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Shubhangi R Kadam
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, B A College of Agriculture, Anand Agriculture University, Anand, Gujarat, India

NJ Jadav
Major Research Guide, Professor and Head, Department of Soil Science and Agricultural Chemistry, B A College of Agriculture, Anand Agriculture University, Anand, Gujarat, India

IR Bagwan
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, NM College of Agriculture, Navsari Agriculture University, Navsari, Gujarat, India

Corresponding Author:
Shubhangi R Kadam
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, B A College of Agriculture, Anand Agriculture University, Anand, Gujarat, India

Residual effect of farm yard manure, sulphur and zinc in *rabi* maize on growth, yield and quality of summer greengram

Shubhangi R Kadam, NJ Jadav and IR Bagwan

Abstract
A field experiment was conducted at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during summer seasons of 2019-20 and 2020-21 to evaluate re sidual influence of FYM, sulphur and zinc (applied to preceding maize crop in maize -greengram cropping sequence) on growth, yield and quality of Summer greengram under middle Gujarat condition. The experiment was laid out in a randomized block design with factorial concept, comprising eighteen treatment combinations *i.e.* two levels of FYM (0 and10 t FYM/ha), three levels of sulphur (0, 20 and 40 kg S/ha) and three levels of zinc (0, 2.5 and 5 kg Zn/ha) with three replications. The results revealed that residual effect of 10 t FYM/ha, 40 kg S/ha and 5 kg Zn/ha significantly increased plant height at harvest, seed yield, haulm yields as well as protein content (%) in seed during individual year and in pooled results were significantly influenced by the various levels of FYM, sulphur and zinc. FYM x sulphur interaction was found significant in case of seed and haulm yield during the year 2020, 2021 and pooled mean, sulphur x zinc interaction was found significant in case of protein content in seed during 2021 and pooled. All the parameters were increased with increasing levels of FYM, sulphur and zinc.

Keywords: *Vigna radiata* L., FYM, sulphur, zinc, growth, yield and quality

Introduction

Greengram (*Vigna radiata* L. Wilczek) is one of the most ancient and extensively grown leguminous crops of India. It is a native of India and Central Asia and commonly known as moong, mung, mungo, golden gram. It is the third important pulse crop after chickpea and pigeonpea, cultivated throughout India. It has multiple uses as vegetable, pulse, fodder and green manure crop. Its seed is more nutritive, palatable, digestible and on flatulent than other pulses grown in the world. It is a good source of protein (20-24%), carbohydrates (60-62%), fat (1.0%), fiber (4.0%) and ash (3.0%). Greengram protein is deficient in methionine and cysteine but rich in lysine making it an excellent complement to rice. It maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in sustainable agriculture. In India, it is cultivated in Rajasthan, Madhya Pradesh, Gujarat, Bihar, Maharashtra, Orissa and Andhra Pradesh. It is grown usually as rainfed crop and can also be grown as pre-monsoon and late monsoon crop. Summer greengram occupied 30.53 lakh ha area and contributes 15.09 lakh tonnes in pulse production in the country (Anonymous, 2018) [1].

The application of organic manures induce improvement in physical, chemical and biological properties of soil and building up of secondary and micronutrients, counteracting deleterious effects of soil acidity, salinity and alkalinity and alkalinity and substances of soil health are the key beneficial effects associated with FYM application. The addition of organic manures improved the status of S, Zn, other micro and macronutrients in soil over time.

Considering the significance of FYM, S and Zn in crop production and quality improvement, it is an imperative to select a crop sequence, which enables rational fertilizer application and sustains soil productivity as monoculture leads to continuous exhaustion of the nutrients from the same soil horizon. Organic matter having chelating characteristics of that availability of sulphur is in for SO_4^-, SO_2^- and Zn in Zn^{++} form in soil. The adoption of suitable cropping cycle not only helps in efficient utilization of soil, water and fertilizer resources but sustains soil in a long run. Among different cropping systems maize-green gram includes cereals and pulses, which is widely adopted by the farmers of middle Gujarat under loamy sand soil condition. Under such intensive agriculture, development of improved technology with proper crop sequences plays a major role in increasing productivity and net return.

Therefore, S and Zn with FYM supplementation under intensive agriculture is necessary to maintain soil fertility and crop productivity.

