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Effect of Zinc and Thiourea Fertilizer at Different Stages for Growth and Yield of Green Gram

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment titled "Effect of zinc and thiourea fertilizer at different stages for growth and yield of green gram" was conducted during *Zaid* - 2023 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. To study the Response of zinc and thiourea fertilizer at different stages for growth and yield of green gram. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%). The treatments consist of three levels of Zinc – 2.5 kg/ha, Zinc – 4.0 kg/ha, Zinc – 5.5 kg/ha. Three levels of Thiourea, Thiourea (500 ppm), Thiourea (500 ppm)- 30 DAS, Thiourea (500 ppm)- 45 DAS. The experiment was laid out in randomized block design with ten treatments each replicated thrice. Results revealed that the higher plant height (38.32 cm), higher number of nodules (23.55), higher

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plant dry weight (9.93 g/plant), higher crop growth rate (9.17 g/m^2/day) higher number of pods/plant (22.88), higher number of seeds/pod (10.06), higher test weight (34.23 gm), higher seed yield (1222.69 kg/ha) and higher stover yield (2006.02 kg/ha) were significantly influenced with application of Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS. Higher gross return (94758.22 INR/ha), higher net return (65643.22 INR/ha) and higher B:C ratio (2.25) were also recorded in treatment-9 Zinc 5.5 kg/ha + Thiourea (500 ppm) – 45 DAS.

Keywords: green gram; zinc; thiourea; growth parameters; yield attributes and economics.

1. INTRODUCTION

Leguminous green gramme [*Vigna radiata* (L.) Wilczek] is a self-pollinated crop grown in the dry and semi-arid parts of the nation. It may be grown well in areas with sporadic rainfall and is drought-resistant on well-drained loamy to sandy loam soils. Although it is primarily a crop for the rainy season, early maturing varieties have demonstrated that it may also be a great crop for the spring and summer. Green gramme has a high protein content of 24.5% and contains a lot of lysine (460 mg/g) and tryptophan (60 mg/g). In addition to an adequate amount of minerals, sprouted grains contain a significant amount of ascorbic acid and riboflavin (0.21 mg/100 g) (Gopalan et al., 1995). Given that it is a transient crop, it is ideal.

Micronutrients are required for normal plant development. Lack of which has a negative impact on plant growth, metabolism, and reproduction. Zinc is widely used in several sections of the country. (Zn) is the third most important plant nutrient, after nitrogen and phosphorus [1]. One of the factors preventing the best crop output is zinc, which has in recent times come to light. Since it acts as an activator of the dehydrogenase and proteinase enzymes, which help in the synthesis of carbohydrates and protein, it is crucial for the formation of chlorophyll, protein, and nucleic acid as well as the utilization of nitrogen and phosphorus by plants. Tryptophan, which is a precursor to the auxin hormone, contains zinc. It also has a connection to how water interacts and absorbs. Both manufactured and natural organic compound synthesis in plants depends on zinc. It is largely involved in a number of enzymatic activities, including as the production of tryptophan and the molecules needed to make growth hormones.

Thiourea is essential to plant physiology as both a sulfhydryl molecule and an amino compound similar to urea. Thiourea applied to the leaves enhances CO2 absorption by the stomata. Thiourea is essential for regulating the redox state of membrane proteins because it can quench reactive oxygen species (ROS) produced under heat stress. Under heat stress, the oxidized form of the sulfhydryl group may be responsible for membrane damage, which was considerably decreased using exogenous thiourea. Thiourea treatment dramatically reduced oxidative stress, which is consistent with its involvement in preventing lipid peroxidation in cells**.** This was also linked to higher overall antioxidant activity when subjected to heat stress.

Considering the facts and to bridge the research gap highlighted above, the present experiment entitled, “Effect of zinc and thiourea on growth and yield of Green gram”, was conducted at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Zaid*-2022.

