

Original Research Article

Effect of soil application and foliar spray of sulphur nutrition on growth and yield of Black gram (*Vigna mungo* L.)

Abstract

Aim: To study the effect of sulphur nutrition on soil application and foliar spray of black gram cultivation.

Study design: The Factorial Randomized Block Design (**FRBD**) was used. The treatments of soil application of sulphur viz., No basal, Gypsum @ 25 kg ha⁻¹, SOB @ 2 kg ha⁻¹ as basal and foliar spray viz., No spray, pulse wonder @ 5 kg ha⁻¹ on 30 DAS, K₂SO₄ @ 1% on 45 DAS, pulse wonder @ 5 kg ha⁻¹ on 30 DAS + K₂SO₄ @ 1% on 45 DAS **were used**.

Place and Duration of Study: This research trail was conducted during the Winter season (February – May) of 2022 at ICAR-Krishi Vigyan Kendra, Sirugamani, Trichy, Tamil Nadu, India.

Methodology: The study consisted of ~~combination of~~ 12 combination of treatments in FRBD which was replicated thrice. The black gram (~~var. iety of~~ Vamban 8) was used for this study. The observations **were** recorded during the different phases of growth at regular intervals.

Results: The experimental results revealed that the interaction effect **of** application of gypsum as basal along with foliar spray of pulse wonder + K₂SO₄ found **to be** superior **and** recorded significantly higher growth, yield and quality parameters viz., plant height, number of branches plant⁻¹, dry matter accumulation, SPAD value at 20 DAS, 40 DAS and 60 DAS number of pods plant⁻¹, number of seed pod⁻¹, pod length, pod weight and sulphur content in seed. Gypsum as basal application along with foliar spray of pulse wonder + K₂SO₄ ~~could~~ proved **to be** the best and increased ~~to the~~ grain ~~of the~~ yield of 30% over the no basal application and no foliar spray. Thus application of gypsum @ 25 kg ha⁻¹ as basal and foliar spray of pulse wonder @ 5 kg ha⁻¹ on 30 **DAS** + K₂SO₄ @ 1% on 45 DAS could be recommended for improving the productivity of black gram.

Keywords: Gypsum, Sulphur Oxidizing Bacteria (SOB), **TNAU** pulse wonder, Potassium sulphate (K₂SO₄) and Black gram (**Var. Vamban 8**)

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1. Introduction

In India, pulses have generally known as the only source of protein for the underprivileged (Prajapati *et al.*, 2013). They play a vital part in ensuring that people's diets have a well-balanced protein component. Worldwide, India is the largest importer of pulses, accounting for 34% of the world's food use and the foremost country for pulse cultivation, contributing 25% to global supply and 27% to consumption, respectively. Indian Council of Medical Research (ICMR) recommends 47.9 g of pulses per person per day in 2020 as in contrast to the World Health Organization (WHO) standard of 80 g per day. This represents a decrease in the availability of pulses per person from 60 g in 1951 to 2020. (How 60 g ??) (Also include the reference of this data here.

Black gram (*Vigna mungo*) is among India's most extensively grown pulse crops. In southern states like Tamil Nadu, Andhra Pradesh and Karnataka black gram is mostly grown and relished. It is a significant crop due to the many advantages, including enhancing soil fertility through biological nitrogen fixation and serving as vital sources of protein. A suitable fertilization schedule is necessary to increase black gram productivity. Inadequate nutrient delivery has a detrimental effect on the production of black gram, health of the soil and even farmer profits. Considering that black gram has a shorter growth season than other pulses, it needs more calcium, magnesium and sulphur out of these 16 essential components (Lakshmi *et al.*, 2017). Sulphur is the second-most essential nutrient for pulses after phosphorus. Nowadays, it is well acknowledged that, in addition to primary nutrients, secondary nutrient in particular, sulphur plays a significant role in enhancing pulse productivity (Girish, 2015). The International Plant Nutrition Institute has stated that there is a nutrient crisis in Indian soils and has also determined that without nutrient recycling, "Indian agriculture's nutrient balance sheet is likely to remain negative." Additionally, the persistent degradation of physical, chemical, and biological qualities (of soil ??) encouraged secondary and micronutrient shortages, which precludes farmers from introducing pulse crops even in typical pulse producing tracts. The majority of soils worldwide are currently deficient in sulfur because of several causes, such as the use of sulphur-free fertilizer, intensive farming using high-yielding cultivars and extremely low sulphur returns with organic manures (Jamal *et al.*, 2010).

