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Effect of FYM, phosphorus and PSB on yield, nutrient content and uptake by green gram (*Vigna radiata* (L.) Wilckzek) on loamy sand

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Abstract
A field experiment was conducted during *kharif* season 2014 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, to study the effect of FYM, phosphorus and PSB on nutrient content and uptake by green gram on loamy sand. The experiment encompassed two levels of FYM *viz.,* 0 and10 t ha^{-1} and seven levels of phosphorus *viz.,* PSB, 20 kg P_2O_5 ha^{-1}, 20 kg P_2O_5 ha^{-1} + PSB, 30 kg P_2O_5 ha^{-1}, 30 kg P_2O_5 ha^{-1} + PSB, 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} + PSB. The experiment was laid out in randomized block design (Factorial) with three replications. The results revealed that significantly the highest seed (727 kg ha^{-1}) and stover (1399 kg ha^{-1}) yields of green gram was recorded due to application of 40 kg P_2O_5 ha^{-1} + PSB @ 10 t FYM/ha. Application of phosphorus @ 40 kg P_2O_5 ha^{-1} + PSB was recorded the maximum removal of nutrients from the soil. The maximum N, P, K, S, Fe and Zn content and uptake by green gram was recorded due to application of 40 kg P_2O_5 ha^{-1} + PSB over the rest of the treatments. Significantly the highest phosphorus build up in soil after harvest of the crop was observed under the treatment of 40 kg P_2O_5 ha^{-1} + PSB.

Keywords: Greengram, phosphorus, PSB, FYM and uptake

Introduction
Green gram is also known as *mung, moong, mungo,* golden gram, chickasaw pea and Oregon pea. It contains about 25 per cent protein, 1.3 per cent fat, 3.5 per cent minerals, 4.1 per cent fiber and 56.7 per cent carbohydrate. The origin of cultivated green gram is India and central Asia. In India, it occupied an area of 3.44 million hectares having total production of 1.4 million tons of grain with productivity of 407 kg/ha. In India, major green gram producing states are Orissa, Madhya Pradesh, Rajasthan, Maharashtra, Gujarat and Bihar.
In Gujarat, it is grown on an area of 2.30 lakh ha with the production of 1.21 lakh tones and productivity of 526 kg/ha. Phosphorus plays a key role in various physiological processes like root growth and dry matter production, nodulation and nitrogen fixation and also in metabolic activities especially in protein synthesis. It helps in establishing seedling quickly and also hastens maturity as well as improves the quality of crop produce. The most obvious effect of phosphorus is on the root system of plants. It promotes the formation of lateral and fibrous roots, which facilitates to bacteria for nodulation and ultimately increases the nitrogen fixation in leguminous crops. The role of organic manure is well recognized and considered as balance manures which supplies macro and micro nutrients essential to plants. Farm yard manure (FYM) is one of the important organic manures, which supplies a suitable mineral balance and improves nutrient availability by enzymes. The PSB like *Pseudomonas* and *Bacillus* also enhances the availability of phosphorus to the plant by converting insoluble phosphorus from the soil in the soluble form. The PSB like *Pseudomonas striata* bacterial inoculation was found as equivalent to supply 50 kg P_2O_5 /ha through single super phosphate (Gour *et al.,* 1980). More over use of this bio-fertilizer also reduced the environmental pollution caused by heavy use of chemical fertilizers (Deshmukh and Bhapkar, 1982) [3]. Therefore, the present research work was carried out to access the effect of FYM, phosphorus and PSB on yield, nutrient content and uptake by Green gram (*Vigna radiata* (L.) Wilckzek) of Loamy Sand.

Materials and Methods

In order to achieve the pre-set objectives of the present investigation, a field experiment was conducted during the *summer* season of 2014-15 at Agronomy Instructional Farm, Department of Agronomy, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat (India), is situated at 24º -19' North latitude and 72º – 10' East longitude with an altitude of 154.52 meter from the mean sea level. It represents the North Gujarat Agro-climatic Zone IV. This zone is characterized by semi-arid climate. The weather conditions are quite favourable for normal growth and development of the crop. In general, monsoon is warm and moderately humid; winter is fairly cold and dry while summer is quite hot and dry. The monsoon commences by the last week of June and retreats by the end of September with an average rainfall of 622.9 mm received in about 24 rainy days.

