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Effect of FYM, Phosphorus and PSB on Growth, Yield Attributes, Yield and Economics of *Kharif* Green Gram (*Vigna radiata* (L.) Wilczek)

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during *Kharif* 2020 and 2021 at Kanpur, India to find out the effect of FYM, phosphorus and PSB on growth and yield of Green gram variety Shweta. There were twenty treatment combinations of 4 levels of FYM t ha^{-1}: control (F_0), 1.0 t (F_1), 2.0 t (F_2), and 3.0 t (F_3), and 5 levels of phosphorus kg ha^{-1} and PSB viz., PSB only (P_1), 20 kg P_2O_5 (P_2), 20 kg P_2O_5 + PSB (P_3), 40 kg P_2O_5 (P_4) and 40 kg P_2O_5 + PSB (P_5) laid out in Factorial Randomized Block Design and replicated thrice. The FYM, phosphorus, and PSB were applied as per treatment.

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The higher growth attributes and number of pods per plant, pod weight plant^{-1}, test weight, seed yield, gross income, net income and B:C ratio were recorded with 3t FYM/ha among the FYM levels and 40 kg P_2O_5 /ha + PSB among the levels of PSB and phosphorus.

Keywords: Economics FYM; green gram; phosphorus; PSB; yield.

1. INTRODUCTION

Green gram [*Vigna radiata* (L.) Wilczek] is one of the important pulse crops grown in the arid and semi-arid regions of India. It is basically a short duration *kharif* pulse crop and can also be grown as catch crop between *rabi* and *kharif* seasons. Being a leguminous crop, it can fix atmospheric nitrogen. Its green plants are used as fodder after removing the mature pods. In India, Green gram occupies 34.37 lakh ha area and contributes to 17.83 lakh tonnes in pulse production [1]. In, Uttar Pradesh the total area under Green gram was 0.49 lakh ha with an annual production of 0.14 lakh tonnes [1]. In India, the availability of large quantity of FYM rich in organic matter necessitates the need for supplementing it with the fertilizers. Application of FYM to field crops also avoids its use for burning purposes. Indian soils are poor to medium in available phosphorus. Phosphorus is immobile in soil system and hardly 15-20 % of the applied P is utilized by a crop to which it is applied. The rest remains in a fixed state in soil. The P solubilizing microorganisms can mineralize organic P into a soluble form. These micro-organisms render more P into solution than is required for their own growth and metabolism, the surplus is available for plants to absorb. Phosphorus (P) is one of the major essential elements required for the growth and development of the plants. Plants generally take up P in inorganic form ($H_2PO_4^-$, HPO_4^{2-}) from soil solution [2]. In leguminous crops, P promotes root nodulation, nitrogen fixation, nutrient use efficiency, efficient partitioning of photosynthesis between source and sink, and biomass production [3]. The non-availability of fertilizers at economic prices is another problem for the farmers. Under these circumstances, a system comprising balanced use of fertilizer along with multinutrient organic manures and low cost bio fertilizer needs to be evolved. Keeping the above facts in view an present investigation was planned and carried out at the C.S. Azad University of Agriculture and Technology, Kanpur during *kharif* 2020 and 2021 to study the effect of FYM, phosphorus and PSB on growth and yield attributes, yield and economics of Green gram.

2. MATERIALS AND METHODS

A field experiment was carried out at C.S. Azad University of Agriculture and Technology, Kanpur during *kharif* 2020 and 2021. The soil of the experimental area was sandy loam in texture, slightly alkaline in reaction (pH 7.7, 7.8), low in organic carbon (0.41, 0.42 %) and available N (184.5, 186.0 kg ha^{-1}), medium in available P (16.53, 16.9 kg ha^{-1}) and available K (149.36 151.3 kg ha^{-1}) in 2020 and 2021, respectively. The treatments comprised of combinations of 4 levels of FYM viz., control (F_0), 1.0 t/ha (F_1), 2.0 t/ha (F_2), and 3.0 t/ha (F_3), and 5 levels of phosphorus and PSB viz., PSB only (P_1), 20 kg P_2O_5/ha (P_2), 20 kg P_2O_5/ha + PSB (P_3), 40 kg P_2O_5/ha (P_4) and 40 kg P_2O_5/ha + PSB (P_5) laid out in Factorial Randomized Block Design and replicated thrice. The Green gram variety shweta was used during both years. The crop was sown in lines 45 cm apart with a plant to plant distance of 10 cm using a seed rate of 15 kg/ha.