Black gram production is aided by sulphur treatment, which also promotes grain quality. As a component of the amino acids cystein, cysteine and methionine, sulphur has a significant impact on the synthesis of proteins by pulses. Sulphur fertilizer interacts with other fertilizer constituents to promote nutrient uptake, particularly nitrogen and to enhance fertilizer efficiency while also enhancing crop quality and yield (Tandon and Messick, 2007). In leguminous plants, it (Sulphur ?) also facilitates nodulation and nitrogen fixation. Application of sulphur at different stages of crop growth improves the concentration as well as total uptake of nitrogen, phosphorus, potassium,

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calcium, sulphur, zinc and boron (Patil *et al.*, 2011). Hence, it is not necessary to apply sulphur every season. In order to maximize the production of black gram, it is necessary to maximize the availability of sulphur in the suitable amounts, at the appropriate times and in the appropriate proportions. Keeping in view the importance of sulphur nutrition, an investigation has been carried out to assess the effects of sulphur for higher growth and yield in black gram.

2. Materials and Methods

A field trial was carried out to examine the effects of sulphur nutrition on the yield and quality of black gram (*Vigna mungo* L. **var. Vamban 8**) during Winter season of 2022 (Feb-May) at the ICAR-Krishi Vigyan Kendra in Sirugamani, Trichy. It is placed in the Cauvery Delta Zone of the state of Tamil Nadu at 10°45' N latitude and 78°36' E longitude at an elevation of 85 meters above mean sea level and it receives a mean annual rainfall of 818 mm. ~~that is very well dispersed.~~ During the time when the crop was being produced **a maximum** temperatures ~~as maximum as of~~ 36.3°C and ~~as a minimum temperature of as~~ 23.0°C were ~~recorded~~ **measured**. Before laying out the experiment, composite soil samples from 0 to 30 cm depth were taken from the location and examined for a series of physical and chemical characteristics. The textural class of soil was silty clay loam and initial soil status was pH 7.22, **EC** (1.63 dSm⁻¹), low in organic carbon (0.18 %), available nitrogen (87 kg ha⁻¹), available phosphorus (7.8 kg ha⁻¹), medium in available potassium (165 kg ha⁻¹) and low in available sulphur (4.7 kg ha⁻¹).

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The treatments comprised three levels of soil application of sulphur (No basal, Gypsum @ 25 kg ha⁻¹, SOB @ 2 kg ha⁻¹) and four levels of foliar spray (No spray, pulse wonder @ 5 kg ha⁻¹ **on 30 DAS**, K₂SO₄ @ 1% **on 45 DAS**, pulse wonder @ 5 kg ha⁻¹ on 30 DAS + K₂SO₄ @ 1% on 45 DAS) thereby, making twelve treatment combinations. The experiment consisted of three replications with a factorial randomized block design which was performed by using the **VBN** (Bg) 8 variety. NPK ha⁻¹ was given in the prescribed dose of 25:50:25. When the seeds were sown, the fertilizers were evenly distributed to each plot. Gypsum and SOB were applied as a basal soil treatment at the time of sowing. On 30 and 45 DAS, according to the treatment plan, TNAU Pulse Wonder and potassium sulphate were supplied by a foliar spray.

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The data was collected at three different phases of growth, comprising 20 DAS, 40 DAS and 60 DAS. The measurements of growth characteristics, such as plant height, branch count plant⁻¹ and dry matter accumulation (kg ha⁻¹) ~~and along with~~ physiological parameter of **SPAD value** were undertaken. The yield characteristics of grain and haulm yield (kg ha⁻¹), number of pod plant⁻¹, number of seed pod⁻¹, pod length and pod weight **were taken into account**. According to the methodology outlined by Gomez and Gomez (1984), the crop data that were observed were statistically examined **(by which test?? Give the name of statistical test employed here like**

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ANOVA, Chi square or critical difference CD?? And at what level of significance). Where the treatments were significant, critical differences were calculated at a 5% probability level. Non-significant treatment differences were indicated by NS (**In Table Number?? Mention here**).