2. MATERIALS AND METHODS

At the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, the experiment was carried out during *Zaid*-2022. which is situated 98m above mean sea level (SL) at 25.24' 42" N latitude, 81.50' 56" E longitude. Ten treatments, each replicated three times, were used in the experiment's Randomised Block Design. Each treatment's plot was 3m by 3m. The treatments consist of three levels of Zinc – 2.5 kg/ha, Zinc – 4.0 kg/ha, Zinc – 5.5 kg/ha. Three levels of Thiourea, Thiourea (500 ppm), Thiourea (500 ppm)- 30 DAS, Thiourea (500 ppm)- 45 DAS are contributing factors. At the time of sowing, N, P and K were supplied, and three are used as basal. Each plot's 1 m2 was used for harvesting. And five plants were randomly chosen from it for the purpose of observing the yield and growth metrics. Here are the specifics of the treatment:

T1 -(Zinc 2.5 kg/ha+ Thiourea (500 ppm)), T2 -(Zinc 2.5 kg/ha+ Thiourea (500 ppm) at 30 DAS), T3 – (Zinc 2.5 kg/ha+ Thiourea (500 ppm) at 45 DAS), T4 -(Zinc 4.0 kg/ha+ Thiourea (500 ppm)), T5 -(Zinc 4.0 kg/ha+ Thiourea (500 ppm) at 30 DAS), T6 -(Zinc 4.0 kg/ha+ Thiourea (500 ppm) at 45 DAS), T7 -(Zinc 5.5 kg/ha+ Thiourea (500 ppm)), T8 -(Zinc 5.5 kg/ha+ Thiourea (500 ppm) at 30 DAS), T9 -(Zinc 5.5 kg/ha+ Thiourea (500 ppm) at 45 DAS). Plant height, nodules per plant, dry weight, grain production, and stover yield were all observed and reported. By using the analysis of variance approach, the data were statistically analysed [2].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant Height (cm): At Harvest, significantly higher Plant height (38.32 cm) was observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). However, treatments-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The significantly higher Plant height (38.32 cm) was observed with the application of zinc 5.5 kg/ha. zinc significantly involved in increasing the plant height Zinc's impact on developing plants' metabolism may be what causes the observed reaction to zinc application, as seen by the growth in plant height under zinc treatment, and observed that zinc spraying had a favorable effect on plant height Shanti et al. [3]. Thiourea treatment may cause further growth in plant height. These positive changes in the crop may be attributed to improved crop growth and development due to thiourea treatment action, which may have targeted the meristematic activity of apical tissues with stimulatory effects on cell division, resulting in increased shoot length and cell number for improved leaf area (primarily due to increased Sulphur and nitrogen nutrition). Similar outcome was reported by Aradhya et al. [4].

Number of Nodules/Plant: At Harvest, significantly higher number of nodules (5.79) were observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). However, treatments-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The significantly higher number of nodules (5.79) were observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). Increase in nodules number with the help of zinc it helps to improve more nodulation and leghemoglobin formation. Proper nutrition of plants with Zn increases the amount of glucose flowering to the roots and ATP biosynthesis. These are in conformity with the present findings of Valenciano et al. [5].

No. of Branches/Plant: At Harvest, significantly higher number of branches (6.32) were observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). However, treatments-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The significantly higher number of branches (6.32) were observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). It might be due to the application of Zinc. Zinc results in significantly enhanced branching in pulses mainly attributed to promotion of bud and branch development by the auxins whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photo assimilates Krishna et al. [6].

Plant Dry Weight (g): At Harvest, significantly higher dry weight (9.93 gm/plant) was observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). However, treatments-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

significantly higher dry weight (9.93 gm/plant) was observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). With the application of zinc, it is also considered to be a precursor for auxin synthesis, involved in nitrogen metabolism and several oxidation reduction reactions, stability of RNA and starch formation. Thus, it's suitable supply effects in higher dry matter production, ultimately growth and development of plants. Parallel results were found by Meena et al. [7]. While explaining the role of thiourea sulphydryl compounds in maize productivity, Sahu and Solanki [8] were of the view that probably photosynthates transport was improved because of improved dry matter partitioning. The partitioning of dry matter in plants depends on its distribution between leaves, stem and sink.

Crop Growth Rate (g/m^2/day): At 45-60 DAS, significantly higher crop growth rate (9.17 g/m^2/day) was observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). However, treatments-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

Significantly higher crop growth rate (9.17 g/m^2/day) was observed in the treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). Zn might contribute to an increase in crop growth rate. Zinc is essential for photosynthesis, enzyme activation, fertilization, and assimilate translocation, all of which contribute to increased seed output. The improved crop growth and development might be attributed to the combination application of zinc. The current investigation's findings are consistent with those of Pallepati et al. [9].

