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Effect of Potassium and sulphur on yield and economics of different treatment combinations on black gram (*Vigna mungo* L.)

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Abstract
During Zaid 2021, a field experiment was conducted at the Department of Agronomy's Research Farm. The study used a Randomized Block Design with nine treatments that were duplicated three times. The treatments details *viz.*, T_1: 20 kg K ha^{-1} + 15 kg S ha^{-1}, T_2: 30 kg K ha^{-1} + 20 kg S ha^{-1}, T_3: 40 kg K ha^{-1} + 25 kg S ha^{-1}, T_4: 20 kg K ha^{-1} + 15 kg S ha^{-1}, T_5: 30 kg K ha^{-1} + 20 kg S ha^{-1}, T_6: 40 kg K ha^{-1} + 25 kg S ha^{-1}, T_7: 20 kg K ha^{-1} + 15 kg S ha^{-1}, T_8: 30 kg K ha^{-1} + 20 kg S ha^{-1}, T_9: 40 kg K ha^{-1} + 25 kg S ha^{-1} was used. The result showed that max. seed yield (1456.67 kg ha^{-1}), Stover yield (3086.67 kg ha^{-1}), harvest index (32.06) and highest gross return (80,191 ₹ ha^{-1}), net return (56391 ₹ ha^{-1}), and Benefit: Cost ratio (2.36) was recorded with the application of 40 kg Potassium per hectare pulse 25 kg of Sulphur per hectare.

Keywords: Black gram, potassium, sulphur, economics

Introduction
Pulses are an important component of a nutritionally balanced diet. For vegetarians, these are the most important sources of protein. Pulses serve as a primary crop, a catch crop, a cover crop, green manure, and an intercrop in the cropping system (Hussain, F. *et al*., 2011) About 18,000 species make up the Leguminoceae family, which are distinguished by their pods and alternate pinnate or trifoliate leaves (Jhadav *et al.*, 2014). Even today, those who don't consume meat can get all of their protein from lentils and milk. Over the decades, the constant growth in the population, together with the stagnating production of pulses, resulted in calorie deficiency and a nutritional supply imbalance. The per capita availability of pulses declined from 60.7 g in 1951 to 35.9 g in 2000, compared to the ICMR's recommended pulse intake of 50 g/capita/day. (In recent years, there has been legitimate worry about the decline in per capita availability of pulses.) During the main seasons of Kharif and Rabi, pulse crops are being replaced with high yielding varieties of cereals (Chaturvedi and Masood Ali, 2002).

Urdbean, often known as black gram (*Vigna mungo* L. Hepper), is an old and well-known leguminous crop (Karthikeyan *et al.*, 2020) [7]. In India, black gram accounts for 10% of total pulse production. It is a member of the Leguminosae family and the papilionaceae subfamily, and has been farmed as one of the main crops in Madhya Pradesh and throughout the country for centuries. India is the world's leading producer and user of black gramme. It produces 15 to 19 lakh tonnes of black gramme per year from roughly 35 lakh hectares of land, with an average output of 500 kilogrammes per hectare. (Ministry of Agriculture, GOI 2014-15) [1]. Black gram contains a great balance of all elements, including protein (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids, and vitamins. It's high in vitamin A, B1, B3, and thiamine, riboflavin, niacin, and vitamin C, but low in thiamine, riboflavin, niacin, and vitamin C. Albumin and globulin account for 78 to 80 percent of the nitrogen content. Phosphorus is abundant in the dried seeds (Raushan *et al.*, 2020) [11].

Pulses' productivity potential is not being achieved, and the low productivity of black gram can be attributed to large-scale agriculture on rainfed and marginal soils, as well as low input conditions (Anon, 2015) [2]. Fertility management is critical among all yield limiting factors to ensure higher crop development on depleted soils, as nutrients play a critical role in enhancing pulse seed yield (Chandrasekhar and Bangarusamy, 2003) [4].