3. Results and Discussion

3.1. Growth and physiological parameters

Application of sulphur to the soil and foliar spray has a substantial impact on the growth parameters and physiological parameter of black gram. The observation on growth character and physiological parameter was taken on 20 DAS, 40 DAS and 60 DAS (Table 1). The results revealed ~~that~~ the taller plant height (28.2 cm) and ~~better~~ SPAD value (40.6) ~~was significantly recorded~~ under application of gypsum as basal ~~which was~~ followed by SOB. Among the foliar spray, pulse wonder + K₂SO₄ attained a maximum number of branches plant⁻¹ (5.63) and dry matter accumulation (1688 kg ha⁻¹) over the no spray. Similarly in interaction ~~the~~ a maximum of plant height (22.4 cm, 33.6 cm and 41.9 cm), number of branches plant⁻¹ (4.5, 6.2 and 8.8), dry matter accumulation (850 kg ha⁻¹, 1925 kg ha⁻¹ and 2845 kg ha⁻¹) and SPAD meter (44.6, 48.7 and 44.5) **as observed on 20 DAS, 40 DAS and 60 DAS respectively** could be proved from plot receiving soil application of gypsum and foliar spray of pulse wonder + K₂SO₄ respectively, while minimum of growth and physiological parameter were recorded from a plot receiving no basal and no spray (Table 1a-1e). However, it was on par with soil application of gypsum + foliar spray of K₂SO₄ and soil application of SOB + foliar spray of pulse wonder.

The plant height and number of branches plant⁻¹ could be more ~~in-number~~ because of the established role that sulphur plays in promoting cell division, the process of photosynthesis, and the creation of chlorophyll. Similar findings were reported by Mir *et al.*, (2013) and Sivakumar *et al.*, (2018). It also encourages the development of the plant's root nodules, which make more sulphur available during the vegetative growth cycle. These findings were well supported by the work of Yadav (2004) and Srivastava *et al.*, (2006).

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Sulphur also determines the quantity of dry matter in black gram by facilitating the development of chloroplast protein, which increases photosynthetic efficiency and consequently, increases dry matter production per plant. ~~and also~~ Nitrogen helps to maintain increased auxin levels, which accounts for the considerable rise in dry matter accumulation. The findings in the present study are in conformity with Sangeetha *et al.*, (2010) and Meshram *et al.*, (2015). Sulphur nutrient intake was facilitated, which enhanced the photosynthesis due to an increase in chlorophyll content and promoted plant growth and other determined characteristics of black gram. The result had concurrence with findings of Brahim *et al.*, (2017) and Jaiswal *et al.*, (2019).

3.2. Yield attributes and Quality

Significantly higher number of pods plant⁻¹ (39.1), seeds pod⁻¹ (6.60), pod length (5.58 cm), pod weight (0.59 g) and sulphur content in seeds (0.21%) were registered under soil application of gypsum followed by SOB application (Table 2). Foliar spray of pulse wonder + K₂SO₄ registered significantly higher number of pods plant⁻¹ (40.8), seeds pod⁻¹ (6.85), pod length (5.79 cm), pod weight (0.62 g) and sulphur content in seeds (0.22%) compared to other applications (Table 2). The interaction between sulphur nutrition of soil application and foliar spray differed significantly and highest number of pods plant⁻¹ (46.2), seeds pod⁻¹ (7.58), pod length (6.49 cm), pod weight (0.69 g) and sulphur content in seeds (0.24%) **was** found superior under soil application of gypsum and foliar spray of pulse wonder + K₂SO₄ (Table 2b). The latter treatment was on par with number of pods plant⁻¹ (40.8), seeds pod⁻¹ (12.4), pod length (8.0 cm), pod weight (**give Value??**) and sulphur content in seeds (0.21%) on soil application of gypsum + foliar spray of K₂SO₄ and soil application of SOB + foliar spray of pulse wonder (Table 2a).

This might be due to more availability of sulphur in both vegetative and reproductive stages. The importance of sulphur in vegetative structures and strong sink strength through the development of reproductive structures and the synthesis of assimilates, activation of enzymes to fill economically significant sinks was the reason for its influence on yield attributes. Higher sulphur content in grain with fertilizer application may result from greater nutrient uptake as the amount of nutrients in the soil increased. Similar outcomes were found by Singh and Yadav (2004), Dey *et al.*, (2021) and Jamal *et al.*, (2005).

