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 soil application and foliar spray of sulphur nutrient application in growth and development 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, K_2SO_4 @ 1% on 45 DAS, pulse wonder @ 5 kg ha^{-1} on 30 DAS + K_2SO_4 @ 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 12 combination of treatments in FRBD which was replicated thrice. The black gram (Var. 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 + K_2SO_4 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 + K_2SO_4 proved to be the best and increased the grain 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 + K_2SO_4 @ 1% on 45 DAS could be recommended for improving the productivity of black gram.

Keywords: Gypsum, Sulphur Oxidizing Bacteria (SOB), Pulse wonder, Potassium sulphate (K_2SO_4) and Black gram (Var. Vamban 8).

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 in contrast to the World Health Organization (WHO) standard of 80 g per day.

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 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 Cysteine, cystine 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 enhancing crop quality and yield (Tandon and Messick, 2007). In leguminous plants, 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, calcium, sulphur, zinc and boron (Patil *et al.*, 2011). Hence, it is not necessary to apply sulphur every season. In order to increase 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 nutrition 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. During the time when the crop was being produced a maximum temperature of 36.3°C and a minimum temperature of 23.0°C were recorded. 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, Electrical Conductivity (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}).

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, K_2SO_4 @ 1% on 45 DAS, pulse wonder @ 5 kg ha^{-1}on 30 DAS + K_2SO_4 @ 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 Vamban (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.

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}) along with physiological parameter of Soil Plant Analysis Development (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 using analysis of variance (ANOVA). Where the treatments were significant, critical differences were calculated at a 5% probability level. Non-significant treatment differences were indicated by NS (Table 1c).

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 the taller plant height (28.2 cm) and better SPAD value (40.6) under application of gypsum as basal followed by SOB. Among the foliar spray, pulse wonder + K_2SO_4 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 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 could be proved from plot receiving soil application of gypsum and foliar spray of pulse wonder + K_2SO_4 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 K_2SO_4 and soil application of SOB + foliar spray of pulse wonder.

The plant height and number of branches plant^{-1} could be more 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.*, (2021). 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).

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. 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 + K_2SO_4 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 application (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 + K_2SO_4 (Table 2b). The latter treatment was on par with number of pods plant^{-1} (39.3), seeds pod^{-1} (5.59), pod length (8.0 cm), pod weight (0.59) and sulphur content in seeds (0.21%) on soil application of gypsum + foliar spray of K_2SO_4 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 + K_2SO_4 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 + K_2SO_4 recorded significantly higher grain (971 kg ha^{-1}) and haulm yield (1902 kg ha^{-1}). Soil application of gypsum + foliar spray of K_2SO_4 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). 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 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).

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			
Soil Application	**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**	31.9	30.2	28.3	**30.1**
Gypsum	18.5	29.3	36.8	**28.2**	3.7	5.2	7.2	**5.37**	763	1688	2464	**1638**	42.7	41.3	39.7	**41.2**
SOB	17.3	27.3	34.9	**26.5**	3.4	4.8	6.6	**4.93**	724	1558	2316	**1532**	40.3	38.8	36.8	**38.6**
SEd	**0.35**	**0.57**	**0.82**		**0.07**	**0.12**	**0.17**		**22**	**31**	**43**		**0.63**	**0.59**	**0.46**	
CD (P=0.05)	**0.73**	**1.19**	**1.72**		**0.15**	**0.24**	**0.35**		**45**	**65**	**90**		**1.31**	**1.23**	**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**	32.5	30.8	28.9	**30.7**
Pulse Wonder	16.6	26	33.7	**25.4**	3.2	4.5	6.2	**4.63**	714	1509	2212	**1478**	38.9	37.9	35.9	**37.6**
K_2SO4	14.8	25.5	32.1	**24.1**	2.9	4.2	5.8	**4.3**	683	1448	2135	**1422**	37.6	36.1	34.5	**36.1**
Pulse Wonder + K_2SO4	19.6	30.3	37.8	**29.2**	3.9	5.4	7.6	**5.63**	782	1732	2550	**1688**	44.2	42.4	40.4	**42.3**
SEd	**0.41**	**0.66**	**0.96**		**0.08**	**0.13**	**0.19**		**25**	**36**	**50**		**0.72**	**0.68**	**0.53**	
CD (P=0.05)	**0.85**	**1.37**	**1.98**		**0.17**	**0.28**	**0.4**		**52**	**75**	**104**		**1.51**	**1.42**	**1.1**	

*(SOB – Sulphur oxidizing bacteria, DAS – Days After Sowing, DMP – Dry Matter Production, SPAD – Soil Plant Analysis Development, SEd – Standard deviation, CD – Critical difference)

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**				

(Composition: S_1- No basal, S_2- Gypsum, S_3-SOB & F_1- No spray, F_2- Pulse wonder, F_3- K_2SO_4, F_4- Pulse wonder + K_2SO_4)

