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Response of Molybdenum and Foliar Application of Zinc on Growth and Yield of Cowpea (*Vigna unguiculata* L.)

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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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Original Research Article

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ABSTRACT

During the summer of 2022, the experiment was carried out at a crop research farm for agricultural research in the department of agronomy. Three different doses of molybdenum (800, 1000, and 1200 g/ha) were applied to the soil as treatments, coupled with zinc (5 kg/ha, 1% foliar spray, 2.5 kg/ha along with 0.5% foliar spray), as well as a control. Ten treatments were used in the experiment, which was designed as an RBD and triple replicated. The highest plant height, maximum number of branches, maximum number of root nodules, plant dry weight, CGR, RGR, and yield parameters, such as more pods per plant, seeds per pod, test weight, seed yield, and stover yield, were observed after the application of 1200g molybdenum with 2.5kg of zinc and 0.5% foliar spray.

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1. INTRODUCTION

One of the most significant pulses planted in the summer and rainy season is the cowpea (*Vigna unguiculata* L.), also known as the black eye pea or lobia. It is a member of the Leguminaceae family and is grown for its long, soft, green pods, which are consumed as vegetables and dried seeds as pulses. Plants and its foliage are utilised as green manure. Since the protein content of its green leaves is around 3-4%, its immature green pods are about 4-5%, and its mature seeds are about 23.09–28.75%, it is a significant source of poor man's protein. The green pods are a good source of lysine, tryptophan, B group vitamins, minerals, and carbs. Its protein has a great biological value since it can strengthen a diet high in carbohydrates significantly to increase its nutritional value. Conversely, nutritionally detrimental factors.

It has been hypothesised that zinc, an essential mineral nutrient that functions as a cofactor in over 300 enzymes and proteins involved in cell division, nucleic acid metabolism, and protein synthesis, inhibits the activities of several antioxidant enzymes, causing significant oxidative damage to membrane lipids, proteins, chlorophyll, and nucleic acids. Several levels of zinc's effects on glucose metabolism exist. Furthermore, Zn is necessary for the production of tryptophan, which is a precursor to auxin-indole-3-acetic acid. Zinc can significantly boost cowpea output and quality for use as animal feed. More than 50% of soil samples from Bhopal, India's Indian Institute of Soil Science, and 60% of soil samples from Haryana were found to be deficient in zinc, respectively.

Little leaves and short internodes, which give the plant a stunted look, are indicators of zinc deficiency. Poor fodder characteristics result from all of these. In India, more than 50% of soil sample tests revealed zinc deficiency; in addition, in Haryana, 60% of soil sample tests revealed zinc deficiency, according to ICAR-Indian Institute of Soil Science, Bhopal. Poor zinc uptake will accompany a zinc deficit in the soil, which will also result in poor fodder output and quality. Because zinc is an important component for animal nutrition as well, a shortage in animals can be corrected by adding zinc to soil in the right amounts [1].

Because it plays a crucial part in more than 60 enzymes that catalyse various redox processes, molybdenum (Mo) is also a crucial trace nutrient. It has a significant impact on nitrogen transport in plants because of its vital function in nitrogen fixation via the enzymes nitrogenase and nitrate reductase. On the other hand, a lack of Mo in crops causes the growth of flowers to be stunted, smaller in size, and less mature, which reduces grain output [2].

2. MATERIALS AND METHODS

The materials, methodology, and techniques used in the current experiment, titled "Response of molybdenum and foliar application zinc on growth and yield of cowpea (*Vigna unguiculata* L.), are presented in this chapter under the headings listed below. Also included is a brief description of the experiment's site, the characteristics of the soil, the sampling methods used, the climatic conditions during the crop's growing season, previous cropping practises, calendar operations, and statistical analysis.

To examine the impact of foliar zinc spray and molybdenum application at three different levels on summer cowpea development and production characteristics. The experiment was carried out at the Naini Agricultural Institute 2022 Crop Research Farm, SHUATS, Prayagraj. Geographically, the study's experimental site is situated at 25.28oN latitude, 81.54oE longitude, and 98 m elevation above mean sea level (MSL). The experimental field's neutral, deep soil is made up of central Gangetic alluvium. With the aid of an auger, pre-sowing soil samples were extracted from a depth of 15 cm.

