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Effect of nitrogen and sulphur levels on yield and economics of cluster bean (*Cyamopsis tetragonoloba* L.)

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Abstract
A field experiment was conducted during *Kharif* season 2023 at Crop Research Farm, Department of Agronomy. Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh. The treatments consisted of three levels of Nitrogen (10, 15 and 20 kg/ha) and three levels of Sulphur (20, 25 and 30 kg/ha) along with control (20-40-20 NPK kg/ha). The experiment was laid out in a Randomized Block Design with ten treatments which have replicated thrice. The results of the experiment revealed that the Application of Nitrogen at 20 kg/ha along with Sulphur 30 kg/ha (Treatment 9) recorded significantly higher Seed yield (1.69 t/ha), higher Stover yield (3.27 t/ha) and harvest index (33.13%). The same treatment also recorded maximum gross return (INR.79332.07 /ha), net return (INR. 55152.07 /ha) and benefit cost ratio (2.28).

Keywords: Cluster bean, nitrogen, sulphur, yield and economics

Introduction

Cluster bean (*Cyamopsis tetragonoloba* L.), commonly known as Guar, is a significant legume crop cultivated primarily in rainfed regions of arid and semi-arid Rajasthan during the *Kharif* season. Renowned for its resilience and ability to withstand drought, Guar has earned its name from its widespread use as cattle feed, referred to as "Gow ahaar" (where "Gow" means cow and "Ahaar" means feed). Beyond its culinary use, Guar is valued for its gum content, predominantly found in the seeds' endosperm. It is a crop that is extremely resistant to drought. Its deeply ingrained roots provide more potential for rainfed crops because they help the plant use the rainfall that is available more effectively. Furthermore, the crop thrives in somewhat alkaline and saline conditions. There is no other legume crop so hardy and drought tolerant as cluster bean (Kherawat *et al.* 2013) [7]. Cluster bean can grown in diverse range of environmental conditions due to its drought tolerance capacity. As a dual purpose (food and feed) legume, it can be grown as a monocrop or in intercrop systems. In India cluster bean is mostly cultivated to a large extent in states *viz*., Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Maharashtra, Karnataka and Andhra Pradesh. Due to its hardy nature, it is popular vegetable crop grown in summer season. This legume is very valuable plant within a crop rotation cycle as it gives in symbiosis with nitrogen fixing bacteria. One crop that improves soil is the cluster bean, which has the nitrogen-fixing bacterium Rhizobium japonica on its root nodules. This bacteria fixes nitrogen in the soil, adding between 50 - 150 kg of nitrogen per hectare. As a legume crop, cluster beans have the ability to fix nitrogen from the atmosphere through their useful root nodules (Kumhar *et al*. 2012) [6]. A leguminous crop, cluster beans may fix 37–196 kg of nitrogen per hectare annually. It can fix approx 37-196 kg atmospheric nitrogen per hectare per year in soil. Sometimes it is used in reclamation of saline and alkaline soils (Mahata *et al*. 2009) [9].

India dominates the global production of guar grain, contributing 80% of the total output. Cultivated over an area of 3.93 million hectares, India produces 1.62 million tonnes of guar grain annually, with a relatively low productivity of 413 kg/ha (NRAA, 2020). Additionally, India is the primary exporter of guar-gum worldwide.

Regarding cluster beans, India cultivates them over an area of 3.14 million hectares, yielding 1.5 million tonnes annually, with a productivity of 484 kg/ha (DA&FW, 2021-22). In Uttar Pradesh, the area under cluster bean cultivation spans 1979 hectares, producing 1418 tonnes, with a productivity of 0.72 tonnes/ha (DA&FW, 2021-22).

Nitrogen is indispensable for crop growth, serving as a fundamental element in chlorophyll, amino acids, and protein synthesis. Its application not only enhances leaf area and photosynthetic activity but also leads to increased dry matter production. Additionally, nitrogen plays a critical role in plant metabolism, serving as a vital component in proteins, enzymes, and cellular structures. Its profound impact on the quality, yield, and development of cluster beans has been noted in studies such as Saxena *et al*. (2003) [12]. Despite leguminous crops exhibiting less responsiveness to nitrogen, even a small initial dosage can significantly accelerate early-stage growth, as highlighted by Sammuria *et al*. (2009) [10]. However, nitrogen remains inaccessible to plants unless fixed, primarily existing as nitrate ($NO3^-$) and ammonium (NH^+). Biological fixation, facilitated by bacteria like *Rhizobium*, *Azotobacter*, and blue-green algae, stands as the primary nitrogen source, ensuring its availability for plant uptake and utilization.