3.3 Yield

The higher grain yield (848 kg ha⁻¹) and haulm yield (1821 kg ha⁻¹) were obtained in soil application of gypsum followed by SOB application. Lower grain (627 kg ha⁻¹) and haulm yield (1358 kg ha⁻¹) **were** registered under no basal (Table 3). Among the foliar spray, pulse wonder + K₂SO₄ recorded significantly higher grain yield (878 kg ha⁻¹) and haulm yield (1796 kg ha⁻¹) compared to no spray (Table 3). The interaction of sulphur nutrition on soil and foliar spray revealed that gypsum and pulse wonder + K₂SO₄ recorded significantly higher grain (971 kg ha⁻¹) and haulm yield (1902 kg ha⁻¹). Soil application of gypsum + foliar spray of K₂SO₄ recorded grain (792 kg ha⁻¹) and haulm yield (1762 kg ha⁻¹) and was on par with soil application of SOB + foliar spray of pulse wonder (Table 3a). **In the The** higher seed yield was observed in combined application of sulphur nutrition on soil and foliar spray which was significantly 30% superior over control.

Sulphur sources may have been used to distribute S, which may have enhanced yield characteristics and total biomass, leading to an increase in seed yield. These findings were well supported by the work of Gosh and Joseph (2008), Geetha *et al.*, (2005) and Tripathi *et al.*, (2012). Straw yield was raised by sulphur increased availability, better nutritional environment, higher

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accumulation of dry matter, and related effects on growth parameters. These findings are in accordance with those of Sandeep and Singh (2009), Muniyasamy *et al.*, (2018) and Maleki *et al.*, (2018).

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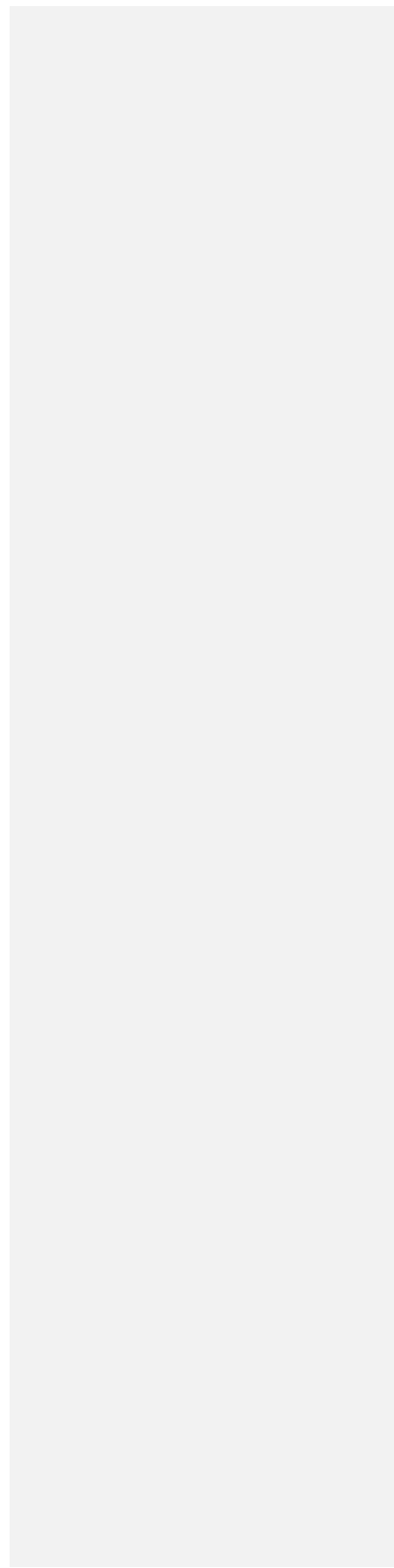


Table 1: Effect of soil application and foliar spray of sulphur nutrients on growth and physiological parameters of black gram