Role of sulphur in Indian agriculture is now gaining importance because of the recognition of its role in increasing crop production, not only for oilseeds, pulses, legumes and forages but also for many cereals (Singh *et al*. 2000) [16]. Removal of sulphur by crops in India is about 1.26 million tonnes, whereas its replenishment through fertilizers is only about 0.76 million tonnes (Tiwari and Gupta, 2006) [21]. Further, the recovery of added sulphur through external sources is only 8-10%. Maize yield loss to an extent of 10 to 30 per cent and up to 35 per cent due to sulphur deficiency according to Pal and Singh (1992) [9]. The sulphur requirement of cereals to produce one tone of cereals is low but uptake per unit area becomes almost equal to that of oilseeds mainly due to higher productivity of cereals (Sutar *et al*., 2017) [20].

Zinc is one of the most important micronutrients for many crop plants such as rice, maize and wheat, or soybean, which all are worldwide cultivated. Zinc also catalyses the biosynthesis of indole acetic acid, acting as metal activator of the enzyme, helps in synthesis of nucleic acids, proteins and stimulates seed formation there by ultimately increasing crop yield. Its deficiency retards photosynthesis and nitrogen metabolism. Therefore, an experiment planned on *rabi* maize-summer greengram cropping sequence to know the residual effect of FYM, sulphur and zinc on growth, yield and quality of summer greengram.

Material and methods

The experiment was conducted at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *summer* seasons of 2019-20 and 2020-21 to evaluate residual effect of FYM, sulphur and zinc on growth, yield and quality of summer greengram under middle Gujarat condition. (FYM, sulphur and zinc applied to preceding maize crop in maize-greengram cropping sequence) The climate of Anand region is semi-arid subtropical with hot summer and cool winter. The mean annual rainfall of this region is 865 mm. During 2019-20 total 63.5 mm of rainfall was received during 43rd, 44th and 45th meteorological weeks during *rabi* season, whereas, total 26.8 mm of rainfall was recorded during 42nd and 50th meteorological weeks during *rabi* season and 16.4 mm of rainfall during 11th meteorological week summer season of 2020-21. The maximum temperature ranged between 22.5-41.5 ^{0}C and minimum temperature ranged between 9.7-22.8 ^{0}C during the crop season of the year 2019-2020, while in the year 2020-21 maximum temperature ranged between 15.4-39.5 ^{0}C and minimum temperature ranged between 5.30-26.3 ^{0}C were recorded. The sunshine hours during summer crop season (February-May) it was ranged from 9.2-11.7 hr/day and 8.8-10.4 hr/day during 2020 and 2021, respectively. The minimum and maximum of mean relative humidity during summer crop season (February-May) of the years 2020 and 2021 ranged from 42.3-60.0% and 46.9-55.8%, respectively.

The soil of the experimental plot was loamy sand in texture, alkaline in reaction [pH(1:2.5) 8.30], low in soluble salts [EC(1:2.5) 0.23 dS/m], organic carbon (0.30%) and available nitrogen (197 kg N/ha), medium in available phosphorus (44.5 kg P_2O_5/ha), high in potash (287 kg K_2O/ha) and deficient in available sulphur (7.56 mg/kg) and zinc (0.55 mg/kg). The experiment comprised of total eighteen treatment combinations in which two levels of FYM (0 and10 t FYM/ha), three levels of sulphur (0, 20 and 40 kg S/ha) and three levels of zinc (0, 2.5 and 5 kg Zn/ha) were laid out in Randomized Block Design having factorial concept with three replications. The recommended dose of fertilizer was applied to greengram (20:40:00 kg N: P_2O_5:K_2O/ha) at the time of sowing. Recommended dose of nitrogen was applied through urea in four equal splits (basal and three fourth dose of nitrogen as top dressing at 30, 45 and 60 days after sowing), recommended dose of P_2O_5 was applied through Diammonium phosphate (DAP) as basal. The seed of greengram variety GAM-5 was drilled in First week of March with spacing of 45 cm x 10 cm and seed rate of 20 kg/ha. The crop was raised with all the standard package of practices and protection measures also timely carried out as they required. At the maturity of crop, randomly five plant were selected (previously tagged) from each plot, picking of pods and harvesting was done first for recording necessary biometric observations. The experimental data recorded for growth parameters, yield attributes and yield parameters were statistically analysed for level of significance.

