Original Research Article

Influence of Sulphur and Molybdenum on Growth and Yield of Black gram (*Vigna mungo L.*)

ABSTRACT

The field experiment was undertaken at Crop Research Farm (CRF) during the *Zaid season* (march to June – 2023). The Department of Agronomy at SHUATS in Prayagraj (UP) on soil with sandy loam in texture to investigate the effect Sulphur and Molybdenum on Growth and Yield of Black gram. The treatments consist of three doses of Sulphur viz., 30 kg ha^{-1}, 40 kg ha^{-1} and 50 kg ha^{-1} and Molybdenum 0.5 kg/ha, 1 kg/ha, foliar molybdenum 1500 ppm whose effect is observed on Black gram (var. Shekhar 2). The experiment was laid out in Randomized Block Design with Ten treatments replicated thrice. The treatment with application of Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm recorded significantly higher plant height (53.77 cm), number of branches $plant^{-1}$ (15.33) and plant dry weight (23.68 g), number of pods per plant (26.27), number of seeds per pod (9.53), test weight (30.52 g), seed yield (1.37 t ha^{-1}) and Straw yield (2.95 t ha^{-1}) compared to other treatment combinations.

Keywords: *Black gran, Economics, Growth, Molybdenum, Yield.*

1.Introduction

Pulses have a specific place in every farming system in the world. Pulses are a substantial and affordable source of protein and amino acids on the Indian subcontinent, particularly for vegetarians. Pulses make up 16–18% of the total protein in the typical Indian diet. By serving as the primary crop, catch crop, cover crop, green manure, and intercrop in the crop rotation system, they can fix atmospheric nitrogen, preserving the life and productivity of the soil. The quantity of pulses produced is far less than what is required to meet even the bare minimum level of per capita consumption. In contrast to the minimal recommendation of 70 g/day/capita as proposed by the Indian Council of Medical Research, the availability of pulses per capita in India is rapidly declining from 69 g/day in 1961 to 53 g/day in 2022 (Chaturvedi and Masood Ali, 2002). One of India's most cherished pulses, black gram originated in South Asia and has been grown there since the dawn of time. In Indian cuisine, it is incredibly prevalent. One of the significant pulses grown in India during both the Kharif and Rabi seasons is black gram. It is widely grown in the southern region of India.

The growth and development of all crops depend on sulphur, one of the 17 minerals for plants that are absolutely necessary. Without fail, the majority of a plant's S needs are taken through the roots as sulphate (SO_4). Sulphur serves a variety of unique roles in plants, just like every other necessary nutrient. Therefore, S deficiency can only be remedied by using sulphur fertiliser. Sulphur plays several important roles in plants, including the synthesis of chlorophyll, the green pigment in leaves that enables photosynthesis, and the production of protein, primarily because S is a component of the three amino acids (cysteine, cystine, and methionine) that contain the s symbol. These amino acids contain about 90% of the sulphur found in plants. activation of enzymes that aid in biochemical reactions within the plant, increases crop yield and improves produce quality, both of which determine the market price a farmer would receive for his produce, specifically with regard to crop quality, sulphur improves protein and oil percentage in seeds, cereal quality for milling and baking, marketability of dry coconut kernel (copra), quality of tobacco.

Similar to phosphorus, molybdenum is another element that lowers the seed yield of pulses in soils with low molybdenum levels (Dhaliwal, 2022). The enzyme nitrate reductase, which catalyses the conversion of NO_3^- to NO_2, requires molybdenum as a necessary component. Additionally, it is a structural part of the nitrogenase enzyme, which helps bacteria in the root nodules of leguminous plants fix atmospheric nitrogen. For the atmospheric nitrogen fixation process to take place, molybdenum is necessary. Molybdenum functions as a cofactor for enzyme systems, aiding in redox reactions, particularly the conversion of nitrates to ammonia prior to the creation of amino acids and proteins in plant cells. Additionally, it serves as a co-factor in the manufacture of ascorbic acid and activates a few dehydrogenases and phosphatases. Considering the above facts, the experiment was conducted to study "Influence of Sulphur and Molybdenum on Growth and Yield of Black gram.

2. Materials and Methods

A field experiment was conducted during *Zaid season* (march – June, 2023) at Crop Research Farm (CRF), Department of Agronomy, SHUATS, Prayagraj (UP). The Crop Research Farm is situated at 25.4137˚ N latitude, 81.8491˚ E longitude and at an altitude of 98 m above mean sea level. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.4), medium in organic carbon (0.48%), medium in available Nitrogen (278.93 kg/ha), low in available Phosphorous (19.03 kg/ha) and medium in available Potash (238.1 kg ha^{-1}). The treatments consist of three doses of Sulphur viz., 30 kg ha-1, 40 kg ha-1 and 50 kg ha-1 and Molybdenum 0.5 kg/ha, 1 kg/ha, foliar molybdenum 1500 ppm whose effect is observed on Black gram (var. Shekhar 2). The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The experiment comprising ten treatment possible combination of above factor, *viz.*, T_1: Sulphur - 30 kg/ha + Molybdenum 0.5 kg/ha T_2: Sulphur - 30 kg/ha+ Molybdenum 1 kg/ha, T_3: Sulphur - 30 kg/ha+ Foliar Molybdenum 1500 ppm, T_4: Sulphur - 40 kg/ha+ Molybdenum 0.5 kg/ha, T_5: Sulphur - 40 kg/ha+ Molybdenum 1 kg/ha, T_6: Sulphur - 40 kg/ha+ Foliar Molybdenum 1500 ppm, T_7: Sulphur - 50 kg/ha+ Molybdenum 0.5 kg/ha, T_8: Sulphur - 50 kg/ha+ Molybdenum 1 kg/ha, T_9: Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm, T_{10}: Control (R D F: 20: 40: 20). Observations regarding growth and yield attributes was recorded during the field experiment.