Treatments	Plant Height (cm)				No. of branches plant ⁻¹				DMP (kg ha ⁻¹)				SPAD value			
	20 DAS	40 DAS	60 DAS	Mean	20 DAS	40 DAS	60 DAS	Mean	20 DAS	40 DAS	60 DAS	Mean	20 DAS	40 DAS	60 DAS	Mean
No Basal	11.3	20.3	26.0	19.2	2.1	3	4.1	3.07	602	1173	1706	1160	28.3	30.2	28.3	28.9
Gypsum	18.5	29.3	36.8	28.2	3.7	5.2	7.2	5.37	763	1688	2464	1638	39.8	42.4	39.7	40.6
SOB	17.3	27.3	34.9	26.5	3.4	4.8	6.6	4.93	724	1558	2316	1532	36.8	39.5	36.8	37.7
SEd	0.35	0.57	0.82		0.07	0.12	0.17		22	31	43		0.56	0.66	0.46	
CD (P=0.05)	0.73	1.19	1.72		0.15	0.24	0.35		45	65	90		1.18	1.38	0.95	
Foliar Spray																
No Spray	11.8	20.9	26.7	19.8	2.2	3.2	4.3	3.23	604	1202	1751	1186	28.9	30.8	28.9	29.5
Pulse Wonder	16.6	26	33.7	25.4	3.2	4.5	6.2	4.63	714	1509	2212	1478	35.9	38.4	35.9	36.7
K ₂ SO ₄	14.8	25.5	32.1	24.1	2.9	4.2	5.8	4.3	683	1448	2135	1422	34.5	36.4	34.5	35.1
Pulse Wonder + K ₂ SO ₄	19.6	30.3	37.8	29.2	3.9	5.4	7.6	5.63	782	1732	2550	1688	40.4	44	40.4	41.6
SEd	0.41	0.66	0.96		0.08	0.13	0.19		25	36	50		0.66	0.77	0.53	
CD (P=0.05)	0.85	1.37	1.98		0.17	0.28	0.4		52	75	104		1.36	1.6	1.1	

Table 1a: Interaction effect of soil application and foliar spray of sulphur nutrients on plant height (cm) of black gram

Treatment	20 DAS					40 DAS					60 DAS				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
S ₁	8.7	11.3	10	15.3	11.3	17.1	20.4	18.7	25.1	20.3	22.9	26.2	23.3	31.4	26
S ₂	14	19.7	17.9	22.4	18.5	23.5	29.3	30.9	33.6	29.3	29.5	38.5	37.4	41.9	36.8
S ₃	12.7	18.8	16.6	21.1	17.3	22	28.4	26.8	32.1	27.3	27.5	36.4	35.6	40	34.9
Mean	11.8	16.6	14.8	19.6	15.7	20.9	26	25.5	30.3	25.7	26.7	33.7	32.1	37.8	32.6
SEd	0.71					1.15					1.66				
CD (P=0.05)	1.47					2.38					3.44				

Table 1b: Interaction effect of soil application and foliar spray of sulphur nutrients on number of branches plant⁻¹ of black gram

Treatment	20 DAS					40 DAS					60 DAS				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
S ₁	1.4	2.1	1.7	3.1	2.1	2.2	3	2.6	4.3	3	3	4	3.5	5.8	4.1
S ₂	2.8	3.9	3.7	4.5	3.7	3.9	5.4	5.3	6.2	5.2	5.2	7.6	7.3	8.8	7.2
S ₃	2.5	3.6	3.4	4.2	3.4	3.4	5.1	4.7	5.8	4.8	4.8	7	6.4	8.2	6.6
Mean	2.2	3.2	2.9	3.9	3.1	3.2	4.5	4.2	5.4	4.3	4.3	6.2	5.8	7.6	6
SEd	0.15					0.23					0.34				
CD (P=0.05)	0.3					0.48					0.7				

(Include the detail of composition of S1, S2, S3 and F1, F2, F3 and F4 here as footnote for the table)

Table 1c: Interaction effect of soil application and foliar spray of sulphur nutrients on dry matter production of black gram

Treatment	20 DAS					40 DAS					60 DAS				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
S ₁	549	600	575	685	602	1101	1168	1082	1432	1173	1465	1699	1568	2091	1706
S ₂	650	785	764	850	763	1338	1746	1741	1925	1688	1960	2581	2472	2845	2464
S ₃	614	759	712	809	724	1256	1613	1522	1840	1558	1828	2356	2365	2714	2316
Mean	604	714	683	782	696	1202	1509	1448	1732	1473	1751	2212	2135	2550	2162
SEd	44					60					87				
CD (P=0.05)	NS					130					180				

Table 1d: Interaction effect of soil application and foliar spray of sulphur nutrients on SPAD meter reading of black gram