The chemical and mechanical analyses were conducted on the composite samples. The soil had a sandy loam texture, had a low organic carbon content (0.36%), and had medium levels of nitrogen (171.48 kg/ha), phosphorus (15 kg/ha), and potassium (232.5 kg/ha) that were readily available. The treatments include three levels of zinc application (800, 1000, and 1200 g/ha) and three levels of molybdenum application (500 g/ha, 1% foliar at 25 DAS, and 2.5 g/ha + 0.5% foliar spray at 25 DAS), respectively. The experiment was set up using a randomised block design, with 10 treatments duplicated three times each, and the control, which consisted of just the N, P, and K (20:40:20 kg/ha) Kashi Kanchan, being suggested. The plots were set up with dimensions of 3 m 3 m, and variety seeds were sowed with a 30 cm by 10 cm space. Plants were trimmed to the proper density at the 4-5 leaf stage. To maintain a consistent plant population, weeds were physically eradicated during the 5-leaf stage, the stem elongation stage, and the flowering stage. Plant growth traits and height.

The following formulas were used to record the following data: (cm), number of branches per plant, dry weight per plant (g), crop growth rate (g/m2/day), and relative growth rate (g/g/day) (A & B). To avoid the crop experiencing water stress at any point, irrigation was applied equally and often to all plots as needed. The crop was completely harvested when it reached physiologic maturity, and biometric observations including the number of capsules per plant, the number of seeds per capsule, the weight in grammes (g) of 1,000 seeds, the yield in tonnes per hectare, and the yield in tonnes per hectare were recorded.

3. RESULTS

3.1 Growth Parameters

Table.1 pertaining that details of influence of molybdenum and foliar application of zinc on growth attributes of cowpea.

3.2 Plant Height (cm)

The application of T9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha + 0.5% Foliar spray at 25 DAS resulted in the maximum plant height (88.13 cm) at 60 DAS, which was statistically at par to treatment of T6: Zn 2.5 kg/ha + 0.5% Foliar spray at 25 DAS + Molybdenum 1000 g/ha (87.96cm).

3.3 Number of Branches

Maximum number of branches (15.44) was reported at 60 DAS with application of T9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha + 0.5% Foliar spray at 25 DAS, which was statistically at par to treatment of T6: Zn 2.5 kg/ha + 0.5% Foliar spray at 25 DAS + Molybdenum 1000 g/ha (15.33)

3.4 Number of Nodules for Plant

At 45 DAS, maximum no. of nodules (17.78) was recorded with application of T_9: Molybdenum 1200 g/ha + Zn- 2.5 kg/ha +0.5% Foliar spray at 25 DAS which was significantly superior over all other treatments and statistically at par with treatment of T_6: Molybdenum 1000 g/ha + Zn – 2.5kg/ha +0.5% Foliar spray at 25 DAS (17.56).

3.5 Dry Weight (g/plant)

At 60 DAS, maximum dry weight (23.73 g) was recorded with application of T_9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS which was significantly superior over all other treatments and statistically at par with treatment of T_6: Molybdenum 1000 g/ha + Zn – 2.5 kg/ha +0.5% Foliar spray at 25 DAS (23.22g) and T_8: Molybdenum 1200 g/ha + 1% Foliar spray at 25 DAS (22.76 g).

3.6 Crop Growth Rate (g/m^2/day)

At 30-45 DAS, maximum Crop growth rate (g/m^2/day) (18.89 g/m^2/day) was recorded with application of T_9: Molybdenum 1200 g/ha + Zn – 2.5 kg/ha + 0.5% Foliar spray at 25 DAS which was significantly superior over all other treatments and low in T_{10}: control-20:40:20 NPK kg/ha (13.20 g/m^2/day).

3.7 Relative Growth Rate (g/g/day)

Relative growth rate (g/g/day) in T1 Molybdenum 800g/ha + Zn 5 kg/ha was measured at 30-45 DAS and was found to be non-significant.

3.8 Yield Attributes

Table 2 pertaining that details of influence of molybdenum and foliar application of zinc on yield and yield attributes.