The dry matter accumulation was recorded from five plant sampled from third row of each plot leaving 0.5 m row length both side as border. The sampled plants cut close to the ground, dried in hot air oven at 60 ^{0}C till constant weight. Nodules collected from five sample plants were dried in open for two days and then dried in oven at 65 ^{0}C for 36 hours for recording dry weight. The number of branches was counted on tagged plants and average number of branches per plant was calculated. Yield attribute *viz.* number of pods/plant, pod weight/plant, seeds/pod were recorded from 5 sampled plants. One thousand grain from each treatment were collected at the time of threshing, counted and weighed and recorded as thousand grain weight. Before threshing, bundle weight in each net plot was taken with the help of spring dial balance. The figures were converted into kg ha^{-1}. After threshing, winnowing and cleaning, seed yield of each net plot was weighed and converted into kg ha^{-1}. Grain yield from each net plot was subtracted from the biological yield to get stover yield per net plot. The harvest index was also recorded by dividing the economic yield by the biological yield. The common cost of cultivation of Green gram was worked out considering the

prevailing market rates of different inputs and operations. Then the cost of each treatment was added to common cost and thus total cost of cultivation for each treatment was worked out and recorded (Rs ha^{-1}). The income received from grain and straw in each treatment were added together to get gross income under different treatments. The cost of cultivation of each treatment was subtracted from gross income of respective treatments and recorded as net profit. The total gross return was divided by total cost of cultivation to get return per rupee of investment.

The data recorded on different crop characters during two years of experimentation were subjected to statistical analysis. Year wise analysis was done as suggested by [4] and subsequently pooled over years after testing the homogeneity of error variances of two years. Statistical analysis was done with the help of window-based SPSS (Statistical Product and Service Solutions) Version 10.0, SPSS, Chicago, IL Software on computer.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The higher number of plants/meter was recorded at 40 kg P_2O_5 + PSB in both the years and pooled. The interaction effect among FYM levels and Phosphorus levels and PSB was non-significant (Table 1). It might be due to fact that the experimental crop was sown with uniform seed rate at uniform row spacing under same climatic condition. Similar observations were also made by Keerthi et al. [5] and Rekha et al. [6].The dry weight (g) at maturity was significantly affected by different doses of FYM, Phosphorus and PSB. The interactions were however non significant. At maturity higher dry matter/plant was recorded in 3t FYM/ha (11.59 g) and it being at par with 2t FYM/ha was significantly superior to 1 t FYM/ha and control. Similar findings were reported by Katara et al. [7]. Further the highest dry matter accumulation $plant^{-1}$ (11.31 g) was recorded in 40 kg P_2O_5/ha + PSB and it being at par with 40 kg P_2O_5/ha alone was significantly superior to 20 kg P_2O_5/ha + PSB, 20 kg P_2O_5/ha and PSB alone in both the years and in pooled analysis. It might be due to favorable condition for regulating the metabolic and enzymatic process in plants as reported by Aslam et al. [8], Chesti et al. [9], Verma et al. [10] and Patel et al. [11]. The number of branches $plant^{-1}$ was also influenced significantly under different treatments of FYM and different levels of phosphorus and PSB. However their interaction effect was non-significant. The highest number of branches $plant^{-1}$ was recorded with the application of FYM 3t/ha (4.95) and it was significantly superior to rest of the treatments. The application of 2t FYM/ha was also significantly superior than 1t/ha FYM and control. Similar finding were also reported by Choudhary et al. [12] and Hossain et al. [13]. Further the highest number of branches $plant^{-1}$ at maturity was recorded in 40 kg P_2O_5 + PSB (4.52) and it being at par with 40 kg P_2O_5/ha alone and 20 kg P_2O_5/ha + PSB was significantly superior over 20 kg P_2O_5/ha and PSB alone. This might be due to application of higher doses of FYM which provide favorable condition for growth and development. The results are in agreement with those of supported by Ehsan et al. [14], Kumar and Yadav, [15] and Kumar et al. [16]. Dry weight of nodules $plant^{-1}$ (g) among the different levels of FYM, phosphorus and PSB increased upto 60 DAS was influenced significantly due to different levels of FYM, phosphorus and PSB however their interaction effect was non-significant. The highest dry weight of nodules was recorded with 3t FYM/ha (14.34 g) at 60 DAS and it was significantly superior to rest of the treatments in both the years and in pooled analysis. This was in conformity with those of Choudhary et al. [12], Malik et al. [17] and Sutrisno and Yusnawan, [18]. The highest dry weight of nodules was recorded with the application of 40 kg P_2O_5/ha + PSB (13.42 g) upto 60 DAS and it was significantly superior to rest of the treatments. The highest dry weight of nodules/plant might be due to favorable condition provided by FYM which increased the dry weight of nodules as reported by Singh et al. [19], Mahetele et al. [20], Tagore et al. [21] and Rathour et al. [22].

