J. Soils and Crops 33 (1) 40-45, June 2023

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

EFFECT OF SULPHUR, ORGANIC MANURES AND BIOFERTILIZERS ON YIELD AND NUTRIENT CONTENT OF SUMMER GREEN GRAM (*Vigna radiata* L.)

N. M. Chaudhari[1], K. H. Patel[2], A. D. Raj[3], S. M. Bambhaneeya[4] and N. H. Garaniya[5]

ABSTRACT

A field experiment was conducted during 2021 to study the effect of sulphur, organic manures and bio-fertilizer on yield and quality of green gram. The result revealed that seed and stover yield of green gram was significantly increased by the sulphur and bio-fertilizer treatments. Application of 40 kg S ha^{-1} (S_3) recorded significantly the highest seed yield (1163.5 kg ha^{-1}) over application of 30 and 20 kg sulphur ha^{-1} (S_2 and S_1). Significantly the highest stover yield of 2334.5 kg ha^{-1} was recorded under the application of 40 kg S ha^{-1} (S_3) followed by 30 kg S ha^{-1} (S_2). Significantly higher seed and stover yield of 1095.1 kg ha^{-1} and 2209.5 kg ha^{-1} was recorded under treatment B_1 (inoculation of PSB + *Rhizobium*) over control (B_0). Application of 40 kg S ha^{-1}and 5 t ha^{-1} FYM along with PSB + *Rhizobium* inoculation was significant on seed yield, stover yield N, P and S content in seed and stover.

(Key words: Sulphur, FYM, vermicompost, PSB, *Rhizobium*, yield, content)

INTRODUCTION

Green gram (*Vigna radiata* L.) occupies prime position among pulses by virtue of its short growth period, high tonnage capacity and outstanding nutrient value as food, feed and forage. Among the pulses, green gram is one of the most important and extensively cultivated pulse crops. In India, green gram occupies an area of about 34.37 lakh hectares with the total production of 17.83 lakh tonnes with an average productivity of 519 kg ha^{-1} and in Gujarat it occupy 0.90 lakh hectares area with production of 0.55 lakh tonnes with an average productivity of 611 kg ha^{-1} in the year 2019-20 (Anonymous., 2020).

Sulphur element is important for crop growth and development especially in pulses. Sulphur is essential for synthesis of proteins, vitamins in pulse crops. Sulphur is also known to enhance the nodulation activity in legumes thus it is increasing the N- fixation. The application of nutrients in combination with organic manure like FYM and vermicompost may serve as a source of nutrients and complexing agents. Phosphorus solubilizing micro-organisms (bacteria and fungi) enable P to become available for plant uptake after solubilization. *Rhizobium* inoculation is a cheapest, easiest and safest way of supplying nitrogen to greengram through well-known symbiotic nitrogen fixation process. Looking into importance of sulphur, organic manures and bio-fertilizer, a field experiment was conducted on effect of sulphur, organic manures and bio-fertilizer on yield and quality of greengram.

MATERIALS AND METHODS

A field experiment was conducted at Soil and Water Management, NARP Phase – II (NARP Farm), Cotton Research Sub Station, N.A.U., Achhalia (South Gujarat Agro Climatic Zone - II) (AES- I) during summer season of 2021 to study the "Effect of sulphur, organic manures and biofertilizers on soil properties, yield and quality of summer green gram (*Vigna radiata* L.)". The soil of the experimental field was clay in texture medium in available nitrogen, medium in phosphorus and high in available potassium. The experiment was laid out in RBD (Factorial concept) design with twelve treatment combinations comprising of all possible treatments of three levels of sulphur *viz*., S_1 (20 kg S ha^{-1}), S_2 (30 kg S ha^{-1}) and S_3 (40 kg S ha^{-1}), two levels of organic manure *viz*., O_1 (5 t FYM ha^{-1}) and O_2 (1 t vermicompost ha^{-1}) and two levels of bio-fertilizer *viz*., B_0 (No inoculation) and B_1 (PSB + *Rhizobium* inoculation) were tested in factorial randomized block design with three replications. Green gram variety GM-6 was sown by opening of furrow at a distance of 30 x 10 cm. The full dose of fertilizers was applied according to the treatments manually before sowing the seeds. Biofertilizer was applied as seed inoculation. The phosphorus was applied as DAP and sulphur was applied as elemental sulphur. All the recommended cultural practices and plant protection measures were followed throughout the experimental periods.

