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Effect of doses and sources of sulphur on growth and yield of black gram (*Vignamungo*L.Hepper) under rainfed condition of Vindhyan Soil

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Abstract
A field experiment was conducted at Rajiv Gandhi South Campus, BHU, Barkachha Mirzapur to evaluate the effect of sources and levels of sulphur on growth and yield of black gram. Sulphur sources viz., gypsum, elemental sulphur and ammonium sulphate were used at different levels viz., 0, 20, 40 and 60 kg S ha^{-1} in this study. The experiments consisted of 12 treatments and were laid out in factorial randomized block design with three replications. Among the sources, gypsum registered its significant superiority over other sources. With respect of levels, application of 40 kg S ha^{-1} recorded highest growth (plant height, leaf area index, dry matter production and number of branches $plant^{-1}$) and also yield components (number of pods $plant^{-1}$ and number of seeds pod^{-1}) and yield (grain and haulm) of black gram. This study showed that supplementation of sulphur as gypsum significantly increased the growth and yield of black gram. This is might be due presence of calcium in the increases growth and yield of black gram. It was followed by elemental sulphur and ammonium sulphate.

Keywords: Black gram, sulphur, growth and yield

Introduction
Pulses are the main source of protein in the Indian diet where majority of the population comes under vegetarian category. The steady increase in the population taken together with the stagnant production of pulses over the decades resulted in insufficiency in calories and imbalance in nutritional supply. The per capita availability of pulses decreased from 60.7 g in 1951 to 35.9 g in 2000 as against the ICMR recommended pulses intake of 50 g/capita/day (In recent years, there has been understandable concern about decline in the per capita availability of pulses. An important reason is the replacement of pulse crops with high yielding variety of cereals during the main seasons of *Kharif* and *Rabi*. (*Chaturvedi and Masood Ali, 2002).* Black gram (*Vignamungo*) is one of the world's important pulse crop. It is the principle pulse crop in India about 19.40 % in Madhya Pradesh followed by 17.88 % Uttar Pradesh. Black gram is a crop which can grow in any type of soil having low pH and high pH, acidic and alkaline /sodic soil. Black gram does not required high fertile soil for their growth and development (nodule formation, chlorophyll content, plant height, trifoliate and grain filling). Sulphur is recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium in all the crops in general oilseeds and pulses, particular but importance of sulphur application has not so for fully relished by farmers. Unfortunately, degree and spread of sulphur deficiency in Indian soil are gradually increasing. In 1990, 130 districts of Indian soils were being found deficient in sulphur whereas after a decade due to ignorance, situation had further became aggregated. Therefore, another 70 districts, sulphur deficient added in this list (Tondan and Massick, 2000). Sulphur sources viz., gypsum, elemental sulphur and ammonium sulphate were tried at different levels viz., 0, 20 and 40 kg S ha^{-1} in this study. Among various sulphur fertilizers, gypsum, elemental sulphur and ammonium sulphur are well known sulphur fertilizers. Gypsum is cost effective, mine origine source of sulphur in India and more than 90% of which contributed by Rajsthan. Significance of sulphur application and its sources has already been established and sulphur may be one option for enhancing the black gram yield. The Shekhar-3 variety of black gram was developed by Indian Institute of Pulses Research Kalyanpur, Kanpur UP. The highly protein containing, it is a branched, 35-40 cm in height variety with 90 days to maturity which makes it tolerant of lodging. In addition, it has intermediate protein content and an alkali spreading value with high pod recovery. Because of its maturity is (90 days). Shekhar-3 height-40-45 cm, maturity-85-90 days, resistant to wilt disease, pod borer, pod length- 7-8 cm, number of grains per pod- 6-7,

seed shape- round, colour- black yield- 12-15 q/ha grain etc.

Material and Method

The experiment was conducted on the Agricultural Research Farm, Rajiv Gandhi South Campus, Banaras Hindu University Barkachha Mirzapur during *Kharif* seasons 2017. Sulphur sources viz., gypsum *viz*. 0, 20, 40, 60 kg S ha^{-1} and same doses of elemental sulphur and Ammonium sulphate were applied. The experiments consisted of 12 treatments and were laid out in factorial randomized block design with three replications. The total number of plats was36. Data was taken three growth stages such as 30 DAS, 60 DAS and at the time of harvesting. The plant height was measured from ground level to the tip of terminal leaf at harvest and recorded in cm. The numbers of branches were counted and the mean number of branches $plant^{-1}$ was recorded at 45 DAS. Each plot was recorded observation and expressed in kg ha^{-1}. In this experiment the treatment sources were applied at the time of sowing as basal dressing and also the recommended dose of N, P and K were applied. In data observation the different growth parameter such as plant height, number of branches, number of $leaves^{-1}$, root $nodules^{-1}$, root volume and root $weight^{-1}$ were recorded at three times such as 30 DAS, 60 DAS & at the time harvest and yield parameter such as pod length, number of pod per plant, number of seed per pod at time of harvesting as manually as same stage.