3. Result and Discussion

3.1 Growth

According to the recorded and tabulated data pertaining to growth parameters, the significantly higher plant height (72.55 cm), maximum number of Branches per plant (15.33) and higher plant dry weight (43.68 g) was recorded in treatment with application of Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm.

The positive role of sulphur, a major structural component of cells, may have contributed to the increase in plant growth by encouraging cell division and cell expansion. The primary components of vegetative growth are new leaves, stems, and nodules. Products from photosynthesis that are delivered to these locations are mostly employed in the synthesis of proteins. These results are in close conformity with findings of Aman *et al.* (2020) and Akter *et al*. (2013). On the other hand, the increased plant growth may be due to the fact the symbiotic nitrogen fixation process depends on the nitrogenase enzyme, which contains molybdenum as one of its components. Additionally, it is found in the enzyme nitrate reductase, which converts nitrates into ammonia in plants, increasing the synthesis of amino acids and proteins in plant cells and promoting greater growth and development. These results were in close conformity with findings of Dhaliwal *et al.*, (2022).

3.2 Yield attributes

According to the yield characteristics data that was collected and analysed at harvest, maximum number of pods per plant (16.73), maximum number of seeds per pod (11.67) and higher seed index (18.38g) was recorded in treatment with the application of Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm.

Sulphur application was found to considerably increase seed production. This was partly owing to the plant's improved growth, which produced an adequate supply of photosynthates for the formation of the sink at the ideal fertiliser level. Similar findings were reported by Aman e*t al.*, (2020), Anil e*t al.*, (2018), Venkatesh e*t al.*, (2002). Due to molybdenum's special role in improved nitrogen fixation, which increases availability to the plants for effective growth and development, a higher number of pods per plant may be the result of its application. As a result of improvements in photosynthesis and carbohydrate metabolism, more photosynthates and metabolites were produced in the source and later transferred to newly created sinks, such as reproductive structures (flowering and seed setting), which ultimately increased the number of pods/plants. Similar findings were reported by Raut e*t al.*, (2004).

3.3 Yield

After evaluated the data recorded post harvesting of crop show that significantly higher seed yield (1.59 t/ha), higher Haulm yield (4.16 t/ha) and harvest index (27.62%) was recorded in treatment with the application of Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm.

The cumulative impact of increasing growth and yield parameters is what led to the increase in grain and Stover yield. This might be ascribed to a better supply of sulphur because of its enhanced ability to absorb and use radiant energy, which ultimately led to crop plants producing a lot of dry matter, which raises the yield. similar findings were reported by Bala (2021), Aman *et al.*, (2020). The administration of molybdenum may also have greatly boosted seed yield due to increased growth traits like nodulation, plant height, and traits that are associated with yield, such as pods per plant and seeds per pod. These results are in close conformity with the findings of Ranjit Chatterjee *et al.* (2015).

3.4 Economics

The economic return of Black gram was analyzed after harvesting the crop based on market pricing, the result indicated a growing trend in with the increasing yield trend across treatment.

The maximum Gross returns (INR 96,040.00/ha), Net returns (INR 67,8443.56/ha) and Benefit cost ratio (2.36) was evaluated in treatment with the application of Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm.

4. Conclusion

Based on the above experimental findings, it is concluded that application of nutrients in combination of Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm accomplished better growth parameters, yield attributes, higher seed yield, higher gross returns and net returns in cowpea under eastern Uttar Pradesh conditions.

5. References

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Table 1. Growth attributes of Black gram as influenced by Sulphur and Molybdenum.