3.2 Yield Attribute

The number of pods $plant^{-1}$, weight of pods $plant^{-1}$ (g), number of seeds pod^{-1}, weight of seeds $plant^{-1}$ (g) and test weight (g) increased significantly due to different levels of FYM, phosphorus and PSB. However their interaction effect among different levels of FYM, phosphorus and PSB was non-significant (Table 2). The highest number of pods $plant^{-1}$ (14.70), weight of pods $plant^{-1}$ (7.44 g), number of seeds pod^{-1} (9.62), weight of seeds $plant^{-1}$ (4.01g) and test weight (41.36g) were recorded with 3t/ha FYM and it was significantly superior to other levels of

Table 1. Effect of FYM, phosphorus and PSB on growth attribute of green gram

Treatment	Plant population per running meter			Dry weight (g) at Maturity			No. of branches plant^{-1} at maturity			Dry weight of nodules plant^{-1} (g) at 60 DAS		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Level of FYM t ha^{-1}												
0 t ha^{-1}	10.86	10.99	10.93	10.41	10.52	10.47	3.90	3.91	3.91	11.91	11.99	11.95
1 t ha^{-1}	10.66	11.00	10.83	10.93	11.04	10.99	4.18	4.15	4.16	12.79	12.76	12.77
2 t ha^{-1}	10.73	10.86	10.80	11.17	11.30	11.23	4.48	4.47	4.48	13.27	13.26	13.27
3 t ha^{-1}	10.60	10.99	10.80	11.49	11.69	11.59	4.94	4.96	4.95	14.34	14.34	14.34
SEd ±	0.254	0.306	0.199	0.139	0.173	0.103	0.082	0.099	0.063	0.169	0.196	0.128
CD at 5%	N.S.	N.S.	N.S.	0.281	0.351	0.203	0.166	0.200	0.125	0.342	0.396	0.253
Level of phosphorus and PSB												
PSB	10.50	10.91	10.71	10.70	10.85	10.77	4.14	4.15	4.15	12.63	12.69	12.66
20 Kg P_2O_5	10.75	10.75	10.75	10.94	11.09	11.02	4.36	4.35	4.35	12.85	12.76	12.80
20 Kg P_2O_5+ PSB	10.75	11.00	10.87	11.01	11.13	11.07	4.39	4.39	4.39	13.06	13.17	13.11
40 Kg P_2O_5	10.66	10.99	10.83	11.15	11.21	11.18	4.47	4.46	4.46	13.42	13.42	13.42
40 Kg P_2O_5+ PSB	10.92	11.17	11.04	11.20	11.41	11.31	4.52	4.51	4.52	13.43	13.41	13.42
SEd ±	0.284	0.342	0.222	0.155	0.173	0.115	0.092	0.110	0.071	0.189	0.219	0.143
CD at 5%	N.S.	N.S.	N.S.	0.314	0.351	0.227	0.185	0.223	0.140	0.382	0.443	0.282

Table 2. Effect of FYM, phosphorus and PSB on yield attributes of green gram

Treatment	Number of Pods/Plant			Weight of pod/plant (g)			Number of seed/pod			Weight of seed/plant (g)			Test weight (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Level of FYM t ha^{-1}															
0 t ha^{-1}	11.64	11.75	11.70	4.54	4.54	4.55	7.58	7.63	7.60	2.76	2.75	2.76	40.12	40.13	40.13
1 t ha^{-1}	13.49	13.58	13.54	4.63	5.60	5.62	7.93	7.93	7.93	3.13	3.15	3.14	40.29	40.30	40.30
2 t ha^{-1}	13.94	14.10	14.02	6.44	6.42	6.43	8.49	8.50	8.50	3.61	3.62	3.62	40.73	40.75	40.74
3 t ha^{-1}	14.54	14.86	14.70	7.46	7.43	7.44	9.62	9.62	9.62	4.01	4.01	4.01	41.35	41.36	41.36
SEd ±	0.188	0.198	0.135	0.170	0.185	0.124	0.163	0.179	0.120	0.041	0.052	0.033	0.113	0.087	0.071
CD at 5%	0.381	0.401	0.267	0.344	0.375	0.246	0.330	0.363	0.237	0.083	0.106	0.065	0.228	0.175	0.140
Level of phosphorus and PSB															
PSB	12.85	12.98	12.91	5.31	5.32	5.31	7.94	8.01	7.97	2.99	2.99	2.99	40.30	40.31	40.31
20 Kg P_2O_5	13.06	13.19	13.13	5.84	5.82	5.83	8.24	8.26	8.25	3.28	3.28	3.28	40.58	40.59	40.59
20 Kg P_2O_5+ PSB	13.54	13.73	13.63	6.07	6.03	6.05	8.40	8.40	8.40	3.39	3.40	3.40	40.64	40.65	40.65
40 Kg P_2O_5	13.68	13.88	13.78	6.29	6.27	6.28	8.62	8.62	8.62	3.55	3.55	3.55	40.76	40.78	40.77
40 Kg P_2O_5+ PSB	13.89	14.10	13.99	6.58	6.55	6.57	8.82	8.81	8.82	3.68	3.68	3.68	40.84	40.86	40.85
SEd ±	0.210	0.221	0.151	0.190	0.207	0.139	0.182	0.201	0.134	0.046	0.059	0.037	0.126	0.097	0.079
CD at 5%	0.426	0.448	0.299	0.384	0.419	0.275	0.369	0.406	0.265	0.093	0.119	0.072	0.255	0.196	0.167