Results and discussion

Plant population

A perusal of data given in both the tables expressed that residual effect of FYM, sulphur and zinc levels as well as their possible interactions did not exert any imperial impact on plant population of succeeding greengram crop at 20 DAS and at harvest during both the years and in pooled results. These results were in close conformity with Gudadhe *et al.* (2008) [5] and Ombase *et al.* (2018) [8].

Plant height

The appraisal of data pertaining in Tables 1 indicated that different levels of FYM, sulphur and zinc did not exert any significant residual influence on plant height at 30 DAS during both the years and in pooled results.

Effect of FYM

The appraisal of data pertaining in Table 1 indicated that FYM did not produced significant difference on plant height at 30 DAS. Numerically higher plant height (13.35, 13.40 and 13.38 cm) was recorded under 10 t FYM/ha during 2020, 2021 and in pooled results, respectively. The corresponding significantly higher plant height due to application of 10 t FYM/ha at harvest was 40.40, 41.62 and 41.01 cm was noted during 2020, 2021 and in pooled results, respectively, which was 12.2 per cent higher over control in pooled results. Sindhi *et al.* (2016) [15] observed that residual effect of application of RDF + FYM @ 10 t/ha recorded higher plant height, number of branches per plant in greengram which was at par with remaining treatments except control at 30 DAS, but in case of at harvest. The results were also agreed with Shanwad *et al.* (2010) [13] in maize-bengalgram, Faujdar *et al.* (2014) [3] in maize crop, Ombase *et al.* (2018) [8] in maize-greengram cropping sequence.

Effect of Sulphur

The appraisal of data pertaining in Tables 1 indicated that there was no significant influence on plant height at 30 DAS due to different levels of sulphur. However, numerically, higher plant height (13.51, 13.55, 13.53 cm) was registered under 40 kg S/ha during 2020, 2021 and in pooled results, respectively. At harvest, the plant height of greengram was progressively increased with increasing levels of sulphur during both the years and in pooled basis. The higher plant height (40.64, 42.08 and 41.36 cm) was noticed under 40 kg S/ha as compared to control being at par with that of 20 kg S/ha during 2020 and 2021. The results were found similar with Bharati and Poongathai (2008) [2] maize-greengram sequence, Singh *et al.* (2014) [17] in pearlmillet-wheat cropping sequence.

Table 1: Plant population and plant height of greengram as influenced by different treatments

Treatments	No. of plants per meter row length						Plant height (cm)					
	20 DAS			At harvest			30 DAS			At harvest		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Levels of FYM (t /ha)												
FYM_0	9.53	9.54	9.54	9.35	9.36	9.36	12.85	12.92	12.89	36.28	36.84	36.56
FYM_{10}	9.63	9.65	9.64	9.41	9.42	9.41	13.35	13.40	13.38	40.40	41.62	41.01
S. Em ±	0.16	0.16	0.11	0.15	0.16	0.11	0.25	0.25	0.18	0.61	0.60	0.43
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.76	1.74	1.21
Levels of Sulphur (kg /ha)												
S_0	9.53	9.54	9.53	9.32	9.32	9.32	12.62	12.71	12.66	35.60	35.62	35.61
S_{20}	9.61	9.62	9.61	9.39	9.40	9.40	13.18	13.23	13.20	38.78	40.00	39.39
S_{40}	9.61	9.63	9.62	9.44	9.45	9.44	13.51	13.55	13.53	40.64	42.08	41.36
S. Em ±	0.19	0.20	0.14	0.18	0.20	0.14	0.31	0.30	0.22	0.75	0.74	0.53
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.15	2.13	1.49
Levels of Zinc (kg /ha)												
$Zn_{0.0}$	9.54	9.54	9.54	9.32	9.32	9.32	12.55	12.62	12.59	36.76	37.07	36.92
$Zn_{2.5}$	9.59	9.61	9.60	9.39	9.40	9.39	13.55	13.60	13.58	38.33	39.62	38.98
$Zn_{5.0}$	9.62	9.64	9.63	9.44	9.44	9.44	13.21	13.26	13.24	39.94	41.00	40.47
S. Em ±	0.19	0.20	0.14	0.18	0.20	0.14	0.31	0.30	0.22	0.75	0.74	0.53
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.15	2.13	1.49
Significant Interaction(s)	-	-	-	-	-	-	-	-	-	-	-	-
Year effect			NS	-	-	NS	-	-	NS	-	-	NS
CV%	8.46	8.64	8.55	8.32	9.12	8.73	10.07	9.75	9.91	8.27	8.01	8.14

Effect of Zinc
The data presented in Table 1 revealed that residual effect of zinc did not produce significant influence on plant height of greengram at 30 DAS during both the years and in pooled results. The perusal of data given in Table 4.33 revealed that application of 5.0 kg Zn/ha logged significantly the highest plant height at harvest (39.94, 41 and 40.47 cm) than control and 2.5 kg Zn/ha during 2020 and 2021 and in pooled results. The results were close conformity with conclusions of Patil *et al*. (2018) [10] in sorghum-greengram cropping system.

