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Effect of Levels of Phosphorus and Sulphur on Growth and Yield of Blackgram (*Vigna mungo* L.)

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A B S T R A C T

The present investigation titled "Effect of levels of phosphorous and sulphur on growth and yield of Blackgram (*Vigna mungo* L.)" was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *zaid* season of 2019. Shekhar-2 variety was selected for conducting the trial. The experiment was laid out in Randomized Block Design consisting of 9 treatments replicated thrice with the treatment combination of three levels of phosphorus *viz.*,P_1 – 30 kg ha^{-1}, P_2 - 40 kg ha^{-1}, P_3- 50 kg ha^{-1} and three levels of sulphur *viz.*,S_1- 20 kg ha^{-1}, S_2- 25 kg ha^{-1}, S_3- 30 kg ha^{-1}. The results revealed that the treatment T_6 (P at 40 kg ha^{-1}+S at 30 kg ha^{-1}) recorded maximum plant height (32.77 cm), number of nodules per plant (18.56), dry weight (11.92 g $plant^{-1}$), Crop Growth rate (CGR) (0.703g $m^{-2}day^{-1}$), number of pods per plant (24.51), number of grains per pod (6.40), test weight(47.60 g), grain yield (2.76 t ha^{-1}) and protein content (24.28%). However, the maximum stover yield (6.22 t ha^{-1}) was obtained with the treatment T_5 (P at 40 kg ha^{-1}+ S at 25 kg ha^{-1}). Maximum gross return (₹ 124200 ha^{-1}), net return (₹ 82422.58 ha^{-1}) and B:C ratio (2.97) was recorded with the treatment T_6 (P at 40 kg ha^{-1}+S at 30 kg ha^{-1}).

Introduction

The word "pulse" is derived from the Latin word "*puls*" means pottage, i.e. seed boiled to make porridge or thick soup (Patel, 2017). Pulses, also known as grain legumes are secondary to cereals in production and consumption in India. They are found to contain low fat, low sodium, high fibre, no cholesterol and are a good source of protein, minerals, various vitamins and amino acids. Pulses provide 25% of protein requirements of predominantly vegetarian population. The World Health Organisation (WHO) recommends a per capita consumption of pulses at 80 gram per day and the Indian Council of Medical Research (ICMR) has recommended a minimum consumption of 47 g. Pulse crops are one of the most sustainable crops a farmer can grow. Pulses are less water requiring crop, prevent soil erosion due to their deep root system, give good ground coverage, fit well in crop rotation and crop mixtures and fix atmospheric nitrogen through symbiosis. These crops have the ability to reduce atmospheric nitrogen to

usable form through biological nitrogen fixation (BNF) in association with root nodule bacteria. Blackgram (*Vigna mungo* L.) commonly known as urdbean is a deep rooted drought hardy crop. It is a self-pollinated leguminous crop which contains 24% protein, 60% carbohydrate, 1.3% fat, 3.2% minerals, 0.9% fibre, 154 mg calcium, 385 mg phosphorus and 9.1 mg iron. It is rich in vitamin A, B_1, B_3 and has small amount of thiamine, riboflavin, niacin and vitamin C in it. It contains 78% to 80% nitrogen in the form of albumin and globulin. The dry seeds are good source of phosphorus. After removing pods, its plant may be used as good quality green or dry fodder or green manure. It can be grown on all type of soils ranging from sandy loam to heavy clay except alkaline and saline.

In India, 44.93 lakh hectare area is under blackgram cultivation with a total production of 29.26 lakh tonnes. (Directorate of Pulse development, Annual report 2016-17). Agricultural feasibility and economic viability of blackgram as sole as well as intercrop in crop sequences have been established due to unique property of maintaining and restoring soil fertility through biological nitrogen fixation as well as conserving and improving physical properties of soil by virtue of its deep root system and leaf fall.

Despite of these features, the productivity of this crop is below the average owing to several constraints. The major reason for the low productivity of black gram in the country, apart from natural constraints, is due to supply imbalance use of nutrients. Proper fertilization is essential to improve the productivity of blackgram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur.