Table 3. Effect of FYM, phosphorus and PSB on yield of green gram

Treatment	Seed Yield (kg ha^{-1})			Stover Yield (kg ha^{-1})			Biological Yield (kg ha^{-1})			Harvest Index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Level of FYM t ha^{-1}												
0 t ha^{-1}	615	616	616	1023	1030	1027	1638	1646	1642	37.54	37.41	37.47
1 t ha^{-1}	697	701	699	1195	1163	1179	1885	1864	1874	36.98	37.60	37.29
2 t ha^{-1}	825	793	809	1394	1335	1365	2219	2144	2182	37.15	37.70	37.43
3 t ha^{-1}	996	891	894	1499	1473	1486	2392	2354	2371	37.44	37.85	37.65
SEd ±	17.9	20.8	13.5	28.8	33.5	21.8	33.3	37.6	24.8	0.070	0.084	0.055
CD at 5%	36.3	42.0	26.8	58.2	67.8	43.2	67.3	7.62	4.91	0.141	0.170	0.110
Level of phosphorus with PSB												
PSB	665	666	666	1141	1138	1139	1805	1791	1798	36.85	37.17	37.01
20 Kg P_2O_5	734	712	723	1248	1221	1234	1982	1953	1967	37.03	37.47	37.25
20 Kg P_2O_5+ PSB	766	761	764	1298	1258	1278	2060	2019	2039	37.21	37.69	37.45
40 Kg P_2O_5	799	790	795	1337	1298	1318	2136	2088	2112	37.40	37.82	37.61
40 Kg P_2O_5+ PSB	828	823	825	1366	1337	1351	2184	2159	2171	37.89	38.06	37.98
SEd ±	20.1	23.2	15.1	32.2	37.5	24.4	37.2	42.1	27.7	0.078	0.094	0.062
CD at 5%	40.6	47.0	30.0	65.1	75.9	48.3	75.3	85.2	54.9	0.158	0.190	0.123

Table 4. Effect of FYM, phosphorus and PSB on economics of green gram

Treatment	Cost of cultivation (Rs ha^{-1})			Gross income (Rs ha^{-1})			Net income (Rs ha^{-1})			B : C ratio		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Level of FYM t ha^{-1}												
0 t ha^{-1}	24851.00	25148.00	25009.50	46827.20	47889.60	47358.40	21976.20	22741.60	22358.90	1.89	1.90	1.89
1 t ha^{-1}	25843.00	26148.00	25995.50	53143.80	54380.20	53762.00	27300.80	28232.20	27766.50	2.05	2.08	2.07
2 t ha^{-1}	26843.00	27148.00	26995.50	62852.00	62846.00	62849.00	36009.00	35698.00	35853.50	2.33	2.31	2.32
3 t ha^{-1}	27843.00	28148.00	27955.50	68238.80	69249.40	68744.10	40395.00	41186.00	40790.80	2.45	2.46	2.46
SEd ±	-	-	-	542.10	326.73	315.54	244.90	326.47	201.59	0.037	0.034	0.024
CD at 5%	-	-	-	1097.72	661.61	624.76	495.90	661.08	399.15	0.075	0.068	0.048
Level of phosphorus with PSB												
PSB	24399.00	24656.00	24527.50	50704.50	51841.75	51273.13	26305.50	27185.75	26745.63	2.07	2.09	2.08
20 Kg P_2O_5	25539.00	25836.00	25000.00	55901.25	56839.75	56370.50	30362.25	31003.75	30683.00	2.18	2.19	2.19
20 Kg P_2O_5+ PSB	26259.00	26556.00	26407.50	58366.50	59061.25	58713.88	32107.50	32505.25	32306.38	2.22	2.22	2.22
40 Kg P_2O_5	27399.00	27736.00	27567.50	60839.00	61367.25	61103.13	33440.00	33631.25	33535.63	2.21	2.21	2.21
40 Kg P_2O_5+ PSB	28129.00	28456.00	28292.50	63016.00	63846.50	63431.25	34886.75	35496.25	35191.50	2.23	2.24	2.23
SEd ±	-	-	-	606.09	365.30	352.78	273.80	365.00	225.39	0.042	0.038	0.027
CD at 5%	-	-	-	1227.29	739.71	698.50	554.43	739.11	646.27	0.084	0.076	0.054