Table 2: Seed yield, haulm yield and seed protein of greengram as influenced by different treatments

Treatments	Seed yield (kg /ha)			Haulm yield (kg /ha)			Protein content in seed (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Levels of FYM (t /ha)									
FYM_0	964	1004	984	1559	1611	1585	21.80	22.02	21.91
FYM_{10}	1273	1322	1297	2018	2127	2072	22.65	22.82	22.74
S. Em ±	23.8	23.7	16.8	31.5	34.6	23.4	0.23	0.17	0.14
C. D. at 5%	68.5	68.3	47.5	90.7	99.5	66.1	0.65	0.50	0.40
Levels of Sulphur (kg /ha)									
S_0	997	1040	1019	1615	1669	1642	21.58	21.35	21.46
S_{20}	1139	1186	1162	1822	1910	1866	22.30	22.79	22.55
S_{40}	1218	1262	1240	1928	2027	1977	22.80	23.13	22.96
S. Em ±	29.2	29.1	20.6	38.6	42.4	28.7	0.28	0.21	0.17
C. D. at 5%	83.9	83.6	58.2	111.1	121.9	81.0	0.80	0.61	0.49
Levels of Zinc (kg /ha)									
$Zn_{0.0}$	1026	1067	1046	1633	1701	1667	21.05	20.61	20.83
$Zn_{2.5}$	1129	1175	1152	1809	1900	1854	22.52	22.95	22.74
$Zn_{5.0}$	1200	1246	1223	1922	2005	1964	23.11	23.70	23.40
S. Em ±	29.2	29.1	20.6	38.63	42.37	28.67	0.28	0.21	0.17
C. D. at 5%	83.9	83.6	58.2	111.13	121.89	80.99	0.80	0.61	0.49
Significant Interaction(s)	F X S	F X S	F X S	F X S	F X S	F X S	-	S X Z	S X Z
Year effect			Non. Sig.	-	-	NS			NS
CV%	11.1	10.6	10.8	9.2	9.6	9.4	5.30	4.03	4.70

Interaction effect
The interaction of residual effect of FYM, sulphur and zinc had not exerted any significant difference in plant height of greengram recorded at 30 DAS and at harvest.

Greengram yield (seed)
The seed yield of greengram was significantly influenced by application FYM, sulphur, zinc and FYM x S interaction during 2020, 2021 and in pooled basis. The interaction

between FYM x Zn, S x Zn and FYM x S x Zn was found non-significant during both the years of experimentation and in pooled results.

Effect of FYM

The residual effect of 10 t FYM/ha applied to maize crop on greengram seed yield was significantly higher than no FYM application during 2020, 2021 and in pooled results. The seed yield of greengram recorded under 10 t FYM/ha was 1273, 1322 and 1297 kg/ha, respectively during 2020, 2021 and pooled mean. It was significantly higher than no FYM application to maize crop. The increased in seed yield of greengram under 10 t FYM/ha was to the tune of 31.8 per cent in pooled results. This might be associated with the application of 10 t FYM/ha to maize crop enhanced the microbial population in rhizosphere by proving the energy source as carbon and nitrogen through FYM, temporarily increased the soil pH condition during maize crop growth stage as well as enhanced the nutrient availability and nutrient use efficiency of added nutrients to maize crop through chemical fertilizers. This might be reflected into built up of residual soil fertility. This was benefited to succeeding greengram crop for recording the higher seed yield of greengram supported by results of Sipai *et al.* (2015) [18] mustard and Lakum *et al.* (2020) [6] in maize-chickpea cropping sequence.