Fourteen treatment combinations comprising of two FYM levels *viz*., 0 t FYM/ha (F_0) and 10 t FYM/ha (F_1) and seven treatments of phosphorus *viz*., P_1 (Only PSB), P_2 (20 kg P_2O_5/ha), P_3 (20 kg P_2O_5/ha + PSB), P_4 (30 kg P_2O_5/ha), P_5 (30 kg P_2O_5/ha + PSB), P_6 (40 kg P_2O_5/ha) and P_7 (40 kg P_2O_5/ha+ PSB) were evaluated in factorial randomized block design by replicating three times. The soil of the experimental field was loamy sand in texture, low in organic carbon (0.17 %), available sulphur (8.50 mg/kg) and nitrogen (160.7 kg/ha); medium in available phosphorus (48.9 kg/ha), iron (7.60 mg/kg) and zinc (0.58 mg/kg) and high in available potash (286 kg/ha) with 7.6 pH. Greengram cultivar GM 4 was sown on 4th July the year behind the plough at row spacing of 45 cm@ of 20 kg seed/ha. The plants were spaced at 15 cm by thinning after 20 days of sowing. PSB was inoculated with seed just before sowing as per treatments requirement. DAP was applied as placement method 3-5 cm below the seed at sowing time. At sowing a 20 kg N dose was maintained to all treatments for early better growth. The crop was harvested at second week of September. The representative dry samples of shoots and seeds were analyzed for ascertaining the nutrient (N, P, K, S, Fe and Zn) content and uptake. The N, P, K, S, Fe and Zn contents were analyzed by micro-Kjeldahl, Vanadomolydo phosphoric acid yellow-colour, flame Photometric method, Turbidimetric and DTPA extraction methods respectively. Available N, P_2O_5,K_2O, S, Fe and Zn content in soil were analyzed by alkaline permanganate, Olsen's method, Flame photometric, Turbidimetric method and DTPA extraction methods, respectively. The collected data for various parameters were statistically analyzed using Fishers' analysis of variance (ANOVA) technique and the treatments were compared at 5% level of significance.

Results and Discussion

Effect of FYM

FYM application showed significantly better effect of grain and straw yield /ha as compared to control (Table 3). Application of FYM @ 10 t/ha (F1) produced significantly higher seed (700 kg/ha) and stover yield (1345 kg/ha) as compared to 0 t/ha FYM (F0). The above findings are in complete agreement with earlier work of Kokani *et al.* (2015) [10] and Khan *et al*. (2017) [9]. These results clearly suggest that grain yield is an artifact of several yield components, which are dependent on source (photosynthesis/metabolites/nutrients) and sink (yield components particularly number of grains per spike and test weight) and improvement in all these aspects under the influence of organic fertilization resulted in realization of higher productivity in terms of grain and stover yield. While higher production of total biomass under FYM application seems to be on account of its profound influence on both vegetative and reproductive events of crop growth (Shete *et al.* 2010) [12].

Significantly maximum P, K, and S content in seed (0.583, 1.597 and 0.21 %) and N, P, K, and S content in stover (0.49, 0.18, 2.80 and 0.10%) were registered in application of 10 t FYM/ha (F_1) as compared to no FYM(F_0), respectively (Table 1). Significantly maximum N, P, K, and S uptake by seed (25.59, 4.02, 11.18 and 1.46 kg ha^{-1}) and N, P, K, and S uptake by stover (6.68, 2.50, 37.87 and 1.34 kg ha^{-1}) were registered in application of 10 t FYM/ha (F_1) as compared to no FYM(F_0), respectively (Table 2). Iron and Zn content in seed and stover of greengram were found significantly higher due to 10 t/ha FYM application. Total Fe and Zn uptake by 10 t FYM/ha (F_1) was 8.2 and 15.28 per cent higher than no FYM (F_0), respectively. Similar results were also reported by Sutaria *et al.* (2010) [14], Jat *et al.* (2012) [7], and Jat and Alhawat (2010) [6].

Improved nutritional status in plant parts under FYM application primarily seems to be on account of enrichment of these nutrients in soil, secondly it can be attributed to their efficient extraction per translocation in the plant system due to enhanced activities of roots on account of pivotal role of FYM on maintenance of better physico-chemical and biological properties of the soils. Similar results were also reported by Shankar *et al.* (2014) [11] and Kokani *et al.* (2015) [10]. Significant increase in nutrient uptake with the application of FYM seems to be due to the fact that uptake of nutrients is product of biomass accumulated by particular plant part and its nutrient content. Thus, positive impact of FYM on both these ultimately led to higher accumulation of nutrients. Application of 10 t FYM/ha (F_1) recorded significantly the highest available N (209.10 kg/ha), P_2O_5 (58.45 kg/ha), K_2O (306.93 kg/ha), S (8.71 mg/kg), Fe (6.508 mg/kg), and Zn (0.60 mg/kg) status than no FYM(F_0) application (Table 3).The magnitude of increase in available N, P_2O_5, K_2O, S, Fe, and Zn were to the tune of 9.5, 5.3, 4.06, 7.4, 8.5 and 5 per cent, respectively over control. It is imperative that the increase in soil nutrient content and enhancing physico-chemical as well as biological properties of the soil due to addition of 10 t/ha FYM. It is imperative that the increase in soil nutrient content was due to addition of 10 t/ha FYM. These results are in line with the results reported by Ghanshyam *et al.* (2010) [5] and Subbarayappa *et al.* (2011) [13].