3.9 Number of Pods/Plants

Maximum number of pods/plant (19.89) was recorded in the treatment with application of T9: Molybdenum 1200 g/ha + Zn 2.5 kg/ha + 0.5% Foliar spray at 25 DAS, which was statistically at par to treatment of T6: Zn 2.5 kg/ha + 0.5% Foliar spray at 25 DAS + Molybdenum 1000 g/ha (19.77)

3.10 Number of Seeds/Pod

Maximum number of seeds/pods (15.55) were recorded in the treatment with application of T9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS, which was statistically at par to treatment with application of T6: Molybdenum 1000 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS (15.22).

Table 1. Influence of molybdenum and foliar application of zinc on growth attributes of cowpea

Treatment	Plant height (cm)	No of nodules/ plant	No of branches /plant	Dry weight /plant(g)	Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
Molybdenum 800 g/ha + Zn - 5 kg/ha	74.33	13.00	13.00	18.22	13.98	0.046
Molybdenum - 800 g/ha + Zn -1% Foliar spray at 25 DAS	78.27	14.56	13.11	19.79	15.09	0.041
Molybdenum 800 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS	84.15	15.11	14.33	20.15	15.52	0.045
Molybdenum 1000 g/ha + Zn - 5 kg/ha	79.31	16.45	14.56	22.08	17.76	0.039
Molybdenum 1000 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS	78.71	16.33	14.78	20.77	15.56	0.038
Molybdenum 1000 g/ha + Zn– 1% kg/ha +0.5% Foliar spray at 25DAS	87.96	17.56	15.33	23.22	18.41	0.036
Molybdenum 1200 g/ha + Zn- 5 kg/ha	83.35	16.44	14.33	21.28	16.93	0.043
Molybdenum 1200 g/ha + Zn -1% Foliar spray at 25 DAS	82.83	16.45	14.56	22.76	17.74	0.036
Molybdenum 1200 g/ha + Zn- 2.5 kg/ha +0.5% Foliar spray at 25DAS	88.13	17.78	15.44	23.73	18.89	0.036
Control (20:40:20 NPK kg/ha)	72.60	13.89	12.44	17.19	13.20	0.045
F Test	S	S	S	S	S	NS
S.Em(±)	0.08	0.42	0.18	0.49	0.58	0.003
CD(P=0.05)	0.25	1.24	0.53	1.46	1.73	-

Table 2. Influence of molybdenum and foliar application of zinc on yield and yield attributes of cowpea

Treatments	No of pods /plant	No of seeds/ pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Molybdenum 800 g/ha + Zn - 5 kg/ha	15.66	12.33	11.38	0.73	1.36	34.97
Molybdenum - 800 g/ha + Zn -1% Foliar spray at 25 DAS	16.66	12.55	12.00	0.84	1.78	31.98
Molybdenum 800 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS	17.55	13.00	12.66	0.96	1.59	37.65
Molybdenum 1000 g/ha + Zn - 5 kg/ha	18.00	13.55	12.49	1.02	1.99	33.79
Molybdenum 1000 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS	18.77	14.00	13.30	1.16	1.94	37.52
Molybdenum 1000 g/ha + Zn – 1% kg/ha +0.5% Foliar spray at 25 DAS	19.77	15.22	15.01	1.51	2.15	41.15
Molybdenum 1200 g/ha + Zn - 5 kg/ha	18.66	13.89	13.39	1.16	1.89	37.89
Molybdenum 1200 g/ha + Zn-1% Foliar spray at 25 DAS	19.00	14.11	14.00	1.25	2.00	38.47
Molybdenum 1200 g/ha + Zn- 2.5 kg/ha +0.5% Foliar spray at 25 DAS	19.89	15.55	15.14	1.56	2.25	40.97
Control (20:40:20 NPK kg/ha)	15.44	12.00	11.21	0.69	1.20	36.55
F Test	S	S	S	S	S	S
S.Em(±)	0.08	0.20	0.20	0.02	0.03	0.75

3.11 Test Weight

Maximum test weight (15.14 g) was recorded during treatment with application of T9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha + 0.5% Foliar spray at 25 DAS, which was statistically at par to treatment with T6: Molybdenum 1000 g/ha + Zn - 2.5 kg/ha + 0.5% Foliar spray at 25 DAS and significantly superior to all other treatments (15.01g)**.**

3.12 Seed Yield (t/ha)

Treatment with application of T_9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS was recorded maximum seed yield (1.56 t/ha) which was significantly superior over all other treatments and statistically at par with treatment of T_6: Molybdenum 1000 g/ha + Zn – 2.5 kg/ha +0.5% Foliar spray at 25 DAS (1.51)