Treatment	20 DAS					40 DAS					60 DAS				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
S ₁	24.2	27.6	27.1	34.4	28.3	26.1	30.2	28.2	36.4	30.2	24.2	27.6	27.1	34.4	28.3
S ₂	32.5	41.7	40.4	44.6	39.8	34.1	44.3	42.5	48.7	42.4	32.5	41.7	40.4	44.5	39.7
S ₃	30.2	38.6	36.1	42.3	36.8	32.1	40.7	38.4	46.8	39.5	30.2	38.6	36.1	42.3	36.8
Mean	28.9	35.9	34.5	40.4	34.9	30.8	38.4	36.4	44	37.38	28.9	35.9	34.5	40.4	
SEd	1.14					1.33					0.92				
CD (P=0.05)	2.36					2.77					1.91				

Table 2: Effect of soil application and foliar spray of sulphur nutrients on yield attributes and quality of black gram

Treatments	No. of pod plant ⁻¹	No. of seed pod ⁻¹	Pod length (cm)	Pod weight (g)	Sulphur content (%)
Soil Application					
No Basal	24.7	4.29	3.72	0.38	0.15
Gypsum	39.1	6.6	5.58	0.59	0.21
SOB	35.8	6.11	5.17	0.54	0.19
SEd	0.75	0.13	0.08	0.01	0.003
CD (P=0.05)	1.55	0.27	0.17	0.02	0.006
Foliar Spray					
No Spray	25.7	4.42	3.83	0.39	0.15
Pulse Wonder	34.4	5.89	5.01	0.52	0.19
K ₂ SO ₄	32.2	5.51	4.67	0.49	0.18
Pulse Wonder + K ₂ SO ₄	40.8	6.85	5.79	0.62	0.22
SEd	0.86	0.15	0.09	0.01	0.003
CD (P=0.05)	1.79	0.31	0.19	0.03	0.007

Table 2a: Interaction effect of soil application and foliar spray of sulphur nutrients on yield attributes and quality of black gram

Treatments	No. of pod plant ⁻¹	No. of seed pod ⁻¹	Pod length (cm)	Pod weight (g)	Sulphur content (%)
Soil Application					
No Basal	24.7	4.29	3.72	0.38	0.15
Gypsum	39.1	6.6	5.58	0.59	0.21
SOB	35.8	6.11	5.17	0.54	0.19
SEd	0.75	0.13	0.08	0.01	0.003
CD (P=0.05)	1.55	0.27	0.17	0.02	0.006
Foliar Spray					
No Spray	25.7	4.42	3.83	0.39	0.15
Pulse Wonder	34.4	5.89	5.01	0.52	0.19
K ₂ SO ₄	32.2	5.51	4.67	0.49	0.18
Pulse Wonder + K ₂ SO ₄	40.8	6.85	5.79	0.62	0.22
SEd	0.86	0.15	0.09	0.01	0.003
CD (P=0.05)	1.79	0.31	0.19	0.03	0.007

Comment [Ma10]: Table 2 and 2a have same values and exactly same. Check if wrong copied here

Table 3: Effect of soil application and foliar spray of sulphur nutrients on yield of black gram

Treatments	Grain yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Soil Application		
No Basal	627	1358
Gypsum	848	1729
SOB	798	1626
SEd	15.68	29.74
CD (P=0.05)	32.51	61.68
Foliar Spray		
No Spray	633	1357
Pulse Wonder	774	1609
K ₂ SO ₄	746	1522
Pulse Wonder + K ₂ SO ₄	878	1796
SEd	18.10	34.34
CD (P=0.05)	37.54	59.48

Table 3a: Interaction effect of soil application and foliar spray of sulphur nutrients on yield of black gram

Treatments	Grain yield (kg ha ⁻¹)				Haulm yield (kg ha ⁻¹)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
F1	561	693	645	633	1207	1468	1396	1357
F2	612	873	836	774	1345	1785	1698	1609
F3	592	856	789	746	1235	1762	1569	1522
F4	741	971	921	878	1644	1902	1842	1796
Mean	627	848	798	757	1358	1729	1626	1571
SEd	31.35				59.48			
CD (P=0.05)	65.02				123.36			

Figure-1. Effect of soil application and foliar spray of sulphur nutrients on Plant height and DMP of black gram (Give units of DMP and plant height in the graph and heading too)