Treatments	Plant Height (cm)	Plant Dry Weight (g)	No. of Branches per Plant	CGR (g m^{-2} day^{-1})	RGR ($g^{-1}g^{-1}day^{-1}$)
Sulphur - 30 kg/ha + Molybdenum 0.5 kg/ha	41.65	4.18	5.40	1.32	0.0162
Sulphur - 30 kg/ha+ Molybdenum 1 kg/ha	45.51	5.41	5.67	1.79	0.0171
Sulphur - 30 kg/ha+ Foliar Molybdenum 1500 ppm	48.57	6.17	6.13	2.44	0.0210
Sulphur - 40 kg/ha+ Molybdenum 0.5 kg/ha	43.57	4.38	6.47	1.38	0.0161
Sulphur - 40 kg/ha+ Molybdenum 1 kg/ha	46.35	5.71	6.60	2.02	0.0184
Sulphur - 40 kg/ha+ Foliar Molybdenum 1500 ppm	51.51	7.73	8.33	4.45	0.0332
Sulphur - 50 kg/ha+ Molybdenum 0.5 kg/ha	44.47	4.89	6.40	1.74	0.0186
Sulphur - 50 kg/ha+ Molybdenum 1 kg/ha	48.15	6.88	6.73	3.13	0.0248
Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm	52.48	8.46	8.60	4.61	0.0310
Control (RDF 20:40:20)	39.99	3.83	4.87	1.39	0.0189
F test	S	S	S	S	S
SEm(±)	0.46	0.03	0.11	0.07	0.0007
CD (p=0.05)	0.83	0.13	0.29	0.22	0.0023

Treatment	Yield attributes		
	No. of pods plant^{-1}	**No. of seeds Pod^{-1}**	**Seed Index (g)**
Sulphur - 30 kg/ha + Molybdenum 0.5 kg/ha	16.40	5.33	28.75
Sulphur - 30 kg/ha+ Molybdenum 1 kg/ha	20.47	6.33	29.06
Sulphur - 30 kg/ha+ Foliar Molybdenum 1500 ppm	24.00	8.60	29.53

Treatment	Seed Yield (t ha^{-1})	Haulm Yield (t ha^{-1})	Harvest Index (%)
Sulphur - 40 kg/ha+ Molybdenum 0.5 kg/ha	17.27	5.27	28.84
Sulphur - 40 kg/ha+ Molybdenum 1 kg/ha	22.13	7.73	29.22
Sulphur - 40 kg/ha+ Foliar Molybdenum 1500 ppm	24.87	9.13	29.94
Sulphur - 50 kg/ha+ Molybdenum 0.5 kg/ha	19.40	6.33	28.94
Sulphur - 50 kg/ha+ Molybdenum 1 kg/ha	24.53	8.13	29.83
Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm	26.27	9.53	30.52
Control (RDF 20:40:20)	14.60	5.27	27.84
F test	S	S	S
SEm(±)	0.18	0.16	0.01
CD (p=0.05)	0.52	0.48	0.04

Table 2. Yield attributes of Black gram at harvest as influenced by Sulphur and Molybdenum.

Sulphur - 30 kg/ha + Molybdenum 0.5 kg/ha	0.79	2.06	27.73
Sulphur - 30 kg/ha+ Molybdenum 1 kg/ha	0.90	2.48	26.57
Sulphur - 30 kg/ha+ Foliar Molybdenum 1500 ppm	1.14	2.67	29.94
Sulphur - 40 kg/ha+ Molybdenum 0.5 kg/ha	0.84	2.17	27.99
Sulphur - 40 kg/ha+ Molybdenum 1 kg/ha	0.95	2.56	27.08
Sulphur - 40 kg/ha+ Foliar Molybdenum 1500 ppm	1.27	2.86	30.70
Sulphur - 50 kg/ha+ Molybdenum 0.5 kg/ha	0.87	2.27	27.68
Sulphur - 50 kg/ha+ Molybdenum 1 kg/ha	1.18	2.75	29.99
Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm	1.37	2.95	31.76
Control (RDF 20:40:20)	0.76	1.98	27.66
F test	S	S	S
SEm(±)	0.01	0.01	0.23
CD (p=0.05)	0.02	0.03	0.67

Table 3. Yield of Black gram at harvest as influenced by Sulphur and Molybdenum.

Table 4. Economics of Black gram at harvest as influenced by Sulphur and Molybdenum.

S. No	Treatments	Economics			
		Cost of Cultivation	Gross returns	Net Returns	B:C ratio
1.	Sulphur - 30 kg/ha + Molybdenum 0.5 kg/ha	27,585.34	55463.33	27,877.99	1.01
2.	Sulphur - 30 kg/ha+ Molybdenum 1 kg/ha	28,185.34	62720.00	34,534.66	1.23
3.	Sulphur - 30 kg/ha+ Foliar Molybdenum 1500 ppm	27,485.34	79963.33	52,477.99	1.91
4.	Sulphur - 40 kg/ha+ Molybdenum 0.5 kg/ha	28,138.74	58916.67	30,777.93	1.09
5.	Sulphur - 40 kg/ha+ Molybdenum 1 kg/ha	28,738.74	66476.67	37,737.93	1.31
6.	Sulphur - 40 kg/ha+ Foliar Molybdenum 1500 ppm	28,038.74	88573.33	60,534.59	2.16
7.	Sulphur - 50 kg/ha+ Molybdenum 0.5 kg/ha	28,696.44	60923.33	32,226.89	1.12
8.	Sulphur - 50 kg/ha+ Molybdenum 1 kg/ha	29,296.44	82553.33	53,256.89	1.82
9.	Sulphur - 50 kg/ha+ Foliar Molybdenum 1500 ppm	28,596.44	96040.00	67,443.56	2.36
10.	Control (RDF 20:40:20)	25,318.74	53060.00	27,741.26	1.10