Phosphorus plays a key role in photosynthesis, metabolism of sugars, energy storage and transfer, cell division, cell enlargement, transfer of genetic information, root growth, nodulation and nitrogen fixation in plants. Increase in yield brought by P application is significant and economically viable owing to its wide spread deficiency in soils of India in general. It also plays an important role in the process of photosynthesis, energy conservation and transportation, cell division and meristematic growth in living tissues, grain quality and most of physico-bio-chemical activities. Accordingly, 80 percent of the soils in India need P application at recommended rates, whereas, the application of some quantity of P fertilizers would be essential to arrest P mining from the soils so as to sustain high yield of crops.

Sulphur is another important essential plant nutrient. Involvement of sulphur in plants metabolism and yield responses makes sulphur as the fourth major element after nitrogen, phosphorus and potassium. Sulphur plays an important role in physiological processes like synthesis of sulphur containing amino acids (cystine and methionine) and Chlorophyll. It is also responsible for synthesis of certain vitamins (biotine and thiamine), co-enzyme-A, metabolism of carbohydrates, fat and protein. Sulphur also promotes nodulation in legumes. In this way, sulphur can be very helpful in enhancing the productivity of pulses including urdbean. Wide spread S deficiency have been observed on larger areas due to use of high analysis S free fertilizers like urea and diammonium phosphate (DAP) in high yielding varieties and intensive cropping, and is more conspicuous in light textured soils low in organic matter (Prajapati *et al.*, 2013). Phosphorus fertilizer application results in increased of anion adsorption sites by phosphate, which releases sulphate ions into the soil solution (Tiwari and Gupta, 2006).

Thus, it may be subjected to leaching if not taken up by plant roots. Studies have indicated both synergistic and antagonistic relationship between sulphur and phosphorus but their relationship depends on their rate of application and crop species. The interaction of these nutrient elements may affect the critical levels of available phosphorus and sulphur below which response to their application could be observed. Information on effect of combined application of P and S on yield, quality and content of each nutrient in black gram is rather limited. Hence the present investigation titled "Effect of levels of phosphorous and sulphur on growth and yield of Blackgram (*Vigna mungo* L.)" was conducted.

Materials and Methods

Field experiment was conducted during *zaid* season of 2019 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. Shekhar-2 variety was selected for conducting the trial. Total 9 treatment combination comprising of three levels of phosphorus *viz.*,P_1 – 30 kg ha^{-1}, P_2 - 40 kg ha^{-1}, P_3- 50 kg ha^{-1} and three levels of sulphur *viz.*, S_1- 20 kg ha^{-1}, S_2- 25 kg ha^{-1}, S_3- 30 kg ha^{-1} were evaluated in Randomized Block Design with three replications. The soil of the experimental plot was Sandy loam in texture having medium to good drainage, EC 0.27dS m^{-1}, and soil pH 7.4. The chemical analysis of soil revealed the following values - organic carbon was estimated to be 0.32%, nitrogen 188.3 kg ha^{-1}, phosphorus 34.5 kg ha^{-1}, potassium 87 kg $ha^{-1}$and sulphur 14.74 ppm. Blackgram variety "Shekhar- 2" seeds were sown at 30 cm × 15 cm spacing according to the seed rate of 30 kg ha^{-1}.

The recommended dose of nitrogen (20 kg ha^{-1}) and potassium (20 kg ha^{-1}) was applied as basal dose just before sowing and phosphorus and sulphur were applied as per the treatments. Urea, DAP, MoP and Sulphur powder were taken as fertilizer sources for N,P,K and S respectively.

Results and Discussion

Growth attributes

Data presented in Table 1 shows effect of levels of phosphorus and sulphur on growth attributes of Blackgram such as plant height, number of nodule, plant dry weight, crop growth rate (CGR) and relative growth rate (RGR). Among different phosphorus and sulphur levels, the highest values were recorded with the application of P at 40 kg ha^{-1} along with S at 30 kg ha^{-1}. The interactive effect of phosphorus and sulphur significantly influenced all the growth parameters except RGR. The results revealed that the treatment T_6 (P at 40 kg ha^{-1}+S at 30 kg ha^{-1}) recorded maximum plant height (32.77 cm), number of nodules per plant (18.56), dry weight (11.92 g $plant^{-1}$) and Crop Growth rate (0.703 g m^{-2} day^{-1}). Increased plant growth might be due to better nutritional environment in root zone. Phosphorus is a vital component of ADP and ATP and it plays an important role in conservation and transfer of energy in metabolic reaction. It also stimulates cell division resulting in increased growth of plants and also improves nodulation and N fixation by roots. Increased growth of plants leads to higher plant dry weight. With increasing levels of phosphorus, the response of sulphur also increased significantly. Sulphur availability results in better formation of nodule, nitrogenase enzyme, chlorophyll etc and thereby influencing growth components of the crop. The results are similar to the findings of Yadav *et al.*, (2017), Niraj and Prakash (2015), Mir *et al.*, (2013), Chettri and Mondal (2004) and Kumar *et al.*, (2000).