FYM and control in both the years and in pooled analysis. The increasing doses of FYM increased number of pods plant^{-1}, weight of pods plant^{-1} (g), number of seeds pod^{-1}, weight of seeds plant^{-1} (g) and test weight (g) as compared to control. Similar findings are also reported by Rahman et al. [23], Kumawat et al. [24], Choudhary et al. [12], Yadav et al. [25] and Choudhary et al. [26]. Further the highest number of pods plant^{-1} (13.99), weight of pods plant^{-1} (6.57g), number of seeds pod^{-1} (8.82), weight of seeds plant^{-1} (3.68g) and test weight (40.85g) was recorded with application of 40 kg P_2O_5 + PSB and it was significantly superior to other doses of P_2O_5 + PSB except 40 kg P_2O_5/ha alone. The combined application of phosphorus with PSB increased number of pods plant^{-1}, weight of pods plant^{-1} (g), number of seeds pod^{-1}, weight of seeds plant^{-1} (g) and test weight (g) as compared to phosphorus applied alone. This increase might be due to application of higher doses of phosphorus with PSB which provided favorable condition for growth and better development of plant by providing favorable condition for regulating the metabolic and enzymatic process in plants. Similar observations were reported by Kumawat et al. [27], Pir et al. [28], Singh et al. [29] and Singh et al. [30].

3.3 Yield

The seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), biological yield (kg ha^{-1}), and harvest index (%) were influenced significantly due to different doses of FYM, phosphorus and PSB however their interaction effect was non-significant (Table 3). The highest seed yield (894 kg ha^{-1}), stover yield (1486 kg ha^{-1}), biological yield (2371 kg ha^{-1}), and harvest index (37.65%) were recorded with the application of 3t/ha FYM and it was significantly superior to lower doses of FYM and control on pooled basis. Similar findings were also reported by Kumawat et al. [24], Rekha et al. [6], Choudhary et al. [26] and [16]. The application of levels of phosphorus and PSB also influenced significantly the seed yield (825 kg ha^{-1}), stover yield (1351 kg ha^{-1}), biological yield (2171 kg ha^{-1}), and harvest index (37.98%). The application of 40 kg P_2O_5 + PSB was significantly superior to the rest of the treatments on pooled basis. It may be due to favourable condition provided by higher dose of FYM, phosphorus and PSB which increased the better growth and development of crop with better yield attributes. Similar observations were reported by Malik et al. [31], Singh et al. [29], Rekha et al. [6] and Sharma et al. [32].

3.4 Economics

The highest cost of cultivation (27955.50 Rs ha^{-1}), gross income (68744.10 Rs ha^{-1}), net income (40790.80 Rs ha^{-1}) and B:C (2.46) ratio were recorded with 3 t FYM/ha followed by 2 t/ha FYM and the minimum cost of cultivation was observed under control in both the years and in pooled analysis (Table 4). This may be due to positive effect of FYM on yield of crop through increased growth and yield attributes. Similar findings were also reported by Singh et al. [33], Jat et al. [34], Kishor et al. [35] and Gurjar et al. [36]. However the phosphorus with and without PSB recorded increased cost of cultivation (28292.50 Rs ha^{-1}), gross income (63431.25 Rs ha^{-1}), net income (35191.50 Rs ha^{-1}) and B:C (2.23) ratio with the application of 40 kg P_2O_5/ha + PSB followed by 40 kg P_2O_5 alone, 20 kg P_2O_5/ha + PSB, 20 kg P_2O_5 alone, while the minimum was observed in PSB alone in both the years and in pooled analysis. The increase in net income and B:C ratio might be due to more output as compared to input. Similar findings were reported by Meena et al. [37], Singh et al. [29], Kumar and Yadav, [15] and Teja et al. [38].

4. CONCLUSION

It can be concluded from the above study that application of 3 t ha^{-1} FYM and 40 kg P_2O_5+ PSB is optimum for higher growth and yield attributes, yield and monetary returns in Green gram.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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