3.2 Yield attributes

Number of Pods/Plant: The Significant and higher Number of Pods/Plant (22.88) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) However, the treatment-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par with treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The Significant and higher Number of Pods/Plant (22.88) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). The increase in yield attributes and yield obtained with thiourea application was most probably due to increased crop photosynthesis favoured by both improved photosynthetic efficiency and source to sink relationship. Also, the increase in yield due to application of thiourea might be the result of concomitant increase in number of pods per plant Meena and Sharma [10]. Further, increase in pods per plant might be due to application of Zinc. Zinc has a greater role in the production of auxin and indole acetic acid, which helps in increased plant growth which resulted in more pods per plant similar result were reported by Upadhyay [11].

Number of Seeds/Pod: The Significant and higher Number of Seeds/Pod (10.06) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) However, the treatment-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par with treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The Significant and higher Number of Seeds/Pod (10.06) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) it might be due to with the application of thiourea resulted in significantly higher net photosynthetic rate and concentration of chlorophyll, starch, soluble protein and total free amino acids as well as nitrate reductase activity in leaves compared to control plants and both vegetative and flowering stages and similar reported by Verma et al. [12]. Further increase in number of seeds per pod might be due to Zinc plays a major role in photosynthesis, enzymes activation, fertilization and translocation of assimilates which are responsible for the increase in stover yield Tiwari et al. [13].

Test Weight (g): The Significant and higher test weight (34.23 gm) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) However, the treatment-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par with treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). The treatment of Zn had a substantial impact on the thousand seed weight of lentils. This might be owing to the increased mobilization of photosynthates to developing seeds in T9 as a result of Zn, B, and Mo agronomic biofortification. The findings of this study are consistent with those of Quddus et al. [14] for green gram.

Seed Yield (t/ha): The Significant and higher seed yield (1222.69 kg/ha) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) However, the treatment-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par with treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The Significant and higher seed yield (1222.69 kg/ha) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS). This may be attributable to the crop's accelerated nitrogen metabolism and prolonged moisture retention, especially during the moisture stress period, which may have contributed to the crop bearing more pods plant-1 and seeds pod-1 at harvest, according to Aradhya et al. (2018). Further, increase in yield might be due to the application of micro-nutrient of zinc, it helps in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting [15].

Table 1. Effect of Zinc and Thiourea fertilizer at different stages on growth attributes of green gram

S. No.	Treatments	Plant height	Number of nodules	Number of branches	Plant Dry weight	Crop growth rate ($g/m^2/day$)
1.	Zinc 2.5 kg/ha+ Thiourea (500 ppm)	32.24	3.64	4.75	7.77	6.78
2.	Zinc 2.5 kg/ha+ Thiourea (500 ppm) – 30 DAS	33.95	3.99	4.31	8.27	7.00
3.	Zinc 2.5 kg/ha+ Thiourea (500 ppm) – 45 DAS	34.01	4.83	4.73	8.44	6.89
4.	Zinc 4.0 kg/ha+ Thiourea (500 ppm)	34.57	4.36	5.28	8.37	7.25
5.	Zinc 4.0 kg/ha+ Thiourea (500 ppm) – 30 DAS	35.24	4.99	4.84	8.70	8.07
6.	Zinc 4.0 kg/ha+ Thiourea (500 ppm) – 45 DAS	36.27	5.44	5.39	8.97	7.55
7.	Zinc 5.5 kg/ha+ Thiourea (500 ppm)	37.24	5.36	5.01	9.19	7.91
8.	Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS	37.69	5.61	5.61	9.55	8.37
9.	Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS	38.32	5.79	6.32	9.93	9.17
10.	Control	34.77	4.21	4.58	7.91	4.33
	F test	S	S	S	S	S
	S Em.(±)	0.32	0.34	0.30	0.29	0.43
	CD (p=0.05)	0.94	1.02	0.90	0.87	1.29

Table 2. Effect of Zinc and Thiourea fertilizer at different stages on yield attributes of green gram