(Treatment combinations: S_1F_1- No basal + No spray, S_1F_2 - No basal + Foliar spray of Pulse wonder @ 5 kg ha^{-1} on 30 DAS, S_1F_3 - No basal + Foliar spray of K_2SO_4 @ 1% on 45 DAS, S_1F_4 - No basal + Foliar spray of Pulse wonder @ 5 kg ha^{-1} on 30 DAS + Foliar spray of K_2SO_4 @ 1% on 45 DAS, S_2F_1 - Soil application of Gypsum @ 25 kg ha^{-1} + No spray, S_2F_2 - Soil application of Gypsum @ 25 kg ha^{-1} + Foliar spray of Pulse wonder @ 5 kg ha^{-1} on 30 DAS, S_2F_3 - Soil application of Gypsum @ 25 kg ha^{-1} + Foliar spray of K_2SO_4 @ 1% 5 on 45 DAS, S_2F_4 - Soil application of Gypsum @ 25 kg ha^{-1} + Foliar spray of Pulse wonder @ 5 kg ha^{-1} on 30 DAS + Foliar spray of K_2SO_4 @ 1% on 45 DAS, S_3F_1 - Soil application of SOB @ 2 kg ha^{-1} + No spray, S_3F_2 - Soil application of SOB @ 2 kg ha^{-1} + Foliar spray of Pulse wonder @ 5 kg ha^{-1} on 30 DAS, S_3F_3 - Soil application of SOB @ 2 kg ha-1 + Foliar spray of K_2SO_4 @ 1% on 45 DAS, S_3F_4- Soil application of SOB @ 2 kg ha^{-1} + Foliar spray of Pulse wonder @ 5 kg ha^{-1} on 30 DAS + Foliar spray of K_2SO_4 @ 1% on 45 DAS)

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	28.5	31.9	30.2	37.1	**31.9**	26.1	30.2	28.2	36.4	**30.2**	24.2	27.6	27.1	34.4	**28.3**
S_2	35.3	44.3	42.5	48.7	**42.7**	34.1	42.9	41.8	46.3	**41.3**	32.5	41.7	40.4	44.5	**39.7**
S_3	33.5	40.7	40.1	46.8	**40.3**	32.1	40.5	38.4	44.5	**38.8**	30.2	38.6	36.1	42.3	**36.8**
Mean	**32.5**	**38.9**	**37.6**	**44.2**	**38.3**	**30.8**	**37.9**	**36.1**	**42.4**	**36.8**	**28.9**	**35.9**	**34.5**	**40.4**	
SEd	**1.26**					**1.18**					**0.92**				
CD (P=0.05)	**2.62**					**2.46**					**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_2SO4	32.2	5.51	4.67	0.49	0.18
Pulse Wonder + K_2SO4	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 (%)**			
	S1	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	19.7	29.8	27.2	**25.7**	3.45	5.12	4.70	**4.42**	3.04	4.39	4.07	**3.83**	0.30	0.46	0.42	**0.39**	0.13	0.16	0.15	**0.15**
F2	24.6	41.2	37.4	**34.4**	4.29	7.02	6.37	**5.89**	3.73	5.86	5.43	**5.01**	0.38	0.61	0.57	**0.52**	0.15	0.22	0.21	**0.19**
F3	22.1	39.3	35.0	**32.2**	3.87	6.69	5.95	**5.51**	3.38	5.59	5.03	**4.67**	0.34	0.59	0.54	**0.49**	0.14	0.21	0.19	**0.18**
F4	32.4	46.2	43.7	**40.8**	5.54	7.52	7.43	**6.85**	4.71	6.49	6.17	**5.79**	0.50	0.69	0.65	**0.62**	0.18	0.24	0.23	**0.22**
Mean	**24.7**	**39.1**	**35.8**	**33.2**	**4.29**	**6.60**	**6.11**	**5.67**	**3.72**	**5.58**	**5.17**	**4.82**	**0.38**	**0.59**	**0.55**	**0.50**	**0.15**	**0.21**	**0.19**	**0.18**
SEd	**1.49**				**0.26**				**0.16**				**0.02**				**0.006**			
CD (P=0.05)	**3.09**				**0.54**				**0.34**				**0.04**				**0.012**			

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_2SO4	746	1522
Pulse Wonder + K_2SO4	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 (cm) and DMP (kg ha^{-1}) of black gram

