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Influence of Various Levels of Phosphorus and Sulphur on Growth and Yield of Blackgram in Vylogam Soil Series (*Typic Rhodustalf*)

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ABSTRACT

Background: In India pulses have been considered as the poor man's only source of protein. Blackgram is one of the important pulse crops grown throughout the country. Balanced and site-specific nutrient management is essential to improve the productivity of blackgram. Effective use of phosphorus and sulphur fertilizers requires knowledge about their interaction effect on other nutrients and releasing pattern. The information on combined effect of phosphorus and sulphur on availability of nutrients, yield and uptake of blackgram is rather limited in Tamil Nadu. Keeping in mind the above information a field trial was conducted to study the interaction effect of phosphorus and sulphur on improving the growth and productivity of blackgram.

Methods: The field experiment was carried out in Madurai district, during *Kharif* season 2017. The experiment was laid out in a factorial randomized block design with three replications having 25 treatment combinations *viz*. five levels of phosphorus (0, 20, 40, 60, 80 kg P_2O_5 ha^{-1} applied through Di ammonium phosphate) as factor A and five levels of sulphur (0, 20, 40, 60, 80 kg S per ha^{-1} applied through elemental sulphur) as factor B. The growth and yield parameters were recorded as per standard procedures.

Result: Experimental results revealed that the application of P_2O_5 upto 60 kg ha^{-1} and increasing levels of sulphur upto 40 kg ha^{-1} proved to be the best in improving the growth and yield characters of blackgram. Higher dose of phosphorus and sulphur did not increase the parameters further and showed a negative impact. Thus, interaction of phosphorus and sulphur exhibited a strong synergistic relationship at $P_{60}S_{40}$ kg ha^{-1} on growth and yield of blackgram (variety VBN 4) with grain yield of (1118 kg ha^{-1}) and halum yield of (1683 kg ha^{-1}) in Vylogam soil series (*Typic Rhodustalf*) of Madurai District.

Key words: Blackgram, Interaction, Phosphorus, Sulphur.

INTRODUCTION

Pulses, the wizard of the health owes a strategic position in agricultural sector of India. The human body utilizes between 32 and 78% of protein from pulses ingested. Dietary allowance for adult male is 60 g/day and for adult female 55 g/day (Directorate of pulses development, 2016) but per capita availability is only 42 g/day in India. In recent years, there has been understandable concern about decline in the per capita availability of pulses. To recover this deficit of production it is high time to cultivate pulses crops scientifically with increasing area.

Blackgram is one among the important pulse crop in India, both in terms of total area and production. Currently, blackgram area in the country stands at 4.53 million hectares with a production of 2.09 million and with a productivity of 459 kg ha^{-1}. In Tamil Nadu, blackgram is a popular pulse crop occupying an area of 4.05 lakh hectares with a production of 3.17 lakh tonnes and with a productivity of 783 kg ha^{-1} (Indiastat 2020). The prudent use of fertilizers with appropriate dose and time of application are of the prime importance in securing higher and economic yield.

Phosphorus and sulphur play a vital role in the nutrition of plants. In fact, these are the nutrients, which lack mostly in the soils. Analysis of Indian soils has indicated that, soils are medium to low in the phosphorus and deficient in sulphur. Phosphorus deficiency in soils is widespread and its use efficiency hardly exceeds 20 per cent. Out of 135 districts under pulses, soils in 68 districts are low and 62 districts are medium in available P status (Malik and Malik, 2014). Next most important emerging nutrient that is showing widespread deficiency is sulphur. Sulphur status of Indian soils is going down with each passing year. Soil analysis and crop response data generated by the TSI-FAI-IFA project (1997-2006) re-enforced the findings of the ICAR system. Based on reported results, out of over 49,000 soil samples analyzed across 18 states, 46% of samples were deficient in sulphur and another 30% were medium in available sulphur which could be considered as potentially sulphur deficient.