Effect of Phosphorus

Application of 40 kg P_2O_5/ha + PSB (P_7) registered maximum seed yield of 727 kg/ha. The per cent increase in seed yield under P_7 (40 kg P_2O_5/ha + PSB) was 14.58 per cent over P_1 (PSB) (Table 3). This might be due to significantly increase in P availability and uptake resulted profuse nodulation leading to greater symbiotic N fixation which in turn has positive effect on photosynthesis then on yield/ha. Response of phosphorus was also reported by Chaudhari *et al.* (2016) [1] and Venkatarao *et al.* (2017) [15]. Significantly higher N uptake (Table 2) in seed and stover were registered when crop was fertilized with 40 kg P_2O_5/ha + PSB (P_7). Phosphorus content (Table 1) and uptake (Table 2) was significantly affected due to different levels of phosphorus application. Significantly higher P content and uptake in seed and stover were registered when crop was fertilized with 40 kg P_2O_5/ha +

PSB (P_7). Significantly higher K and S uptake (Table 2) in seed and stover were registered when crop was fertilized with 40 kg P_2O_5/ha + PSB (P_7).

The higher removal of nutrients with this treatment might be due to better development of root and shoot with this treatment resulted in higher nutrient uptake. These results are in accordance with the results of those reported by Dekhane *et al.* (2011) [2] and Jat *et al.* (2013) [8]. This increased content and uptake by seed and stover might be due to increased yield of seed and stover under treatment P_7 (40 kg P_2O_5/ha + PSB). The higher removal of nutrients with this treatment might be due to better development of root and shoot with this treatment resulted in higher nutrient uptake. These results are in accordance with the results of those reported by Dekhane *et al.* (2011) [2], Jat *et al.* (2013) [8], Shankar *et al.* (2014) [11] and Patel *et al.* (2017).

Various levels of phosphorus treatment significantly influenced the P_2O_5 status of soil (Table 3) after the harvest of greengram. Significantly higher values of P_2O_5 (60.00 kg/ha) in soil after harvest of greengram were recorded with application of P_7 (40 kg P_2O_5/ha + PSB). This might be due to higher quantity of phosphorus application and bio fertilizer viz. PSB, resulted in buildup of nutrients in the soil. Similar results were also reported by Dekhane *et al.* (2011) [2]. This might be due to higher quantity of FYM along with bio fertilizers viz. PSB resulted in buildup of nutrients in the soil. Similar results were also reported by Chaudhari *et al.* (2016) [1] and Khan *et al.* (2017) [9] revealed that phosphorus management improved the residual soil fertility after greengram to a greater extent and the gain in organic carbon, total nitrogen and available P_2O_5 over the initial soil nutrient content.

Table 1: N, P, K, S, Fe and Zn content in seed and stover of greengram as influenced by different treatments

Treatments	Content (%)								Content (mgkg^{-1})			
	N		P		K		S		Fe		Zn	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
[A] Levels of FYM (F)												
F_0 : 0 t/ha	3.56	0.487	0.552	0.154	1.39	2.67	0.192	0.087	114.67	101.02	13.87	7.95
F_1 : 10 t //ha	3.65	0.496	0.583	0.182	1.60	2.80	0.208	0.100	118.35	101.73	15.84	8.50
S.Em.±	0.03	0.003	0.009	0.009	0.02	0.04	0.002	0.001	1.21	0.38	0.21	0.08
C.D.(P=0.05)	NS	0.008	0.025	0.025	0.07	0.11	0.006	0.004	3.53	NS	0.61	0.23
[B] Phosphorus treatments (P)												
P_1 : PSB	3.55	0.472	0.527	0.135	1.41	2.63	0.191	0.086	115.25	101.15	14.73	7.66
P_2 : 20 kg P_2O_5/ha	3.57	0.480	0.541	0.144	1.43	2.69	0.194	0.089	116.55	101.25	14.78	7.88
P_3 : 20 kg P_2O_5/ha + PSB	3.59	0.485	0.554	0.154	1.45	2.73	0.197	0.092	116.68	101.33	14.87	8.05
P_4 : 30 kg P_2O_5/ha	3.60	0.492	0.570	0.170	1.48	2.74	0.198	0.092	116.77	101.42	14.92	8.49
P_5 : 30 kg P_2O_5/ha + PSB	3.62	0.503	0.583	0.179	1.55	2.78	0.202	0.097	116.79	101.50	14.90	8.52
P_6 : 40 kg P_2O_5/ha	3.63	0.504	0.598	0.197	1.57	2.79	0.203	0.098	116.77	101.49	14.89	8.51
P_7 : 40 kg P_2O_5/ha + PSB	3.67	0.505	0.598	0.198	1.58	2.80	0.213	0.100	116.75	101.48	14.88	8.50
S.Em.±	0.05	0.005	0.016	0.016	0.04	0.07	0.004	0.003	2.27	0.70	0.39	0.15
C.D.(P=0.05)	NS	NS	0.047	0.046	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: N, P, K, S, Fe and Zn uptake in seed and stover of greengram as influenced by different treatments