The data on seed and stover yield was recorded from the net plot and converted on a hectare basis. Chemical

1. P.G. Student, Dept. of Soil Science and Agril. Chemistry, COA, NAU, Bharuch - 392 012 (Gujarat)
2. Assoc. Professor, Dept. of Soil Science and Agril. Chemistry, COA, NAU, Bharuch - 392 012 (Gujarat)
3. Professor, Dept. of Agronomy COA, NAU, Bharuch - 392 012 (Gujarat)
4 & 5. Asstt. Professors, Dept. of Soil Science and Agril. Chemistry, COA, NAU, Bharuch - 392 012 (Gujarat)

studies about N, P, K, S, Fe, Mn, Zn and Cu content in seed and stover were determined as per different methods *viz.,* Modified Kjeldahl's method (For N) (Jackson, 1979), Wet digestion (Diacid) Vanado molybdo phosphoric acid yellow colour method (for P), Flame photometric method (for K), Turbidimetric method by Spectrophotometer (for S) and Atomic absorption spectrophotometric method (for Fe, Mn, Zn and Cu). The data were analyzed statistically by adopting the standard procedures described by Panse and Sukhatme (1985). The purpose of the analysis of variance was to determine the significant effect of treatments on green gram.

RESULTS AND DISCUSSION

Effect of sulpur

The seed yield of green gram was significantly influenced by the effect of sulphur. Application of 40 kg S ha^{-1} (S_3) recorded significantly the highest seed yield (1163.5 kg ha^{-1}) over application of 30 and 20 kg sulphur ha^{-1} (S_2 and S_1). However, seed yield recorded under the application of 30 kg S ha^{-1} (S_2) and 20 kg S ha^{-1} (S_1) were at par. The percentage increase in seed yield due to application of 40 kg S ha^{-1} (S_3) over 20 kg S ha^{-1} (S_1) and 30 kg S ha^{-1} (S_2) were 26.36 and 16.61, respectively. In the present investigation significant increase in N, P, K and S content was observed due to sulphur application. Mohini *et al.* (2018) found higher seed yield with the application of 30 kg S ha^{-1} in green gram. Marbaniang *et al.* (2020) also reported higher seed yield with the application of 20 kg S ha^{-1} in mung bean.

Data revealed that stover yield of green gram found significantly influenced by effect of sulphur. Significantly the highest stover yield of 2334.5 kg ha^{-1} was recorded under the application of 40 kg S ha^{-1} (S_3) followed by 30 kg S ha^{-1} (S_2). The magnitude of increase in green gram stover yield was 24.73 % and 15.00 % under the treatment of S_3 (40 kg S ha^{-1}) over S_1 (20 kg S ha^{-1}) and S_2 (30 kg S ha^{-1}), respectively. The results for stover yield have similar trends to those on seed yield. Therefore, reasoning and discussion given for seed yield earlier holds true for stover yield also.

N, P, K and S content in seed and stover yield were significantly influenced by the application of sulphur. N, P, K and S content were observed higher under the application of 30 kg S ha^{-1} in both seed and stover. In the present study sulphur significantly increased availability of N, P, K and S which could have resulted in significant increase in N, P, K and S content in seed and stover. The higher concentration of S in green gram seed and stover might be due to increased availability of S in soil due to sulphur application. These results were similar with the finding of Bera and Gosh (2015) and Patel *et al.* (2018). They found highest nutrient content of N, P, K and S in seed and straw under the application of 40 kg S ha^{-1} in green gram.

All other micro nutrient content (Fe, Mn, Zn and Cu) was not significantly influenced by the application of sulphur.

Effect of organic manure

Seed yield, stover yield and nutrient content *viz.,* N, P, K, S, Fe, Mn, Zn and Cu in seed and stover were found non-significant due to effect of organic manure.

Effect of bio-fertilizer

Data presented in Table 1 revealed that seed yield of green gram found significantly influenced by bio-fertilizer inoculation. Significantly higher seed and stover yield of 1095.1 kg ha^{-1} and 2209.5 kg ha^{-1} was recorded under treatment B_1 (inoculation of PSB + *Rhizobium*) over control (B_0). Percentage increasing in the seed and stover yield under the treatment B_1 (PSB + *Rhizobium* inoculation) over B_0 (control) was 14.10 and 13.43, respectively. This result could be attributed due to PSB solubilized the unavailable form of P leading to more uptake of nutrients and inoculation of seeds with proper strain of *Rhizobium* cultures enhance the N fixation from atmosphere and results in better growth, more active root microbes and consequently enhance proper growth and weight of root nodules in green gram which is reflected in significantly higher N, P, K and S content which resulted in increase in growth and seed yield of green gram. Similar earlier research findings were also reported by Kanwar *et al.* (2013). They reported that dual seed inoculation with PSB + *Rhizobium* gave the highest seed yield (812 kg ha^{-1}) and stover yield (1962 kg ha^{-1}) as compared to control treatment in mung bean.