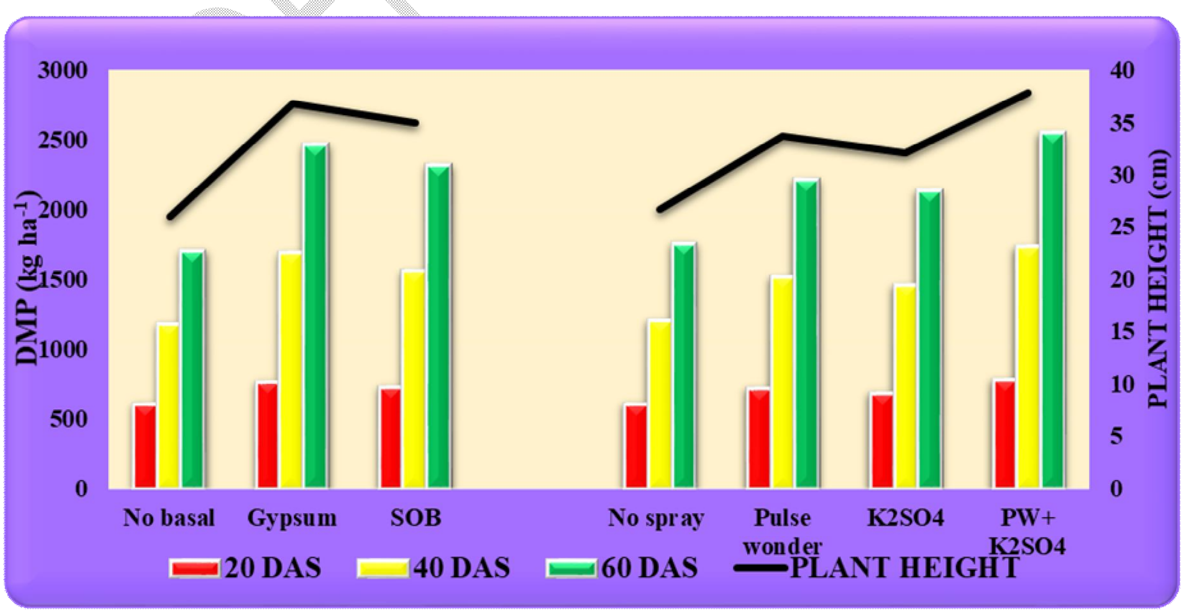
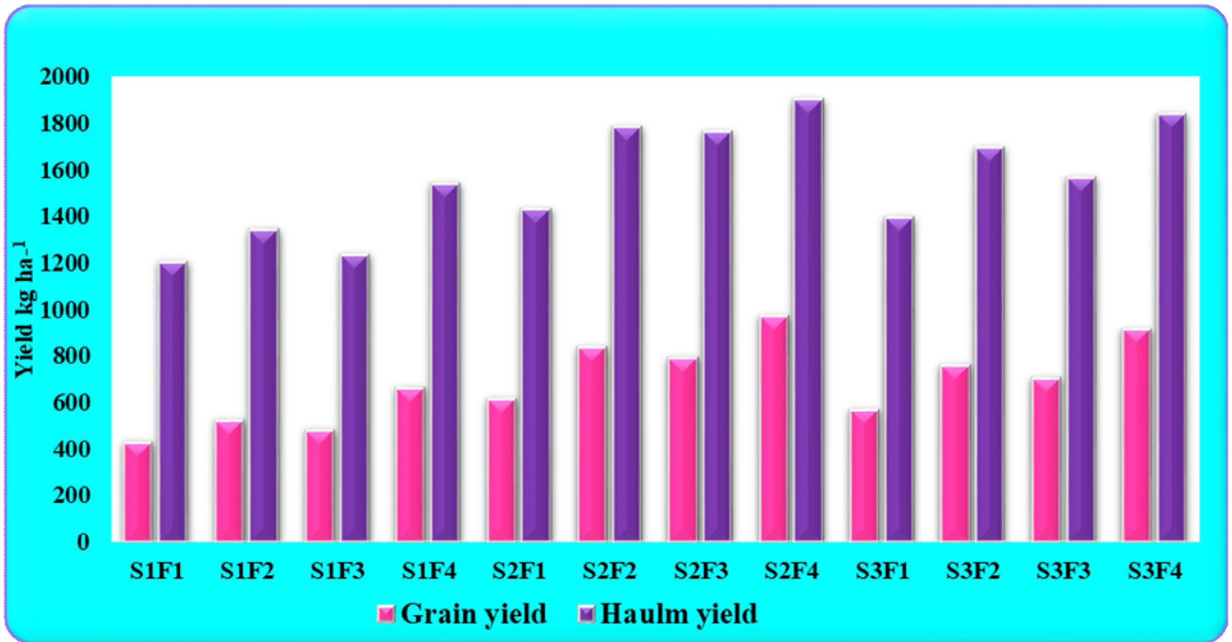


Figure-2. Interaction effect of soil application and foliar spray of sulphur nutrients on yield (kg ha^{-1}) of black gram



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 and soil application of sulphur oxidizing bacteria @ 2 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 increase the grain yield of 30% over the no basal application and no foliar spray. And due to persistent release of available S and its increased uptake 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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