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According to lyotrophic series of anion $OH^- > H_2PO_4^- > SO_4^{2-} > BO_3^- = Cl^-$. One $H_2PO_4^-$ = half of SO_4^{2-} with equimolar concentration. Because of higher bonding strength $H_2PO_4^-$ get adsorbed easily than SO_4^{2}. Sulphate adsorption is completely stopped by the presence of two-thirds of the equivalent amount of phosphate compared to sulphate. 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 (Chaurasia *et al*., 2009). The need of the hour is to forge a holistic understanding of the issues affecting the pulses value chain and need for more research and development on the input side. Therefore, the present investigation was undertaken to study the interaction effects of phosphorus and sulphur application on growth and yield of black gram.

MATERIALS AND METHODS

A field experiment was conducted in farmers' fields at Allangampatti village, Melur block, Madurai district, Tamil Nadu, India situated between 9°30' and 10°30' North latitudes and 77°30' and 78°30' East longitudes with the altitude of 101 M above sea level. The soil of the experimental site belonged to Vylogam series and according to USDA soil taxonomy it was classified as *Typic Rhodustalf*. The soil was sandy loam in texture with pH of 7.12 (neutral) and EC of 0.41 dS m^{-1}. The available nitrogen, phosphorous and potassium content of the soil were 236, 10.23 and 248 kg ha^{-1}, respectively. The available sulphur content of the soil was also found to be deficient (5.20 mg kg^{-1}). The experiment was laid out in factorial randomized block design with three replications having twenty-five treatment combinations *viz*. five levels of phosphorus (0, 20, 40, 60 and 80 kg ha^{-1}) as factor A and five levels of sulphur (0, 20, 40, 60 and 80 kg ha^{-1}) as factor B. Nitrogen was applied at the rate of 25 kg ha^{-1} and potassium at the rate of 25 kg ha^{-1} in all the treatments. Nitrogen was applied through urea, phosphorus through diammonium phosphate, potassium through muriate of potash and S through elemental sulphur (field grade 90% pure). The experimental plot size was 5×4 m. The crop was sown in middle of March. The blackgram variety used was Vamban 4 (CO 4×PDU 102) sown at the rate 30 kg ha^{-1} with a spacing of 30×10 cm. Hand weeding was done twice at 20 and 40 days after sowing. Five plants from each plot were selected at random, after tagging growth and yield parameters were recorded. The data collected were statistically analysed as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of phosphorus and sulphur on growth attributes of blackgram

Plant height

Increasing levels of phosphorus and sulphur and their interaction effect showed significant increase on plant height

Table 1: Effect of different levels of phosphorus and sulphur on growth characters of blackgram.

Phosphorus levels (kg ha^{-1})	Plant height (cm)											Number of branches $plant^{-1}$					
	30 DAS					At harvest											
	Sulphur levels (kg ha^{-1})					Sulphur levels (kg ha^{-1})						Sulphur levels (kg ha^{-1})					
	0	20	40	60	80	Mean	0	20	40	60	80	Mean	0	20	40	60	80	Mean
0	15.2	20.6	24.8	25.3	25.8	22.4	30.7	35.5	39.9	41.5	40.2	37.5	2.0	2.4	2.5	2.6	2.7	2.5
20	20.5	22.4	25.1	25.9	26.2	24.0	34.7	39.6	42.3	43.0	43.3	40.6	2.4	2.5	3.1	3.2	3.2	2.9
40	24.7	26.8	28.3	28.7	26.8	27.1	39.7	43.9	45.5	45.9	43.9	43.8	2.6	3.4	4.0	4.1	3.9	3.6
60	26.3	29.8	35.7	31.2	28.9	30.4	43.3	47.9	50.4	48.3	46.0	47.2	3.2	4.1	4.9	4.3	4.0	4.1
80	27.2	28.20	33.0	29.1	27.1	28.9	41.3	45.4	47.7	42.5	43.5	44.1	3.2	4.1	4.5	4.1	3.7	3.9
Mean	22.8	25.6	29.4	28.1	27.0		37.9	42.5	45.2	44.2	43.4		2.7	3.3	3.8	3.7	3.5	
		P	S	P×S				P	S	P×S				P	S	P×S		
SEm±		0.56	0.56	1.26				0.53	0.53	1.23				0.05	0.05	0.12		
CD (P≤0.05)		1.13	1.13	2.54				1.01	1.01	2.24				0.12	0.12	0.26		