The N content in seed and stover of green gram was significantly affected by inoculation of bio-fertilizer. Significantly higher N content in seed (3.306 %) and stover (0.865 %) of green gram was recorded with PSB + *Rhizobium* inoculation over control. Inoculation of PSB + *Rhizobium* improves the root system of green gram plant and increases the nodulation in root, so plant can easily fix the N and increase the N uptake resulted in higher N content in stover of green gram. Increased N content in seed (3.96 %) and stover (2.00 %) with dual inoculation with *rhizobium* and PSB were observed in green gram by Rani *et al.* (2016) and Dhakal *et al.* (2016).

The P content in seed and stover of green gram was significantly affected by inoculation of bio-fertilizer. Significantly higher P content in seed (0.674 %) and stover (0.492 %) of green gram was recorded with PSB + *Rhizobium* inoculation over control. Inoculation of PSB + *Rhizobium* increases the availability of P in soil and favoured higher absorption and utilization of Kumavat *et al.* (2009) reported that the higher P content in seed and stover with the application of seed inoculation with PSB. Increased P content in seed (0.483 %) and stover (0.284 %) with dual inoculation with *rhizobium* and PSB were observed in green gram by Dhakal *et al.* (2016).

The data clearly indicated that effect of bio-fertilizer significantly influenced the K content in seed and stover of green gram. Significantly higher K content in seed (1.566 %) and stover (2.656 %) of green gram was recorded with PSB + *Rhizobium* inoculation over control. Inoculation of PSB + *Rhizobium* increases the availability of K in soil and favoured higher absorption and utilization of K. Dhakal *et al.* (2018) reported higher K content in seed (1.534 %) and stover (1.307 %) with the application of PSB+ *Rhizobium* in green gram.

The data presented in Table 1 indicated that effect of bio-fertilizer significantly influenced S content in seed and stover of green gram. Significantly higher S content in seed (0.251 %) and stover (0.193 %) was recorded under PSB + *Rhizobium* (B_1) over control (B_0). These results were similar with the finding of Goswami *et al.* (2020). They found that higher S content in seed (0.276 %) and stover (0.149 %) of green gram with the application of PSB + *Trichoderma*.

Data regarding micro nutrient content (Fe, Mn, Zn and Cu) in seed and stover was not significantly influenced by the application of bio-fertilizer.

Interaction effect

Data presented in Table 3 revealed that the treatment combination of $S_3O_1B_1$ (Application of 40 kg S ha^{-1} and 5 t ha^{-1} FYM along with PSB + *Rhizobium* inoculation) recorded significantly higher seed (1341.7 kg ha^{-1}) and stover yield (2479.6 kg ha^{-1}) as compared to rest of the treatment combinations but it was at par with treatment $S_2O_1B_1$ (Application of 30 kg S ha^{-1} and 5 t ha^{-1} FYM along with PSB + *Rhizobium* inoculation), $S_3O_2B_1$ (Application of 40 kg S ha^{-1} and 1 t ha^{-1} vermicompost along with PSB + *Rhizobium* inoculation) and $S_3O_1B_0$ (Application of 40 kg S ha^{-1} and 5 t ha^{-1} FYM). These results revealed a distinct synergistic interaction between sulphur, organic manures and bio-fertilizer.

Decomposition of organic manures is known to supply numerous chelating agents that aid in maintaining the solubility of nutrients. Chelation can help in increasing the solubility, in exchange and release of ions and slow release of ions to the crop. Sulphur fertilizer application stimulates the cell division, photosynthetic process as well as formation of chlorophyll. It also promotes the root nodules in legumes, which cause more sulphur available during vegetative growth period and development of plant occurs (Kumavat *et al.*, 2014). PSB helps in the solubilization activity of phosphorus which bound with Ca, Fe and Al in the soil and get available to the green gram (Rathour *et al.*, 2015). Inoculation of seeds with proper strain of *Rhizobium* cultures enhance the N fixation from atmosphere and results in better growth, more active root microbes and consequently enhance proper growth and dry weight of root nodules in green gram (Gajera *et al.*, 2014). The concentration of nutrients, particularly of P and N in solution and quantity transported to the root by mass flow and diffusion could have greatly increased through complexation of sulphur fertilizer with organics as a chelating compound and biofertilizers in the soil. Further, significant quantity of different organic acids could have been added by decomposition of organics and as a result availability of these nutrients could have increased. Thus, increase in total seed yield was obtained probably due to these reasons.