Effect of Sulphur

The residual effect of varying levels of sulphur significantly increased the greengram seed yield. It was significantly higher (1218, 1262 and 1240 kg/ha) under application 40 kg S/ha as compared to control and 20 kg S/ha during 2020, 2021 and in pooled results, respectively. However, it was statistically at par with 20 kg S/ha during 2021. On pooled basis, the seed yield recorded under 40 kg S/ha was 21.7 and 6.7 per cent higher over control and 20 kg S/ha, respectively. The significant effect for seed yield of greengram by the residual effect of graded levels of sulphur might be because of transformed the sulphur to sulphate (SO_4^-) form and built up the residual soil available sulphur. The transformed residual sulphate form was might be easily absorbed by the greengram for their growth and development. The sulphur plays an important role in chlorophyll synthesis, required for photosynthesis activity in plant systems for synthesis of carbohydrates during crop growth period. Similarly, it enhanced the protein synthesis. At the same time sulphur on their oxidation forms the mineral acid like sulphurs acid (H_2SO_3) which can reduce the soil pH in the vicinity of rhizosphere. This may increased the microbial activity for atmospheric nitrogen fixation by greengram as leguminous crop. All these phenomena cumulatively increased the seed yield of greengram results were agreed with Srinivasrao *et al.* (2010) [19] maize-chickpea and Sipai *et al.* (2015) [18] in mustard crop.

Effect of Zinc

The residual effect of graded levels of zinc significantly increased the seed yield of greengram during both the years of experimentation and in pooled results. Significantly higher seed yield of greengram (1200, 1246 and 1223 kg ha) was recorded under 5.0 kg Zn/ha as compared to control, being at par with that of 2.5 kg Zn/ha during 2020 and 2021. On pooled basis, the higher seed yield of greengram was noticed under 5.0 kg Zn/ha was to the tune of 16.9 and 6.2 per cent over control and 2.5 kg Zn/ha, respectively. The residual effect of zinc on seed yield might be because of addition of zinc to maize crop @ 2.5 and 5.0 kg/ha $ZnSO_4$ raised the zinc content in soil above their critical limit (0.6 mg/kg) after the harvest the maize crop. The sufficient content of residual zinc benefitted the greengram crop for their higher seed yield. The zinc act as cofactor in metabolic activity of plant system for growth and development this might be reflected in higher seed yield of greengram. The results were agreed with Singh *et al*. (2014) [17] in pearlmillet-wheat cropping sequence and Sipai *et al.* (2015) [18] in mustard crop, Sindhi *et al.* (2016) [15] in maize-greengram cropping sequence.

Interaction effect

The data presented in Table 3 revealed the interaction effects of residual FYM and sulphur levels were found significant for seed yield of greengram during 2020, 2021 and in pooled results. At a given level of FYM, seed yield of greengram was increased with the increasing level of sulphur. Significantly higher seed yield of greengram during 2020 (1417 kg/ha), 2021 (1460 kg/ha) and in pooled results (1438 kg/ha) was recorded with combined application of 40 kg S/ha and 10 t FYM/ha, being at par with the treatment combination of 20 kg S/ha and 10 t FYM/ha ($FYM_{10}S_{20}$). The significant effect of interactions might be associated with the residual FYM oxidized the sulphur to sulphate form. The sulphate form of sulphur is easily absorbed by the plant and utilized in their metabolic activity for their growth and development. This was reflected into higher seed yield of greengram. The results were resembled with findings of Sharma *et al.* (2018) [14] in mustard crop.

Table 3: Seed yield of greengram as influenced by FYM x S interaction

Levels of Sulphur (kg /ha)	Seed yield (kg /ha)					
	Levels of FYM (t /ha)					
	2020		2021		Pooled	
	FYM_0	FYM_{10}	FYM_0	FYM_{10}	FYM_0	FYM_{10}
S_0	923	1071	958	1121	941	1096
S_{20}	948	1330	988	1384	968	1357
S_{40}	1020	1417	1065	1460	1042	1438
S. Em. ±	41.3		41.1		29.1	
C. D. at 5%	119		118		82	

Haulm yield of greengram

The haulm yield of greengram was significantly influenced by application FYM, sulphur, zinc and FYM x S interaction during 2020, 2021 and in pooled basis.