In crop production, potassium is referred to as a "quality element." Plant protein levels, starch levels in grains and tubers, Vitamin C levels, and the solid soluble content of fruits all benefit from potassium. The involvement of K in enhancing photosynthetic production and delivery to storage organs such as fruits, grains, and tubers, as well as their conversion to carbohydrates, protein, vitamins, and oil, demonstrates its importance in quality development. When there is a deficiency of K, many metabolic activities, including as photosynthesis, translocation, and enzyme systems, are harmed. According to reports from around the country, potassium (K) as a plant nutrient has a favourable crop response. Potassium treatment boosted pulse crop yields. Increased potassium availability also improves biological nitrogen fixation and protein content in pulse grains (Srinivasa rao *et al.*, 2003) [10]. K is important for enzyme activation as well as biological N fixing and protein content in pulse seeds (Bukhsh *et al.*, 2011) [3]

Unfortunately, the severity and spread of sulphur shortage in Indian soil is steadily rising. In 1990, 130 districts in India's soils were determined to be sulphur deficient, but the problem had worsened over the next decade due to illiteracy. As a result, additional 70 sulphur-deficient districts have been added to the list. (Patel *et al.*, 2018) [9]. Sulphur is another critical nutrient that leguminous crops require in quantities comparable to phosphorus. Sulphur is found in the amino acids cysteine and methionine, and is hence required for protein synthesis. By oxidising cysteine, another sulphur-containing amino acid, cystine, is produced. Sulphur is a component of co-enzymes and is involved in the production of chlorophyll. Sulphur deficiency symptoms are similar to those of nitrogen deficit, with pale yellow or light green leaves (Parashar *et al.*, 2020) [8].

Farmers in any economy produce primarily two types of crops: income crops and staple crops. Cash crops are ones that are grown primarily for the purpose of generating cash for farmers by selling them in the market. Staple crops are grown for both domestic and commercial consumption.

Materials and Method

Experimental site: The trail was carried out at Central Research Farm, NAI, SHUATS' Prayagraj, which is located at 25° 24′30″N latitude, 81° 51′10″ E longitude, and 98 metres above sea level (MSL) Prayagraj has a subtropical climate with summer and winter extremes.

Soil: The soil of the experimental field is part of the central gangetic alluvium. Pre-sowing soil samples were obtained with an auger from a depth of 0-15 cm and examined in a three-fold randomised block design. The composite samples were subjected to chemical and mechanical analysis. The texture of the soil was sandy loam, with low Organic Carbon (0.23 percent), medium potassium (187 kg/ha), and Sulphur levels (0.24).

Experimental Design and Treatments: A (RBD) was used for experiment by taking K and S with different levels. The plot size 2m x 2m. the treatments were T_1: 20 kg K ha^{-1} + 15 kg S ha^{-1}, T_2: 30 kg K ha^{-1} + 20 kg S ha^{-1}, T_3: 40 kg K ha^{-1} + 25 kg S ha^{-1}, T_4: 20 kg K ha^{-1} + 15 kg S ha^{-1}, T_5: 30 kg K ha^{-1} + 20 kg S ha^{-1}, T_6: 40 kg K ha^{-1} + 25 kg S ha^{-1}, T_7: 20 kg K ha^{-1} + 15 kg S ha^{-1}, T_8: 30 kg K ha^{-1} + 20 kg S ha^{-1}, T_9: 40 kg K ha^{-1} + 25 kg S ha^{-1}. The recommended fertiliser doses (RDF) employed in the experiment were 20 kg N, 40 kg P_2O_5, and 20 kg K_2O/ha. Urea, SSP, and MOP were used as nutrient sources. Based on the treatment combinations, sulphur is provided to the plots as a basal whenever soil application is required. Irrigation was employed throughout critical phases and at the right time of sowing.

Table 1: Treatment Details

Treatment	Combination
T_1	20 kg K ha^{-1} + 15 kg S ha^{-1}
T_2	30 kg K ha^{-1} + 20 kg S ha^{-1}
T_3	40 kg K ha^{-1} + 25 kg S ha^{-1}
T_4	20 kg K ha^{-1} + 15 kg S ha^{-1}
T_5	30 kg K ha^{-1} + 20 kg S ha^{-1}
T_6	40 kg K ha^{-1} + 25 kg S ha^{-1}
T_7	20 kg K ha^{-1} + 15 kg S ha^{-1}
T_8	30 kg K ha^{-1} + 20 kg S ha^{-1}
T_9	40 kg K ha^{-1} + 25 kg S ha^{-1}

Results and Discussion

Table 2: Effect of Potassium and Sulphur on Yield of Black gram.