Sulphur, a crucial secondary plant nutrient, has been identified as deficient in soils of semi-arid regions such as Rajasthan, highlighting its significance in Indian agriculture, particularly in enhancing legume production. It is recognized as the fourth major plant nutrient, primarily known for its role in the synthesis of sulphur-containing amino acids like methionine, cystine, and cysteine, as well as in protein, vitamin, and chlorophyll synthesis. Sulphur is integral to many proteins and enzymes, influencing both yield and produce quality. Improved fertilization practices involving sulphur application not only enhance plant growth and yield but also elevate the quality of cluster beans. Sulphur promotes nodulation in legumes and aids in the solubilization of organic nitrogen, thereby reducing the quantity of insoluble nitrogen. Research by Singh and Chauhan *et al*. demonstrated significant yield increases with sulphur application, with observed improvements in both grain and straw production. Further more, phosphorus fertilizer application increases anion adsorption sites, releasing sulphate ions into the soil solution, thereby indirectly aiding in sulphur availability for plants.

Materials and Methods

A field trial was conducted During *Kharif* season 2023, at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). which is located at 25.43'58'' N latitude, 81.84' 63" E longitude and 98 m altitude above the mean sea level (SL). The soil of experimental plot was sandy loam, having a nearly neutral soil reaction (pH 7.1), electrical conductivity 0.48 ds/m, medium in available nitrogen (270.81 kg/ha) and potassium (215.9 kg/ha), and low in available phosphorous (11.5 kg/ha). The experiment was conducted in a Randomized Block Design consisting of ten treatment combinations and three replications. Fertilizers were applied as band placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, double super phosphate (DAP) and murate of potash (MOP), applied as per the recommended dose of 20:40:20 NPK kg/ha. The plot size of each treatment was 3m x 3m. Factors are Nitrogen (10, 15 and 20 kg/ha) and three levels of Sulphur (20, 25 and 30 kg/ha). The Cluster bean crop was sown on 10 August 2023. Harvesting was done by taking $1m^2$ area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The treatment details are as follows T_1: Nitrogen 10 kg/ha + Sulphur 20 kg/ha, T_2: Nitrogen 10 kg/ha + Sulphur 25 kg/ha, T_3: Nitrogen 10 kg/ha + Sulphur 30 kg/ha, T_4: Nitrogen 15 kg/ha + Sulphur 20 kg/ha, T_5: Nitrogen 15 kg/ha + Sulphur 25 kg/ha, T_6: Nitrogen 15 kg/ha + Sulphur 30 kg/ha, T_7: Nitrogen 20 kg/ha + Sulphur 20 kg/ha, T_8: Nitrogen 20 kg/ha + Sulphur 25 kg/ha, T_9: Nitrogen 20 kg/ha + Sulphur 30 kg/ha, and Control Plot. The observations were recorded for number of pods/plant, number of seeds/pod, test weight (g), seed yield (t/ha) and stover yield (t/ha), Harvest Index (%). The observed data was statistically analysed using analysis of variance (ANOVA) as applicable to randomized block design (Gomez and Gomez, 1984) [5].

Results and Discussions

Seed yield (t/ha)

At harvest, significantly higher Seed yield (1.69 t/ha) was recorded Treatment-9 with the application of Nitrogen 20 kg/ha along with Sulphur 30 kg/ha which was superior over all other treatments. However, the treatment-8 Nitrogen 20 kg/ha + Sulphur 25 kg/ha, treatment-7 Nitrogen 20 kg/ha + Sulphur 20 kg/ha were found to be statistically at par with the treatment-9 Nitrogen 20 kg/ha + Sulphur 30 kg/ha. The statement highlights the positive impact of higher nitrogen and sulphur application on plant growth, particularly in groundnut cultivation. Adequate levels of these nutrients contribute to increased accumulation of amino acids and amides, which are then translocated to reproductive organs, enhancing seed setting and filling, consequently improving groundnut yield. Nitrogen is crucial for chlorophyll formation, facilitating photosynthesis and carbohydrate production. Sulphur, on the other hand, promotes tissue differentiation from somatic to reproductive, stimulates meristematic activity, and facilitates the development of floral primordia, leading to increased flower formation and ultimately higher yields. These observations are consistent with findings reported by Ahmed *et al*. (2016) [1].