Effect of FYM

The residual effect of 10 t FYM /ha on the greengram crop significantly gave the higher haulm yield during 2020, 2021 and in pooled results (2018, 2127 and 2072 kg/ha, respectively) over no FYM addition (1559, 1611 and 1585 kg/ha, respectively). The increased seed and haulm yield of greengram due to various treatments to preceding *rabi* maize might be due to addition of FYM resulting in improvement in soil structure which reduced the soil crusting and also serves as a source of energy for soil microflora which resulted in better root nodulation and nitrogen fixation. Utilization of inexhaustible atmospheric nitrogen through biological nitrogen fixation can help a great deal in maintaining soil productivity. These results were in close conformation with those reported by Gawai and Pawar (2006) [4] in sorghum-chickpea cropping sequence, Shanwad *et al.* (2010) [13] in maize-bengalgram, Lakum *et al.* (2020) [6] in maize-chickpea cropping sequence.

Effect of Sulphur

The residual effect of graded levels of sulphur to greengram significantly increased haulm yield during both the years of experimentation and in pooled results. It was significantly higher in addition of 40 kg S/ha during 2020, 2021 and in pooled results (1928, 2027 and 1977 kg/ha, respectively) over control, being at par with 20 kg S/ha during the year 2020 and 2021. This might be due to the fact that sulphur plays an important role in chlorophyll synthesis, required for photosynthesis activity in plant systems for synthesis of carbohydrates during crop growth period. Similarly, it enhanced the protein synthesis. At the same time sulphur on their oxidation forms the mineral acid like sulphurs acid (H_2SO_3) which can reduce the soil pH in the vicinity of rhizosphere. This may increase the microbial activity for atmospheric nitrogen fixation by greengram as leguminous crop. All these phenomena cumulatively increased the seed and haulm of greengram. The results were agreed with Srinivasrao *et al.* (2010) [19] in maize-chickpea cropping sequence and Sipai *et al.* (2015) [18] in mustard crop.

Effect of Zinc

The residual effect of zinc levels significantly increased haulm yield in 2020, 2021 and in pooled results. Application of 5.0 kg Zn/ha registered significantly higher haulm yield (1922, 2005 and 1964 kg/ha) over control, but found at par with 2.5 kg Zn/ha during 2021. On pooled basis, the higher haulm yield of greengram was noticed under 5.0 kg Zn/ha and it was to the tune of 20.4 and 13.64 per cent over control and 2.5 kg Zn/ha, respectively.

The increased in seed and haulm yield may be ascertained to the increased availability of nutrients due to mineralization of organic materials, release of CO_2 increasing fertilizer use efficiency, accumulation of organic carbon and improvement of soil physical properties. The increased greengram seed and haulm yields might be due to addition of FYM to preceding *rabi* maize resulted in improvement in soil structure which reduced the soil crusting and also serves as a source of energy for soil microflora which resulted in better root nodulation and nitrogen fixation. Similar results reported earlier by Gudadhe (2008) [5] in cotton-chickpea, Nawale *et al.* (2009) in sorghum-chickpea, Shanwad *et al.* (2010) [13] in maize-bengalgram and Saha *et al.* (2012) [12] in maize- mustard cropping sequence.

Interaction effect

The data presented in Table 4. revealed that interaction effects of residual FYM and sulphur levels were found significant for haulm yield of greengram during 2020, 2021 and in pooled results. At a given level of FYM, haulm yield of greengram was increased with the increasing level of sulphur. Significantly higher haulm yield of greengram during 2020 (2235 kg/ha), 2021 (2341 kg/ha) and in pooled results (2288 kg/ha) was recorded under combined application of 40 kg S/ha and 10 t FYM/ha, being at par with the treatment combination of 20 kg S x 10 t FYM/ha during 2020 and 2021. The results were resembled with findings of Sharma *et al.* (2018) [14] in mustard crop.

Table 4: Haulm yield of greengram as influenced by FYM x S interaction

Levels of Sulphur (kg /ha)	Haulm yield (kg /ha)					
	Levels of FYM (t /ha)					
	2020		2021		Pooled	
	FYM_0	FYM_{10}	FYM_0	FYM_{10}	FYM_0	FYM_{10}
S_0	1526	1704	1523	1815	1524	1759
S_{20}	1529	2114	1598	2223	1564	2169
S_{40}	1622	2235	1712	2341	1667	2288
S. Em. ±	55		60		41	
C. D. at 5%	157		172		115	

Crude protein content

The protein content in greengram was significantly influenced by application FYM, sulphur, zinc and S x Zn interaction during 2021 year of experimentation and in pooled basis.