Table 1: Effect of doses and sources of sulphur on plant height and number of trifoliate leaf $plant^{-1}$ of black gram in different stages of growth

Treatment	Plant height (cm)			No. of Trifoliate leaf $Plant^{-1}$		
Sulphur Sources	**30 Das**	**60 Das**	**At Harvested**	**30 Das**	**60 Das**	**At Harvested**
GY	23.3	33.84	36.29	6.22	18.31	30.20
AS	24.8	34.14	34.38	5.65	17.93	33.61
ES	22.8	32.00	34.65	5.97	17.75	33.00
SEm	5.54	5.54	5.54	5.54	5.54	5.54
CD(P=0.05)	16.20	16.20	16.20	16.20	16.20	16.20
Sulphur L						
0 kg	22.5	35.68	35.61	5.80	18.27	31.34
20kg	24.0	32.57	35.02	5.73	18.36	31.47
40kg	24.1	32.89	35.92	6.20	17.90	33.14
60kg	23.8	32.16	33.89	6.05	17.46	33.12
SEm	4.80	4.80	4.80	4.80	4.80	4.80
CD(P=0.05)	14.03	14.03	14.03	14.03	14.03	14.03

Table 2: Effect of doses and sources of sulphur on black gram in different stages of plant on number of brances $plant^{-1}$ and root nodule $plant^{-1}$.

	No. of braches plant $^{-1}$			Root Nodules $Plant^{-1}$	
Sulphur Sources	**30 Das**	**60 Das**	**At Harvested**	**30 Das**	**60 Das**
GY	5.53	9.08	15.55	4.92	9.22
AS	5.13	8.60	15.96	5.70	9.71
ES	4.83	8.89	17.31	5.33	9.62
SEm	5.54	5.54	5.54	5.54	5.54
CD(P=0.05)	16.20	16.20	16.20	16.20	16.20
Sulphur L					
0 kg	5.10	8.04	15.70	5.10	9.82
20kg	5.02	9.12	15.91	5.43	9.06
40kg	5.63	8.98	16.55	5.57	9.54
60kg	4.91	9.28	16.93	5.16	9.65
SEm	4.80	4.80	4.80	4.80	4.80
CD(P=0.05)	14.03	14.03	14.03	14.03	14.03

Table 3: Effect of sulphur sources and levels on the yield and yield attributes of black gram

Sulphur Sources	No. of pod $plant^{-1}$	Pod length $plant^{-1}$ (cm)	Grains count (No./pod)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
GY	16.4	7.0	9.3	9.2	23.9
AS	18.9	7.6	10.1	10.3	26.2
ES	19.2	7.9	10.3	10.5	26.4
SEm	0.13	0.11	0.08	0.07	0.10
CD(P=0.05)	0.37	0.32	0.23	0.21	0.28
Sulphur L					
0 kg	12.3	5.2	7.6	8.1	21.4
20kg	14.7	6.6	8.7	8.7	22.8
40kg	19.8	8.4	10.6	10.8	26.7
60kg	20.4	10.6	11.4	12.3	26.3
SEm	0.17	0.14	0.10	0.10	0.13
CD(P=0.05)	0.52	0.41	0.31	0.29	0.37

Table 4: Interaction effect of doses and sources of sulphur on plant hight of black gram

Treatment	Plant Height (cm) 30 Das				Plant Height (cm) 60 Das				Plant Height (cm) at Harvest			
	GY	AS	ES	Avg	GY	AS	ES	Avg	GY	AS	ES	Avg
0	21.4	23.1	23.1	22.5	34.7	35.3	37.0	35.7	37.0	34.0	35.8	35.6
20	25.5	24.6	22.0	24.0	33.7	34.1	29.9	32.6	35.8	33.9	35.3	35.0
40	23.7	25.4	23.3	24.1	34.7	34.4	29.6	32.9	36.6	36.4	34.7	35.9
60	22.5	25.9	22.8	23.8	32.3	32.7	31.5	32.2	35.7	33.2	32.7	33.9
Mean	23.3	24.8	22.8	23.6	33.8	34.1	32.0	33.3	36.3	34.4	34.7	35.1
SEm	2.77				2.8				2.77			
CD(5%)	8.10				8.1				8.10			
S X L	SIG				SIG				SIG			