Treatment	Seed Yield kg ha^{-1}	Haulm Yield kg ha^{-1}	Harvest Index (%)
T_1	903.33	1625.99	30.51
T_2	923.33	1661.99	30.57
T_3	1046.67	1884.00	30.87
T_4	926.67	1668.00	30.79
T_5	1096.67	1974.00	31.17
T_6	1173.33	2111.99	31.37
T_7	940.00	1692.00	30.58
T_8	1293.33	2327.99	31.64
T_9	1456.67	2622.00	32.06
F-test	S	S	S
SE± m	1.82	0.87	0.57
CD at 5%	2.35	1.59	1.45

Treatment T_9 produced the highest yield (1456.67 kg ha^{-1}), while treatment T_1 produced the lowest. This considerable increase in Yield with increased Potassium and Sulphur application could be ascribed to the fact that Sulphur is involved in the formation of amino acids, vitamins, and has a direct role in root development and formative activities. Nitrogen supply was adequate, and the fact that it was a leguminous crop improved Nitrogen availability, which aided vegetative development. Likewise, the increase in yields was attributed to the redirection of a greater amount of assimilates to the developing pods as a result of increased sink strength reversed by increased photosynthate interest. Sulphur supplementation in sufficient amounts also aids in the development of floral botany, or reproductive portions, which improves the creation of pods and kernels in crop plants. The max. Haulm yield was recorded in treatment T_9 (2622.00 kg ha^{-1}) while the lowest was recorded in treatment T_1 (1625.99 kg ha^{-1}) and harvest index max. was observed in treatment T_9 (32.06%) while the lowest was recorded in treatment T_1 (30.51%).

Table 3: Effect of Potassium and Sulphur on economics of production of black gram

Treatment		Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit: Cost ratio
T_1	20 kg K/ha + 15 kg S/ha	21600	49941	28341	1.31
T_2	30 kg K/ha + 20 kg S/ha	22600	51129	28529	1.26
T_3	40 kg K/ha + 25 kg S/ha	23600	57856	34256	1.45
T_4	20 kg K/ha + 15 kg S/ha	21736	51111	29375	1.35
T_5	30 kg K/ha + 20 kg S/ha	22736	60639	37903	1.66
T_6	40 kg K/ha + 25 kg S/ha	22800	64824	41088	1.73
T_7	20 kg K/ha + 15 kg S/ha	21800	52000	30200	1.38
T_8	30 kg K/ha + 20 kg S/ha	23736	71501	48701	2.13
T_9	40 kg K/ha + 25 kg S/ha	23800	80191	56391	2.36

Economics

Cost of cultivation: Highest cost of cultivation was obtained with treatment T_9 of 23800 ₹ha^{-1}, while the lowest of 21600 ₹ ha^{-1} with T_1.

Gross returns: Highest gross returns of 80191 ₹ ha^{-1} was recorded with the treatment T_9, While the lowest was recorded with treatment T_1 of 49941 ₹ ha^{-1}

Net returns: Highest net returns were recorded with the treatment T_9 of 56391₹ ha^{-1}, while the treatment T_1 has recorded the lowest of 28341₹ ha^{-1}.

Benefit Cost Ratio:

Maximum B:C ratio was recorded with treatment T_9 of 2.36, while less of 1.31 with treatment T_1. Higher B:C ratio was obtained with the higher level of Potassium and Sulphur.

Conclusion

The application of Potassium 40 kg ha^{-1} and Sulphur 25 kg ha^{-1} has recorded significantly higher growth and yield parameters and also higher gross and returns which may be preferable for farmers since it is economically more profitable. The conclusion drawn are based on one season data only which requires further confirmation for recommendation.

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Conflict of Interest: As a Corresponding Author, I Rakesh Yadav, confirm that no-one else have any conflicts of interest associated with this publication

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