2.07
CD (5%)	1.37	2.22	3.53	0.41	3.00	`5.99
Interaction Z x T						
SE m (±)	0.95	1.53	2.45	0.38	2.08	4.14
CD (5%)	NS	NS	NS	NS	NS	NS

Table 2 Effect of zinc and thiourea levels on number of branches per plant and effective nodules per plant

Treatments	Number of branches/plant	Number of effective nodules/plant
Levels of Zinc (Z)		
Z_0-(Zinc 0 kg)	7.64	8.33
Z_1-(Zinc 2 kg)	8.84	11.63
Z_2-(Zinc 4 kg)	9.80	14.88
Z_3-(Zinc 6 kg)	11.09	13.53
SE m (±)	0.19	0.27
CD (5%)	0.55	0.77
Levels of Thiourea (T)		
T_0-(Control)	8.59	10.96
T_1-(Foliar spray at branching @ 500 ppm)	9.66	12.85
T_2 -(Foliar spray at flowering initiation @ 500 ppm)	9.02	11.38
T_3-(Foliar spray at branching and flowering initiation @ 500 ppm)	10.10	13.18
SE m (±)	**0.19**	**0.27**
CD (5%)	**0.55**	**0.77**
Interaction Z x T		
SE m (±)	**0.38**	**0.54**
CD (5%)	**NS**	**NS**

Table 3 Effect of zinc and thiourea levels on yield attributes

Treatments	Number of pods/plant	Number of seeds/pod	Seed yield (kg/ha)	Straw yield (kg/ha)
Levels of Zinc (Z)				
Z_0-(Zinc 0 kg)	9.45	6.24	902.92	1846.28
Z_1-(Zinc 2 kg)	10.23	6.69	962.50	2788.33
Z_2-(Zinc 4 kg)	12.48	8.04	1081.17	3306.73
Z_3-(Zinc 6 kg)	16.54	8.99	1273.75	3509.69
SE m (±)	0.30	0.17	22.36	83.67
CD (5%)	0.86	0.50	64.57	241.66
Levels of Thiourea (T)				
T_0-(Control)	10.81	6.97	974.25	2220.70
T_1-(Foliar spray at branching @ 500 ppm)	12.75	7.62	1073.42	3125.46
T_2 -(Foliar spray at flowering initiation @ 500 ppm)	11.57	7.37	1039.42	2915.46
T_3-(Foliar spray at branching and flowering initiation @ 500 ppm)	13.58	7.99	1133.25	3281.41
SE m (±)	0.30	0.17	22.36	83.67
CD (5%)	0.86	0.50	64.57	241.66
Interaction Z x T				
SE m (±)	0.60	0.34	44.71	167.35
CD (5%)	NS	NS	NS	483.33

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Table 4 Economics under influence of different levels of zinc and thiourea in cultivation of Mungbean

Treatments	Gross return (₹)	Net return (₹)	Benefit cost ratio
Levels of Zinc (Z)			
Z_0- (Zinc 0 kg)	81323	35823	1.79
Z_1- (Zinc 2 kg)	87920	41420	1.89
Z_2- (Zinc 4 kg)	99022	51522	2.08
Z_3- (Zinc 6 kg)	116081	67581	2.39
Levels of Thiourea (T)			
T_0- (Control)	88091	42591	1.94
T_1- (Foliar spray at branching @ 500 ppm)	98076	51576	2.11
T_2 - (Foliar spray at flowering initiation @ 500 ppm)	94803	48303	2.04
T_3- ((Foliar spray at branching and flowering initiation @ 500 ppm))	103515	56015	2.18

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