Table 5: Interaction effect of doses and sources of sulphur on number of branches plant^{-1} of black gram

Treatment	NO. of Braches/plant 30 Das				NO. of Braches/plant 60 Das				NO. of Braches/ Harvesting			
	GY	AS	ES	Avg	GY	AS	ES	Avg	GY	AS	ES	Avg
0	4.7	5.8	4.8	5.1	8.0	7.3	8.8	8.0	15.1	15.3	16.7	15.7
20	5.5	4.9	4.6	5.0	9.5	9.2	8.6	9.1	15.7	15.2	16.8	15.9
40	6.3	4.6	6.0	5.6	8.9	8.8	9.2	9.0	15.3	16.0	18.4	16.5
60	5.6	5.2	3.9	4.9	9.9	9.0	8.9	9.3	16.1	17.4	17.3	16.9
Mean	5.5	5.1	4.8	5.2	9.1	8.6	8.9	8.9	15.5	16.0	17.3	16.3
SEm	2.77				2.77				2.76			
CD	8.10				8.10				8.11			
S X L	SIG				SIG				SIG			

Table 6: Interaction effect of doses and sources of sulphur on number of trifoliate leaves plant^{-1} of black gram

Treatment	No. of Trifoliate leaf 30 Das				No. of Trifoliate leaf 60 Das				No. of Trifoliate leaf Harvesting			
L X S	GY	AS	ES	Avg	GY	AS	ES	Avg	GY	AS	ES	Mean
0	6.2	5.6	5.7	5.8	18.7	17.6	18.5	18.3	29.3	33.8	30.9	31.3
20	5.8	5.5	6.0	5.7	17.8	19.1	18.1	18.4	27.8	32.6	34.0	31.5
40	6.8	6.0	5.8	6.2	18.9	17.5	17.3	17.9	32.8	33.5	33.1	33.1
60	6.1	5.5	6.5	6.1	17.8	17.5	17.0	17.5	30.9	34.5	33.9	33.1
Mean	6.2	5.7	6.0	5.9	18.3	17.9	17.8	18.0	30.2	33.6	33.0	32.3
SEm	2.77				2.77				2.77			
CD	8.10				8.10				8.10			
S X L	SIG				SIG				SIG			

Table 7: Interaction effect of doses and sources of sulphur on yield attributes of black gram

Treatment	No. of pod plant^{-1}			Pod length plant^{-1} (cm)			Grains count (No.pod^{-1})		
	GY	AS	ES	GY	AS	ES	GY	AS	ES
0	14.3	14.7	15.0	6.2	6.7	6.8	8.5	9.7	9.2
20	17.7	20.7	21.0	7.5	8.6	8.9	9.6	10.7	10.3
40	17.3	20.2	20.5	7.3	7.8	8.2	9.3	10.2	10.4
60	18.4	20.5	21.8	7.4	7.9	8.9	9.4	10.6	10.9
SEm	0.09			0.08			0.09		
CD	0.27			0.23			0.25		
S X L	SIG			SIG			SIG		

Table 8: Interaction effect of doses and sources of sulphur on yield of black gram.

Treatment	Straw yield (q ha-^{1})			Grain yield (q ha-^{1})		
	GY	AS	ES	GY	AS	ES
0	22.53	22.87	23.07	8.3	8.7	9.0
20	24.60	27.57	27.87	9.8	11.2	11.5
40	24.40	27.20	27.40	9.4	10.8	10.9
60	23.84	25.88	26.11	9.1	10.2	10.4
SEm	0.07			0.05		
CD	0.21			0.15		
S X L	SIG			SIG		

GY= Gypsum, AS=Ammonium sulphate, ES= Elemental sulphur

Result and Discussion

Days taken to attain different growth stages of black gram cultivars at different days of sowing have been depicted in table 1. From table 1 it was revealed that days taken to attain maximum plant height 30 days after sowing, 60 days after sowing and at the time of maturity of L_3 doses of nitrogen given significant effect on plant height and remaining doses have no significant effect. Among two doses, L_3 dose of gypsum is superior. Among the sulphur sources days taken to attain maximum plant height (68.76 cm) and remaining sources (AS andBS) are approximately at par. The interaction effect recorded GY and L_3dose is the superior in case of plant height (table 4). From table: 2 it was revealed that days taken to attain maximum number of trifoliate leaf per plant (17