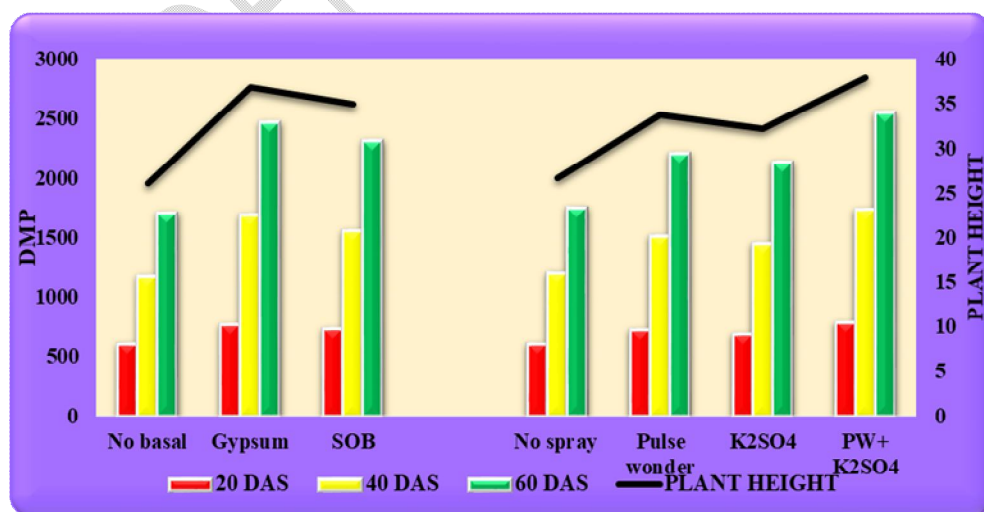
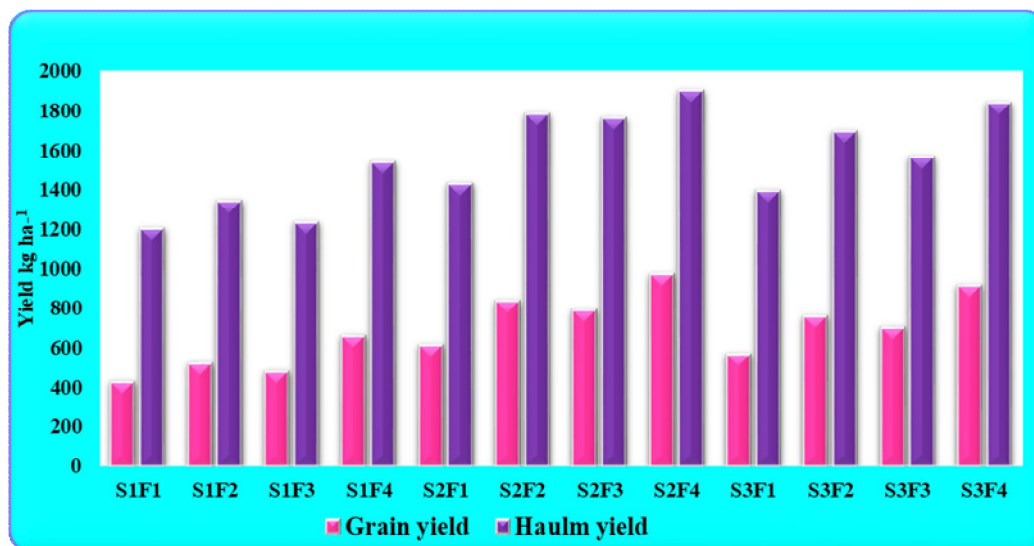


Figure-2. Interaction effect of soil application and foliar spray of sulphur nutrients on yield of black gram



Conclusion

From this study, it has been concluded that soil application of gypsum @ 25 kg ha⁻¹ on basal and foliar spray of pulse wonder @ 5 kg ha⁻¹ on 30 DAS + potassium sulphate at 1% on 45 DAS could be considered as suitable sulphur nutrition and due to persistent release of available S and its increased uptake of S, which finally led to successful assimilation partitioning of photosynthates from source to sink in the post-flowering period and resulted higher growth, seed yield and quality of black gram.

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(All the green highlights are scientific names and need to be put in italics)

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