Effect of FYM

The residual effect of FYM on protein content of greengram seed showed significant during both the years. Significantly the highest value of protein content 22.65, 22.82 and 22.74 per cent were recorded under 10 t FYM/ha during both the years and in pooled results over control. The higher protein content under FYM application might be due to fact that protein molecules are presumably built up through controlled condensation of amino acid molecules formed by combining reduced nitrogen with derivative of carbohydrates obtained with the plant system as a product of photosynthesis and FYM play crucial role in nutrients supplier throughout mineralisation process. Similar results were also reported by Srinivasanarao *et al.* (2010) [19] in maize-chickpea cropping sequence, Ombase *et al.* (2018) [8] in maize-greengram cropping sequence and Lakum *et al.* (2020) [6] in maize-chickpea cropping sequence.

Effect of sulphur

A perusal of data showed in table 2 indicated that residual effect of 40 kg S/ha increased protein content in greengram seed significantly during both the years and in pooled results. Significantly higher protein content of 22.80, 23.13 and 22.96 per cent was recorded during 2020, 2021 and in pooled results, respectively over control, but it was statistically at par with that of 20 kg S/ha during 2021 and in pooled results. On Pooled basis, the increased in protein content under 40 kg S/ha was to the tune of 7.0 and 1.8 per cent over control and 20 kg S/ha, respectively. The beneficial effect recognised may be because of S is a constituent of S containing amino acids, which one is present in protein. Similar results were also expressed by Rawat *et al.* (2021) [11] in maize-wheat cropping sequence.

Effect of zinc

A perusal of data in table 2 indicated that residual effect of zinc demonstrated significantly higher protein content in greengram seed during both the years and pooled results. Significantly higher (23.11, 23.70 and 23.40%) protein content was noted under 5.0 kg Zn/ha over that of control and 2.5 kg Zn/ha during both the years of experiments and in pooled results, except in 2020, wherein protein content recorded under 5.0 kg Zn/ha was statistically at par with that of 2.5 kg Zn/ha. The increased in protein content under 5.0 kg

Zn/ha was to the tune of 12.3 and 2.9 per cent over control and 2.5 kg Zn/ha, respectively in pooled basis. This might be due to fact that as rate of Zn application increases the protein content was also found to be increased. Zinc is present in cell nucleus, nucleolus and chromosomes and zinc stabilizes the structure of DNA, RNA and ribosomes and protein synthesis. Similar results also expressed by Sipai *et al.* (2015) [18] in mustard and Rawat *et al.* (2021) [11] maize-wheat cropping system.

Interaction effect

The data presented in Table 5 revealed that residual effect of combined application of sulphur and zinc was found to be significant on protein content in greengram seed during 2021 and in pooled results. At a given level of sulphur, protein content was increased with the increasing level of zinc. The higher protein content (24.29%) during 2021 and (24.03%) in pooled results was recorded with S_{40} x $Zn_{5.0}$ interaction, which was statistically at par with that of S_{40} x $Zn_{2.5}$ and S_{20} x $Zn_{5.0}$ during year 2021 and S_{20} x $Zn_{5.0}$ interactions in pooled results. These results were in close conformity with the findings of Rawat *et al.* (2021) [11], they reported that addition of sulphur and zinc enhances protein content significantly during both the years of experimentation in maize-wheat cropping system.

Table 5: Protein content in greengram seed as influenced by S x Zn interaction

Levels of Sulphur (S kg /ha)	Protein content in seed (%)					
	Levels of Zinc (kg /ha)					
	2021			Pooled		
	$Zn_{0.0}$	$Zn_{2.5}$	$Zn_{5.0}$	$Zn_{0.0}$	$Zn_{2.5}$	$Zn_{5.0}$
S_0	18.47	22.41	23.16	19.13	22.32	22.93
S_{20}	21.68	23.05	23.65	21.57	22.82	23.25
S_{40}	21.68	23.40	24.29	21.78	23.08	24.03
S. Em. ±	0.37			0.30		
C. D. at 5%	1.06			0.86		

Conclusion

The results revealed that residual effect of 10 t FYM/ha,40 kg S/ha and 5 Kg Zn /ha to the summer greengram crop recorded significantly the highest plant height at harvest, seed and haulm yields of greengram as well as protein content in seed during individual year and in pooled results. The interaction effects of residual FYM and sulphur levels were found significant for seed and haulm yield of greengram during 2020, 2021 and pooled mean and Sulphur x Zn was found to be significant in protein content in seed during year 2021 and pooled results.

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