Plant^{-1}) 30 days after sowing (18 Plant^{-1}), 60 days after sowing (20 Plant^{-1}) and at the time of harvesting (17 Plant^{-1}) of L_3 dose of gypsum given significant effect on number of trifoliate leaf plant^{-1} and remaining doses of sulphur sources have no significant effect. Among the sulphur sources days taken to attain maximum number of trifoliate leaf (68 Plant^{-1}) and remaining sources (AS and BS) are approximately at par. The interaction effect recorded GY and L_3 dose is the superior in case number of trifoliate leaf Plant^{-1} (table 3). The interaction effect recorded GY and L_3 is the superior in case of number of trifoliate leaf Plant^{-1} (table 6). From table: 2 it was revealed that days taken to attain maximum number of branches per plant (17 Plant^{-1}) 30 days after sowing (18 Plant^{-1}), 60 days after sowing (20 Plant^{-1}) and at the time of harvesting (17 Plant^{-1}) of L_3 dose of gypsum given significant effect on number of branches plant^{-1} and remaining doses of sulphur sources have no significant effect. Among the sulphur sources days taken to attain maximum number of branches (68 Plant^{-1}) and remaining sources (AS and BS) are approximately at par. The interaction effect recorded GY and L_3 dose is the superior in case number of branches Plant^{-1}(table 2). The interaction effect recorded GY and L_3 is the superior in case of number of branches Plant^{-1}(table 5).From table: 2 it was revealed that days taken to attain maximum number of root nodules per plant (17 Plant^{-1}) 30 days after sowing (18 Plant^{-1}), 60 days after sowing (20 Plant^{-1}) and at the time of harvesting (17 Plant^{-1}) of L_3 dose of gypsum given significant effect on number of root nodules plant^{-1} and remaining doses of sulphur sources have no significant effect. Among the sulphur sources days taken to attain maximum number of root nodules (68 Plant^{-1}) and remaining sources (AS and BS) are approximately at par. The interaction effect recorded GY and L_3 dose is the superior in case number of root nodules Plant^{-1} (table 3).

From table 3, it was revealed that days taken to attain maximum number of pod plant^{-1}(20 pod plant^{-1}), 30 days after sowing (20 pod plant^{-1}), 60 days after sowing (20 pod plant^{-1}) and at the time of harvesting (20 pod plant^{-1}) of L_3 dose of gypsum given significant effect on number of pod plant^{-1} and remaining doses of sulphur sources have no significant effect. Among the sulphur sources days taken to attain maximum number of pod plant^{-1}(pod plant^{-1}) and remaining sources (AS and BS) are approximately at par. The interaction effect recorded GY and L_3 dose is the superior in case number of pod plant^{-1}(table 3). The interaction effect recorded GY and L_3 is the superior in case of number of pod plant^{-1}(table 7). From table:3 it was revealed that days taken to attain maximum pod length pod^{-1} (20 cm pod^{-1}), 30 days after sowing (20 cm pod^{-1}), 60 days after sowing (20 cm pod^{-1}) and at the time of harvesting (20 cm pod^{-1}) of L_3 dose of gypsum given significant effect on pod length pod^{-1} and remaining doses of sulphur sources have no significant effect. Among the sulphur sources days taken to attain maximum number of pod length pod^{-1}(20cm pod^{-1}) and remaining sources (AS and BS) are approximately at par. The interaction effect recorded GY and L_3 dose is the superior in case number of pod length pod^{-1}(table 3). The interaction effect recorded GY and L_3 is the superior in case of number of pod length pod^{-1}(table 7). From table: 3 it was revealed that days taken to attain maximum number of grain pod^{-1} (20cm pod^{-1}), 30 days after sowing (20 cm pod^{-1}), 60 days after sowing (20 cm pod^{-1}) and at the time of harvesting (20 cm pod^{-1}) of L_3 dose of gypsum given significant effect on number of grain pod^{-1}pod^{-1} and remaining doses of sulphur sources have no significant effect. Among the sulphur sources days taken to attain number of grain pod^{-1}(20cm pod^{-1}) and remaining sources (AS and BS) are approximately at par. The interaction effect recorded GY and L_3 dose is the superior in case number of grain pod^{-} (table3). The interaction effect recorded GY and L_3 is the superior in case of number of grain pod^{-1}(table 7) and same trends in grain yield and straw yield recorded superior (table: 8).

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