Table.1 Effect of levels of phosphorus and sulphur on growth attributes of Blackgram

	60 Days after sowing					
Treatment No.	Treatments combination	Plant height (cm)	Number of Nodules plant^{-1}	Dry weight (g)	Crop growth rate 45-60 DAS (g m^{-2} day^{-1})	Relative growth rate 45-60 DAS (mg g^{-1} day^{-1})
1	P_1 + S_1: 30 kg ha^{-1} + 20 kg ha^{-1}	25.50	7.33	3.70	0.172	0.085
2	P_1 + S_2: 30 kg ha^{-1} + 25 kg ha^{-1}	26.07	8.67	3.89	0.196	0.098
3	P_1 + S_3: 30 kg ha^{-1} + 30 kg ha^{-1}	26.73	8.89	5.36	0.295	0.111
4	P_2 + S_1: 40 kg ha^{-1} + 20 kg ha^{-1}	27.04	8.33	6.63	0.344	0.112
5	P_2 + S_2: 40 kg ha^{-1} + 25 kg ha^{-1}	28.40	14.11	8.39	0.478	0.141
6	P_2+ S_3: 40 kg ha^{-1} + 30 kg ha^{-1}	32.77	18.56	11.92	0.703	0.143
7	P_3 + S_1: 50 kg ha^{-1} + 20 kg ha^{-1}	26.50	10.67	5.07	0.280	0.103
8	P_3 + S_2: 50 kg ha^{-1} + 25 kg ha^{-1}	27.50	10.22	7.67	0.424	0.113
9	P_3 + S_3: 50 kg ha^{-1} + 30 kg ha^{-1}	28.07	11.22	8.15	0.470	0.128
	F- test	S	S	S	S	NS
	S. Ed. (±)	1.025	3.264	2.084	0.135	0.028
	CD (P = 0.05)	2.173	6.919	4.419	0.286	-

Table.2 Effect of levels of phosphorus and sulphur on yield attributes and protein content of Blackgram

	At Harvest						
Treatment No.	Treatments combination	Number of Pods plant^{-1}	Number of grains Pod^{-1}	Test weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Protein content (%)
1	$P_1 + S_1$: 30 kg ha^{-1} + 20 kg ha^{-1}	16.44	3.55	32.60	1.62	5.13	18.07
2	$P_1 + S_2$: 30 kg ha^{-1} + 25 kg ha^{-1}	18.57	4.78	37.09	1.62	5.21	18.99
3	$P_1 + S_3$: 30 kg ha^{-1} + 30 kg ha^{-1}	20.06	4.85	38.24	1.90	4.38	22.30
4	$P_2 + S_1$: 40 kg ha^{-1} + 20 kg ha^{-1}	19.27	5.06	39.83	1.88	5.65	19.18
5	$P_2 + S_2$: 40 kg ha^{-1} + 25 kg ha^{-1}	23.48	5.94	44.78	2.52	6.22	22.67
6	$P_2 + S_3$: 40 kg ha^{-1} + 30 kg ha^{-1}	24.51	6.40	47.60	2.76	6.08	24.28
7	$P_3 + S_1$: 50 kg ha^{-1} + 20 kg ha^{-1}	22.17	5.60	40.87	2.09	5.96	22.48
8	$P_3 + S_2$: 50 kg ha^{-1} + 25 kg ha^{-1}	21.17	5.48	41.52	2.42	6.04	22.35
9	$P_3 + S_3$: 50 kg ha^{-1} + 30 kg ha^{-1}	22.37	6.07	45.15	2.15	6.04	22.58
	F- test	S	S	S	S	S	-
	S. Ed. (±)	0.892	0.486	3.532	0.323	0.294	-
	CD (P = 0.05)	1.890	1.030	7.488	0.685	0.623	-