(Table 1). It was apparent from the data that increasing levels of P upto 60 kg P_2O_5 ha^{-1} markedly recorded the highest plant height of 30.4 cm at vegetative and 47.2 cm at harvest. Phosphorus application results in vigorous growth of root system, which ultimately helps in better absorption and utilization of nutrients from soil solution which reflected in terms of better overall plant growth. The results are in agreement with findings of Salman Khan *et al*. (2017). Application of sulphur at the rate of 40 kg ha^{-1} registered the maximum plant height of 29.4 cm at vegetative and 45.2 cm at harvest stage. This might be ascribed to the favourable effect of sulphur on nitrogen metabolism which reflects on vegetative growth of the plant.

Further the conjoint application of 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} recorded the highest plant height. Tomar *et al.* (2004) also found the positive interaction effect of P and S on the plant height of soybean.

Number of branches plant^{-1}

Experimental results revealed that various levels of P, S and interaction of P×S showed significant variation in number of primary branches plant^{-1} as depicted in (Table 1). Application of 60 kg P ha^{-1} individually recorded the maximum number of primary branches plant^{-1} (4.1). On the other hand, application of 40 kg S ha^{-1} recorded 3.8 numbers of primary branches plant^{-1}. This might be due to the favourable effect of S which leads to higher absorption and translocation of nutrients that get assimilated to the shoot which would have increased the number of primary branches plant^{-1} in blackgram. Further, 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} recorded the highest number of branches plant^{-1} (4.3). These results are in line with findings of Paliwal *et al*. (2009).

Effect of phosphorus and sulphur on yield attributes of blackgram

Results revealed that the yield attributing characters such as number of pods plant^{-1} and number of grains pod^{-1} was significantly influenced by different levels of phosphorus, sulphur and interaction of P×S (Table 2). In regard to phosphorus, the highest number of pods plant^{-1} (26.4) and grains pod^{-1} (6.7) was noted with the application of phosphorus at the rate of 60 kg ha^{-1}. The results are in line with findings of Rani *et al*. (2016) who reported that phosphorus fertilization make the excess assimilates to be stored in the leaves and later translocated into seeds at the time of senescence which ultimately led to higher number of seeds. Also, sulphur application @ 40 kg ha^{-1} registered the maximum number of pods plant^{-1} (24.9) and grains pod^{-1} (6.3). This could be owing to a synergistic relationship between sulphur and most nutrients, which promotes nutrient

Table 2: Effect of different levels of phosphorus and sulphur on yield attributing characters of blackgram.

Phosphorus	Number of pods plant^{-1}						Number of grains pod^{-1}					
levels	Sulphur levels (kg ha^{-1})						Sulphur levels (kg ha^{-1})					
(kg ha^{-1})	0	20	40	60	80	Mean	0	20	40	60	80	Mean
0	7.3	10.4	14.1	14.9	15.2	12.4	4.0	5.0	5.3	5.4	5.5	5.1
20	10.2	14.7	18.1	20.4	22.8	17.2	5.0	5.3	5.4	5.5	5.6	5.4
40	14.6	21.2	27.8	29.4	27.4	24.1	5.1	5.5	5.7	5.6	5.6	5.5
60	17.3	25.8	34.8	28.0	26.3	26.4	5.5	6.5	7.9	7.0	6.7	6.7
80	18.3	22.4	29.5	24.3	22.1	23.3	5.5	6.0	6.9	6.3	5.9	6.1
Mean	13.5	18.9	24.9	23.4	22.8		5.0	5.7	6.3	6.0	5.9	
		P	S	P×S				P	S	P×S		
SEm±		0.51	0.51	1.15				0.08	0.08	0.16		
CD(P≤0.05)		1.03	1.03	2.32				0.14	0.14	0.32		

Table 3: Effect of different levels of phosphorus and sulphur on grain and haulm yield (kg ha^{-1}) of blackgram.