S. No.	Treatments	Pods/plant	Seeds/pod	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
1.	Zinc 2.5 kg/ha+ Thiourea (500 ppm)	15.47	7.15	30.15	837.13	1837.13	31.30
2.	Zinc 2.5 kg/ha+ Thiourea (500 ppm) – 30 DAS	17.94	7.80	31.13	929.36	1876.03	33.12
3.	Zinc 2.5 kg/ha+ Thiourea (500 ppm) – 45 DAS	18.60	8.28	31.28	957.36	1902.36	33.47
4.	Zinc 4.0 kg/ha+ Thiourea (500 ppm)	18.11	8.44	30.44	1011.13	1911.13	34.60
5.	Zinc 4.0 kg/ha+ Thiourea (500 ppm) – 30 DAS	20.63	8.97	30.77	1029.61	1929.61	34.79
6.	Zinc 4.0 kg/ha+ Thiourea (500 ppm) – 45 DAS	21.44	9.23	32.25	1076.41	1938.41	35.70
7.	Zinc 5.5 kg/ha+ Thiourea (500 ppm)	20.12	9.32	30.22	1147.94	1965.28	36.87
8.	Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS	21.44	9.55	33.75	1181.09	1981.09	37.35
9.	Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS	22.88	10.06	34.23	1222.69	2006.02	37.87
10.	CONTROL	15.91	7.22	30.22	830.22	1796.89	31.61
	F-Test	S	S	NS	S	S	S
	SEm±	0.58	0.17	1.02	14.04	12.35	0.36
	CD (P=0.05)	1.17	0.52	---	41.73	36.68	1.07

Table 3. Effect of Zinc and Thiourea fertilizer at different stages on economics of green gram

	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
Zinc 2.5 kg/ha+ Thiourea (500 ppm)	28365	64877.32	36512.32	1.29
Zinc 2.5 kg/ha+ Thiourea (500 ppm) – 30 DAS	28365	72025.66	43660.66	1.54
Zinc 2.5 kg/ha+ Thiourea (500 ppm) – 45 DAS	28365	74195.14	45830.14	1.62
Zinc 4.0 kg/ha+ Thiourea (500 ppm)	28740	78362.83	49622.83	1.73
Zinc 4.0 kg/ha+ Thiourea (500 ppm) – 30 DAS	28740	79794.52	51054.52	1.78
Zinc 4.0 kg/ha+ Thiourea (500 ppm) – 45 DAS	28740	83421.78	54681.78	1.90
Zinc 5.5 kg/ha+ Thiourea (500 ppm)	29115	88965.61	59850.61	2.06
Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS	29115	91534.48	62419.48	2.14
Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS	29115	94758.22	65643.22	2.25
CONTROL	27,240	64342.05	37102.05	1.36

** Data was not subjected to the statistical analysis*

Stover Yield (t/ha): The Significant and higher stover yield (2006.02 kg/ha) was observed in treatment -9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) However, the treatment-8 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 30 DAS) was found to be statistically at par with treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS).

The cumulative effect of increased growth characteristics due to foliar spray treatments was an increase in biological yield as well as seed production. Foliar spray of thiourea 500 ppm at branching and flowering remained at par with thiourea spray 1000 ppm at branching and flowering. Choudhary et al., [16]. Furfur, increase in stover yield might be due to the application of zinc. zinc has been shown greater improvement in stover yield. this may due to zinc shows beneficial effects on chlorophyll content and so it indirectly influences the photosynthesis and reproduction results conformity with [17].

3.3 Economic Analysis

Economics- The result revealed that Maximum gross return (94,758.22 INR/ha), Maximum net return (65,643.22 INR/ha) and highest benefit-cost ratio (2.25) was recorded in treatment-9 (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) as compared to other treatments (Table 3). Higher gross Return, net return and benefit cost ratio was recorded with the application of (Zinc 5.5 kg/ha+ Thiourea (500 ppm) – 45 DAS) it might be due to the higher growth and yield attributes resulting in more seed and stover yield with the recommended application of plant nutrients.

4. CONCLUSION

Based on the above-mentioned results, it can be stated that application of Zinc 5.5 kg/ha along with the application of Thiourea (500 ppm) – 45 DAS, have improved growth metrics and yield characteristics while also being economically viable. Additional tests are required to corroborate the findings because they are based only on one season.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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