N content in seed and stover, P content in seed and stover and S content in seed and stover were significantly influenced by the interaction effect between sulphur, organic manures and biofertilizer.

In the case of N content, treatment combination $S_3O_1B_1$ (Application of 40 kg S ha^{-1} and 5 t ha^{-1} FYM along with PSB + *Rhizobium* inoculation) recorded significantly higher N content in seed (3.603 %) and stover (0.939 %). This result could be attributed due to synergistic effect of sulphur with organic manure and biofertilizers inoculation.

In the case of P content, treatment combination $S_3O_1B_1$ (Application of 40 kg S ha^{-1} and 5 t ha^{-1} FYM along with PSB + *Rhizobium* inoculation) recorded significantly higher P content in seed (0.773 %) and stover (0.539 %). This result could be attributed due to synergistic effect of phosphorus with FYM and PSB inoculation. The result revealed that the synergistic effect of sulphur fertilizer with organic manures and bio-fertilizer increased the P content in seed of green gram.

In the case of S content, treatment combination $S_3O_1B_1$ (Application of 40 kg S ha^{-1}and 5 t ha^{-1} FYM along with PSB + *Rhizobium* inoculation) recorded significantly higher S content in seed (0.281 %) and stover (0.232 %). This result could be attributed due to synergistic effect of sulphur with organic manure and biofertilizers inoculation.

From the results, it can be inferred that green gram (*Var.* GM-6) should be fertilized with S @ 40 kg ha^{-1} and FYM @ 5 t ha^{-1} along with seed inoculation with PSB + *Rhizobium* (each 10 ml kg^{-1} seed) in *summer* season under south Gujarat condition for getting higher yield and maintenance of soil fertility.

Table 1. Yield and macro nutrient content as influenced by sulphur, organic manures and biofertolizers

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	N content (%)		P content (%)		K content (%)		S content (%)	
			Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Sulphur (S)										
S_1 – 20 S kg ha^{-1}	920.8	1871.6	2.968	0.790	0.576	0.436	1.199	2.198	0.219	0.156
S_2 – 30 S kg ha^{-1}	997.8	2030.0	3.078	0.828	0.587	0.455	1.394	2.494	0.234	0.178
S_3 – 40 S kg ha^{-1}	1163.5	2334.5	3.386	0.872	0.701	0.507	1.541	2.711	0.246	0.204
S Em ±	36.1	57.8	0.042	0.010	0.006	0.007	0.019	0.031	0.003	0.003
CD at 5%	105.8	169.6	0.123	0.030	0.019	0.020	0.057	0.090	0.010	0.008
Organic manures (O)										
O_1- FYM 5 t ha^{-1}	1067.1	2118.0	3.178	0.842	0.619	0.469	1.396	2.485	0.230	0.177
O_2- Vermicompost 1 t ha^{-1}	987.7	2039.4	3.110	0.818	0.624	0.463	1.360	2.450	0.236	0.182
S Em ±	29.4	47.2	0.034	0.008	0.005	0.005	0.016	0.025	0.003	0.002
CD at 5%	-	-	-	-	-	-	-	-	-	-
Bio-fertilizer (B)										
B_0 – No inoculation	959.7	1947.9	2.982	0.794	0.569	0.440	1.190	2.279	0.216	0.166
B_1 – PSB + *Rhizobium* inoculation	1095.1	2209.5	3.306	0.865	0.674	0.492	1.566	2.656	0.251	0.193
S Em ±	29.4	47.2	0.034	0.008	0.005	0.005	0.016	0.025	0.003	0.002
CD at 5%	86.4	138.4	0.100	0.025	0.015	0.016	0.047	0.073	0.008	0.006
Interaction										
S × O										
S Em ±	51.0	81.8	0.059	0.014	0.009	0.010	0.027	0.043	0.005	0.004
CD at 5%	-	-	-	-	-	-	-	-	-	-
S × B										
S Em ±	51.0	81.8	0.059	0.014	0.009	0.010	0.027	0.043	0.005	0.004
CD at 5%	-	-	-	-	-	-	-	-	-	-
O × B										
S Em ±	41.6	66.8	0.048	0.012	0.007	0.008	0.022	0.035	0.004	0.003
CD at 5%	-	-	-	-	-	-	-	-	-	-
S x O x B										
S Em ±	72.1	115.6	0.084	0.020	0.013	0.013	0.039	0.061	0.007	0.005
CD at 5%	211.5	339.1	0.246	0.060	0.037	0.040	-	-	0.020	0.016
CV (%)	12.2	9.6	4.62	4.28	3.55	5.01	4.88	4.30	4.94	5.16