Phosphorus	Grain yield (kg ha^{-1})						Haulm yield (kg ha^{-1})					
levels	Sulphur levels (kg ha^{-1})						Sulphur levels (kg ha^{-1})					
(kg ha^{-1})	0	20	40	60	80	Mean	0	20	40	60	80	Mean
0	510	657	701	763	836	693	963	1031	1067	1161	1072	1059
20	621	689	779	823	840	750	1029	1097	1161	1226	1098	1122
40	692	756	866	834	842	798	1092	1156	1219	1252	1187	1181
60	821	993	1118	978	921	966	1156	1459	1683	1414	1356	1414
80	843	911	1047	955	908	933	1223	1288	1589	1350	1283	1347
Mean	697	801	902	871	869		1093	1206	1344	1281	1199	
		P	S	P×S				P	S	P×S		
SEm±		11.39	11.39	25.47				15.52	15.52	30.15		
CD (P≤0.05)		22.90	22.90	51.21				30.63	30.63	62.45		

availability and assimilation, resulting in better grain yield. Furthermore, the use of $P_{60}S_{40}$ in combination had a synergistic impact. This result was consistent with Islam *et al*. (2006) observations in mungbean.

Grain and halum yield

The grain and haulm yield of blackgram was significantly influenced by increasing the levels of phosphorus and sulphur (Table 3). Application of 60 kg P_2O_5 ha^{-1} registered the highest grain yield of 966 kg ha^{-1} and haulm yield of 1414 kg ha^{-1} followed by 80 kg P_2O_5 ha^{-1}. The significant increase in grain and halum yield might be due to the increased supply of phosphorus to the plant which in turn reflected in terms of yield and also favoured carbohydrate and fat metabolism which increased the growth and yield (Pathan *et al*., 2005).

Further application of sulphur @ 40 kg ha^{-1} recorded the maximum grain yield of 902 kg ha^{-1} and haulm yield of 1344 kg ha^{-1}. It might due to the fact that sulphur has a profound effect on creating assimilation area absorbing photosynthetically active radiation (PAR) which resulted in improved yield of blackgram. Our results are in close agreement with the findings of Dhage *et al*. (2014). The magnitude of response in yield was more due to phosphorus application than sulphur application.

The combined application of 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} was found to be synergistic and registered the maximum grain yield of 1118 kg ha^{-1} and haulm yield of 1683 kg ha^{-1}. The synergistic effect of P and S may be due to the utilization of large quantities of nutrients through their well-developed root system and nodules which might have resulted in better development and improved the yield. These results are in line with the findings of Rani *et al*. (2016) who reported that combined application of phosphorus and sulphur would maintain a balance between the applied nutrients and sulphur will enhance the utilization of P by its effect on metabolism. Thus, the higher doses of P and S comparatively contributed lower yield due to the antagonistic effect between two anions competing for absorption at the rhizosphere region thus, affecting the critical levels of other nutrients. These results are in close association with the findings of Singh and Chauhan (2005).

CONCLUSION

Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer uses on the other have favoured the emergence of multi nutrient deficiency in Indian soils. According to field research, a higher level of P combined with a lower S rate increased blackgram yield. However, in order to minimise antagonism and productivity loss, an optimal combination of the two nutrient elements must be identified for specific locations. Overall results of the experiments revealed that the conjoint application of 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} was found to be superior in improving the growth attributes, yield and yield attributes in Vylogam soil series of Madurai district, Tamil Nadu.

Conflict of interest

All authors declare that they have no conflict of interest.

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