Treatments	Uptake (kg ha^{-1})								Uptake (g ha^{-1})			
	N		P		K		S		Fe		Zn	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
[A] Levels of FYM (F)												
F_0 : 0 t/ha	23.31	6.11	3.62	1.97	9.11	33.52	1.25	1.09	74.92	126.69	9.05	10.02
F_1 : 10 t //ha	25.59	6.68	4.02	2.50	11.18	37.87	1.46	1.34	82.98	136.84	11.08	11.44
S.Em.±	0.63	0.15	0.12	0.14	0.24	0.98	0.04	0.03	1.93	2.97	0.23	0.27
C.D.(P=0.05)	1.82	0.43	0.34	0.42	0.71	2.86	0.10	0.10	5.61	8.62	0.67	0.78
[B] Phosphorus treatments (P)												
P_1 : PSB	22.05	5.60	3.27	1.60	8.77	31.27	1.19	1.03	71.91	120.29	9.13	9.14
P_2 : 20 kg P_2O_5/ha	22.57	5.82	3.43	1.74	9.05	32.64	1.23	1.08	73.74	122.61	9.31	9.55
P_3 : 20 kg P_2O_5/ha + PSB	23.52	6.10	3.62	1.92	9.54	34.30	1.29	1.16	76.39	127.40	9.74	10.16
P_4 : 30 kg P_2O_5/ha	24.24	6.36	3.84	2.21	9.97	35.40	1.34	1.18	78.67	131.16	10.06	10.96
P_5 : 30 kg P_2O_5/ha + PSB	25.70	6.86	4.16	2.51	11.01	37.81	1.43	1.31	82.67	138.23	10.66	11.61
P_6 : 40 kg P_2O_5/ha	26.26	6.99	4.23	2.82	11.30	38.70	1.47	1.36	84.28	140.59	10.72	11.79
P_7 : 40 kg P_2O_5/ha + PSB	26.78	7.05	4.38	2.84	11.38	39.73	1.56	1.40	85.00	142.07	10.82	11.89
S.Em.±	1.17	0.28	0.22	0.27	0.46	1.84	0.07	0.06	3.61	5.55	0.43	0.50
C.D.(P=0.05)	3.41	0.80	0.63	0.78	1.33	5.35	0.20	0.18	NS	NS	NS	NS

Table 3: Available N, P_2O_5, K_2O, S, Fe and Zn in soil and yield of greengram as influenced **by different treatments**

Treatments	Available nutrients in soil (kg ha^{-1})			Available nutrients in soil (mg kg^{-1})			Yield (kg ha^{-1})	
	N	P_2O_5	K_2O	S	Fe	Zn	Seed	Stover
[A] Levels of FYM (F)								
F_0 : 0 t/ha	189.15	55.34	293.93	8.06	5.95	0.57	653	1253
F_1 : 10 t //ha	209.10	58.45	306.40	8.71	6.51	0.60	700	1345
S.Em.±	2.10	0.90	3.90	0.10	0.08	0.01	14	28
C.D.(P=0.05)	6.10	2.61	11.33	0.30	0.24	0.02	41	82
[B] Phosphorus treatments (P)								
P_1 : PSB	191.50	53.36	286.86	8.18	5.66	0.55	621	1188
P_2 : 20 kg P_2O_5/ha	195.42	54.15	296.35	8.22	5.88	0.57	633	1211
P_3 : 20 kg P_2O_5/ha + PSB	196.40	55.37	301.90	8.30	6.05	0.58	655	1256
P_4 : 30 kg P_2O_5/ha	196.79	57.13	302.06	8.42	6.49	0.59	673	1293
P_5 : 30 kg P_2O_5/ha + PSB	203.70	58.43	303.24	8.51	6.52	0.60	708	1362
P_6 : 40 kg P_2O_5/ha	204.73	59.82	304.05	8.52	6.51	0.60	721	1386
P_7 : 40 kg P_2O_5/ha + PSB	205.33	60.00	306.70	8.55	6.51	0.60	727	1399
S.Em.±	3.93	1.68	7.29	0.19	0.15	0.01	26	53
C.D.(P=0.05)	NS	4.88	NS	NS	NS	NS	77	154

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