Table.3 Effect of levels of phosphorus and sulphur on economics of blackgram

Treatment No.	Treatments combination	Cost of Cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net Return (₹ ha^{-1})	B:C ratio
1	P_1 + S_1: 30 kg ha^{-1} + 20 kg ha^{-1}	40216.32	72900	32683.68	1.81
2	P_1 + S_2: 30 kg ha^{-1} + 25 kg ha^{-1}	40866.32	72900	32033.68	1.78
3	P_1 + S_3: 30 kg ha^{-1} + 30 kg ha^{-1}	41516.32	85500	43983.68	2.06
4	P_2 + S_1: 40 kg ha^{-1} + 20 kg ha^{-1}	40477.42	84600	44122.58	2.09
5	P_2 + S_2: 40 kg ha^{-1} + 25 kg ha^{-1}	41127.42	113400	72272.58	2.76
6	P_2+ S_3: 40 kg ha^{-1} + 30 kg ha^{-1}	41777.42	124200	82422.58	2.97
7	P_3 + S_1: 50 kg ha^{-1} + 20 kg ha^{-1}	40738.52	94050	53311.48	2.31
8	P_3 + S_2: 50 kg ha^{-1} + 25 kg ha^{-1}	41388.52	108900	67511.48	2.63
9	P_3 + S_3: 50 kg ha^{-1} + 30 kg ha^{-1}	42038.52	96750	54711.48	2.30

Yield and quality attributes

Observations regarding the response of different levels of phosphorus and sulphur on yield attributes and protein content of Blackgram are presented in Table 2.

The data shows that the phosphorus and sulphur significantly influenced all the yield parameters. Among different phosphorus and sulphur levels, the highest number of pods per plant (24.51), number of grains per pod (6.40), test weight (47.60 g), grain yield (2.76 t ha^{-1}) and protein content (24.28%) was recorded with the application of P at 40 kg ha^{-1} along with S at 30 kg ha^{-1}. However, the maximum stover yield (6.22 t ha^{-1}) was obtained with the treatment T_5 consisting of P at 40 kg ha^{-1} along with S at 25 kg ha^{-1}.

The yield attributes were significantly influenced due to better availability of nutrients in the soil. P_2O_5 increased the photosynthetic activity of plant which ultimately led to effective assimilate partitioning of photosynthates from sources to sink in post flowering stage. It also led to the development of extensive root system which increased the water and mineral extraction capacity of plants resulting in better plant growth and yield. This finding was similar to results obtained by Kokani *et al.,* (2014) and Thesiya *et al.,* (2013). Sulphur is a part of amino acid (Cystine), which helps in chlorophyll formation, photosynthetic process, activation of enzymes and higher grain yield. More availability of sulphur during vegetative and reproductive stages of the crop boosted the crop yield. The results were in relation with the findings of Mitra *et al.,* (2006) and Singh *et al.,* (2017).

The response to applied phosphorus with respect to protein content in blackgram is attributed to more nitrogen fixation. Similar results were also reported by Kumawat *et al.,* (2004). Favourable influence of sulphur on protein content was due to synthesis of sulphur containing amino acids and nitrogen uptake. The results were in conformity with Mir *et al.,* (2013).

Economics of treatment

Economic evaluation of the treatments was done on the basis of gross return, net return and benefit: cost ratio (Table 3). It was observed that the treatment receiving P at 40 kg ha^{-1} along with S at 30 kg ha^{-1} registered highest gross return (₹124200 ha^{-1}), net return (₹82422.58 ha^{-1}) and benefit cost ratio (2.97). This might be due to higher yield in this treatment compared to other treatments.

It is concluded that in the experiment on Blackgram, the treatment number 6 in which Phosphorus was applied at 40kg ha^{-1} along with Sulphur at 30kg ha^{-1} recorded higher growth [like plant height (32.77 cm), number of nodules per plant (18.56), dry weight (11.9235 g $plant^{-1}$ and Crop Growth rate (0.703 g m^{-2} day^{-1})] and yield attributes (namely number of pods per plant (24.51), number of grains per pod (6.40), test weight (47.60 g), grain yield (2.76 t ha^{-1}) and protein content (24.28%)) with highest Net Returns (₹ 82422.58 ha^{-1}) and B:C ratio (2.97).

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