Stover yield (t/ha)

The data shows Table-1 significantly higher stover yield (3.27 t/ha) was recorded Treatment-9 with the application of Nitrogen 20 kg/ha along with Sulphur 30 kg/ha which was superior over all other treatments. However, the treatment-8 Nitrogen 20 kg/ha + Sulphur 25 kg/ha was found to be statistically at par with treatment-9 Nitrogen 20 kg/ha + Sulphur 30 kg/ha. Thiourea belonging from a nitrogen containing compound, it is used to mitigate stress as well as denitrification inhibitor. Hence, increased in nitrogen contents and their uptakes might be due to increased concentration of nitrogen in grain and stover favoured by acceleration of nitrogenase activity in leaves through nitrogen metabolism. Consequently, concentration of nitrogen increased in grain and stover that result in higher uptakes by respective parts of mungbean (Sarita *et al.* 2019 and Amin *et al.* 2014) [11, 2]. The application of sulfur may have resulted in a significant and greater seed output because of the strong growth, which may have assisted in increasing dry weight production and more photosynthetic accumulation in the sink, both of which eventually translated into higher seed yield. Similar result was reported by Vyas *et al*. (2020) [16].

Harvest index (%): At harvest, highest harvest index (33.13%) was recorded in treatment-9 with the application of Nitrogen 20 kg/ha + Sulphur 30 kg/ha, though there was significant difference among the treatments

Economics

The data on the economics of different treatments presented in Table 2 showed that the maximum gross return (INR.79332.07 /ha), net return (INR.55152.07 /ha) and benefit-cost ratio (2.28) was recorded treatment-9 with the application of Nitrogen 20 kg/ha along with Sulphur 30 kg/ha and the minimum gross return (INR.55845.62 /ha), net return (INR.32715.62 /ha) and benefit-cost ratio (4.41) was observed in the treatment-1 with the application of Nitrogen 10 kg/ha + Sulphur 20 kg/ha.

Table 1: Effect of Nitrogen and Sulphur levels on yield and yield attributes in cluster bean

S. No.	Treatments combinations	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1	Nitrogen 10 kg/ha + Sulphur 20 kg/ha	1.15	3.04	27.50
2	Nitrogen 10 kg/ha + Sulphur 25 kg/ha	1.26	3.14	28.77
3	Nitrogen 10 kg/ha + Sulphur 30 kg/ha	1.34	3.15	29.83
4	Nitrogen 15 kg/ha + Sulphur 20 kg/ha	1.40	3.16	30.69
5	Nitrogen 15 kg/ha + Sulphur 25 kg/ha	1.42	3.19	30.78
6	Nitrogen 15 kg/ha + Sulphur 30 kg/ha	1.50	3.18	32.03
7	Nitrogen 20 kg/ha + Sulphur 20 kg/ha	1.53	3.18	32.55
8	Nitrogen 20 kg/ha + Sulphur 25 kg/ha	1.60	3.21	33.23
9	Nitrogen 20 kg/ha + Sulphur 30 kg/ha	1.69	3.27	34.13
10	Control (NPK) 20:40:20 kg/ha	1.37	3.18	30.14
	F - Test	S	S	S
	S.Em(+)	0.02	0.03	0.35
	CD (P= 0.05)	0.07	0.09	1.05

Table 2: Effect of Nitrogen and Sulphur level on economics of cluster bean

S. No.	Treatments combinations	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	Benefit-cost ratio (B:C)
1	Nitrogen 10 kg/ha + Sulphur 20 kg/ha	23130.00	55845.62	32715.62	1.41
2	Nitrogen 10 kg/ha + Sulphur 25 kg/ha	23630.00	60753.40	37123.40	1.57
3	Nitrogen 10 kg/ha + Sulphur 30 kg/ha	24130.00	63972.40	39842.40	1.65
4	Nitrogen 15 kg/ha + Sulphur 20 kg/ha	23155.00	66521.53	43366.53	1.87
5	Nitrogen 15 kg/ha + Sulphur 25 kg/ha	23655.00	67430.07	43775.07	1.85
6	Nitrogen 15 kg/ha + Sulphur 30 kg/ha	24155.00	71006.80	46851.80	1.94
7	Nitrogen 20 kg/ha + Sulphur 20 kg/ha	23180.00	72505.32	49325.32	2.13
8	Nitrogen 20 kg/ha + Sulphur 25 kg/ha	23680.00	75322.60	51642.60	2.18
9	Nitrogen 20 kg/ha + Sulphur 30 kg/ha	24180.00	79332.07	55152.07	2.28
10	Control (NPK) 20:40:20 kg/ha	21080.00	65293.58	44213.58	2.10

Conclusion

From the results, it is concluded that application of Nitrogen 20 kg/ha along with Sulphur 30 kg/ha (Treatment 9) in Cluster bean has recorded highest Grain yield, gross return, net return and benefit cost ratio.

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