Table 2. Micro nutrient content as influenced by sulphur, organic manures and biofertolizers

Treatments	Content in seed (mg kg $^{-1}$)				Content in stover (mg kg $^{-1}$)			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Sulphur (S)								
S_1 – 20 S kg ha^{-1}	53.40	33.72	29.08	6.25	140.7	53.73	25.97	5.32
S_2 – 30 S kg ha^{-1}	53.80	33.95	29.75	6.33	143.1	53.92	26.15	5.35
S_3 – 40 S kg ha^{-1}	54.62	34.73	30.30	6.53	147.0	54.33	26.52	5.47
S Em ±	0.65	0.36	0.41	0.09	2.0	0.60	0.25	0.07
CD at 5%	-	-	-	-	-	-	-	-
Organic manures (O)								
O_1- FYM 5 t ha^{-1}	54.21	34.20	30.00	6.47	144.0	54.13	26.24	5.44
O_2- Vermicompost 1 t ha^{-1}	53.67	34.07	29.42	6.28	143.2	53.86	26.18	5.31
S Em ±	0.53	0.29	0.33	0.07	1.7	0.49	0.21	0.06
CD at 5%	-	-	-	-	-	-	-	-
Bio-fertilizer (B)								
B_0 – No inoculation	53.70	34.02	29.22	6.28	142.7	53.86	26.30	5.47
B_1 – PSB + *Rhizobium* inoculation	54.18	34.24	30.20	6.47	144.5	54.13	26.12	5.29
S Em ±	0.53	0.29	0.33	0.07	1.7	0.49	0.21	0.06
CD at 5%	-	-	-	-	-	-	-	-
Interaction								
S × O								
S Em ±	0.92	0.51	0.58	0.13	2.9	0.85	0.36	0.11
CD at 5%	-	-	-	-	-	-	-	-
S × B								
S Em ±	0.92	0.51	0.58	0.13	2.9	0.85	0.36	0.11
CD at 5%	-	-	-	-	-	-	-	-
O × B								
S Em ±	0.75	0.42	0.47	0.10	2.3	0.69	0.29	0.09
CD at 5%	-	-	-	-	-	-	-	-
S x O x B								
S Em ±	1.31	0.72	0.82	0.18	4.0	1.20	0.51	0.15
CD at 5%	-	-	-	-	-	-	-	-
CV (%)	4.19	3.66	4.76	4.88	4.9	3.83	3.36	4.82

Table 3. Interaction effect between sulphur, organic manures and biofertolizers on seed yield, stover yield and nutrient content of green gram

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	N content (%)		P content (%)		S content (%)	
			Seed	Stover	Seed	Stover	Seed	Stover
$S_1O_1B_0$	961.6	1930.6	3.080	0.821	0.515	0.424	0.197	0.140
$S_1O_1B_1$	889.4	1768.1	2.959	0.778	0.609	0.434	0.230	0.163
$S_1O_2B_0$	827.3	1689.4	2.660	0.720	0.546	0.419	0.205	0.145
$S_1O_2B_1$	1005.1	2098.6	3.173	0.839	0.633	0.467	0.246	0.174
$S_2O_1B_0$	859.3	1724.1	2.688	0.749	0.548	0.400	0.215	0.164
$S_2O_1B_1$	1204.6	2433.3	3.481	0.926	0.640	0.528	0.239	0.182
$S_2O_2B_0$	951.9	1871.8	2.977	0.795	0.502	0.432	0.226	0.172
$S_2O_2B_1$	975.5	2090.7	3.164	0.842	0.659	0.461	0.257	0.196
$S_3O_1B_0$	1145.8	2372.2	3.257	0.836	0.631	0.489	0.219	0.181
$S_3O_1B_1$	1341.7	2479.6	3.603	0.939	0.773	0.539	0.281	0.232
$S_3O_2B_0$	1012.5	2099.5	3.229	0.846	0.672	0.478	0.234	0.193
$S_3O_2B_1$	1154.2	2386.6	3.453	0.865	0.729	0.522	0.251	0.209
SEm±	72.1	115.6	0.084	0.020	0.013	0.013	0.007	0.005
CD at 5%	211.5	339.1	0.246	0.060	0.037	0.040	0.020	0.016

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Rec. on 25.07.2022 & Acc. on 06.08.2022