3.13 Stover Yield (t/ha)

Treatment with application of T_9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS was recorded maximum straw yield (2.25 t/ha) which was significantly superior over all other treatments and statistically at par with treatment of T_6: Molybdenum 1000 g/ha + Zn – 2.5 kg/ha +0.5% Foliar spray at 25 DAS (2.15)

3.14 Harvest Index (%)

Treatment with application of T_6: Molybdenum 1000 g/ha + Zn – 2.5 kg/ha +0.5% Foliar spray at 25 DAS was recorded maximum straw yield (41.15 %) which was significantly superior over all other treatments and statistically at par with treatment of T_9: Molybdenum 1200 g/ha + Zn - 2.5 kg/ha +0.5% Foliar spray at 25 DAS (40.97).

4. DISCUSSION

Significantly increased the number of branches per plant between 0 and 10 kg ZnSO4/ha. Also, it was shown that the cowpea considerably increased the number of branches (12.33) when 18 kg/ha of zinc was applied compared to the control. This might be brought on by the metabolism of auxin and the accelerated photosynthetic rate brought on by zinc feeding [1].

The synthesis and activity of molybdo enzymes like nitrogenase, which fixes nitrogen in soil, and nitrate reductase, which assimilates nitrogen, are both dependent on the trace element molybdenum. Without molybdenum in the soil, the plant's molybdoenzymes can degrade and severely impair soil bacteria's ability to fix nitrogen [3].

The best outcomes were identified with zinc or boron effects, which may be explained by their favourable effects on plant metabolism and biological process activity, as well as their stimulating effects on photosynthetic pigments and enzyme activity, which in turn promote vegetative development [4].

Under treatment Mo 4g/kg seed, a significantly greater dry weight (45.11 g/plant) was observed. This may be attributed to increased nutrient availability, increased carbohydrate synthesis, and their distribution to various plant sections, which led to enhanced vegetative development, including the growth of reproductive structures, and ultimately raised the dry weight of the plant [5].

Significant increases in growth parameters observed at high fertiliser levels may be due to the plants' improved absorption of nutrients, which favours better cell division, elongation, amino acid synthesis, and protein expression, which leads to superior expression of various crop growth traits, an increase in growth parameters, and consequently, yield traits and yield at higher levels [6]

The fact that zinc application improved the realisation of blossom into pods may account for the increased quantity of pods per plant. Zinc application may increase the amount of green gramme straw produced as a result of its direct impact on auxin production, which in turn accelerated plant growth elongation processes [7].

However, zinc treatment also promotes the growth of sporogenous tissue, increasing the amount of pollen grains per anther. Moreover, zinc enhances pollen viability, which enables pollen stigma contact. All of these effects work together to promote proper pollen germination and an increase in yield characteristics including the number, size, and weight of pods and seeds [8].

Application of 30 kg/ha of zinc is likely the cause of the increase in yield attributes such as number of pods per plant, 1000 seed weight, grain yield, stover yield, and harvest index. Zinc is essential for plant metabolism as it affects the activity of growth enzymes, maintains the integrity of cellular membranes, is involved in protein synthesis, and controls auxin synthesis and pollen formation. Moreover, it changes ammonia into nitrate in crops, increasing yield [4].

Increased seed yield from seed treated with Mo may be attributable to improved chlorophyll development, which improves photosynthesis and leads to improved plant characteristics, which in turn improves seed yield [9].

When compared to control, the addition of Mo, Fe, and Zn significantly increased the micronutrient concentrations in cowpea grain and stover, which may have been because plant leaves absorbed available elements right away. 2022 (Dhaliwal)

Increased biological output from seed treated with molybdenum may be attributable to better plant germination and balanced growth patterns. When compared to the control, the application of molybdenum and P significantly boosted plant growth, dry matter production, and mash bean grain yield [9,10].

5. CONCLUSION

A significant increase in plant height, number of branches per plant, number of nodules per plant, number of branches per plant, plant dry weight, crop growth rate (g/m2/day), number of pods per plant, number of seeds per pod, seed yield, and stover yield were all observed in the treatment combination T9 (Mo-1200 g/ha + Zinc (2.5 kg/ha + 0.5% foliar spray at 25 DAS).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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