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Response of Greengram (*Vigna radiata*) to rock phosphate enriched compost on yield, nutrient uptake and soil fertility in Inceptisol

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Abstract
A field experiment was conducted during summer season 2014-15 at research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.). Treatment comprised with rock phosphate enriched compost and ordinary compost with recommended dose of nitrogen and potassium in Randomized Block Design replicated as thrice. The grain yield (9.68 q ha^{-1}) and straw yield (39.23 q ha^{-1}) were recorded with application of nutrients through 75% RDF + 6 t rock phosphate enriched compost as compared to control and other treatments. Maximum uptake of nitrogen, phosphorus, potassium and sulphur grain was recorded (34.09, 5.33, 17.66 & 2.29kg ha^{-1}) respectively with application of 75% RDF + 6 t Enriched Compost ha^{-1}. Similar trend was observed in greengram straw with application of nutrients through 75% RDF + 6 t enriched compost also. Soil fertility was gradually increased with the application organic sources. The pH, EC and Organic Carbon (7.57, 0.28 dSm^{-1} and 0.60%) were observed maximum with 100% RDF, 75% RDF + 6 t Enriched Compost and 100% RDF + 20 t FYM ha^{-1}, respectively. The maximum availability of N and K (245.13 and 253.69 kg ha^{-1}) was found with the application of 100% RDF + 20 t FYM ha^{-1} while P and S (22.66 and 19.26 kg ha^{-1}) was found with the treatment of 75% RDF + 6 t Enriched Compost ha^{-1} in the post-harvest soil.

Keywords: Enriched compost, FYM, greengram, ordinary compost, yield, soil fertility

Introduction

Pulses play a very important role in human diet as a source of protein because of their high protein content (20-30%). Green gram (*Vigna radiata* L.) is an excellent source of high quality protein. Among pulses it occupies prominent place and is growing popularly by virtue of the high nutritional value, short growth period, low cost production and adaptability in the off season. Greengram(*Vigna radiata* L.) is one of the most important legume crops. It enhances the soil fertility through nitrogen fixation with the help of symbiotic microbial association. The productivity of greengram in Uttar Pradesh was 577 kg ha^{-1} in 2010-11 (IIPR, 2011) [3]. The productivity of greengram of the country as well as state is very low as compared to other countries. Greengram is capable of fixing atmospheric nitrogen through Rhizobium species living in root nodules, Rhizobium spp. Invades the root hairs of greengram and results in the formation of nodules, where free air nitrogen is fixed. These bacteria, although present in most of the soils help to improve nodulation, N_2-fixation solicit crop growth and yield of leguminous crops (Tagore *et al.* 2013) [13].

The integrated use of enriched compost and inorganic fertilizers ensures higher productivity, minimizes expenditure on costly fertilizer inputs, improves physical properties of soil, efficiency of added nutrients and at the same time ensures good soil health and is also an environment-friendly approach. Combined application of chemical fertilizers and enriched compost improved greengram productivity (Sutaria *et al*. 2010) [12]. Phosphorus plays a vital functional role in energy transfer and metabolic regulation and it is an important structural component of many molecules. Phosphorus fertilization usually result in enhanced nodule number and mass, as well as greater N_2 fixation activity per plant as nodules is strong sink for P, reaching concentrations. Both phosphorus status and P-fixing capacity of soil strongly influences the phosphorus availability, (Rana *et al.* 2011) [11].

Recycling/composting of organic wastes is one of the major solutions for reducing the huge piles of organic wastes and converting it into a value added product. Value addition in organic manures is a system of agriculture that uses environmentally sound techniques for raising crops and livestock that are used in a certain proportion with synthetic compound. The methods used in value addition in organic manures seeks to increase long term soil fertility, balance insect and organism populations and reduce air, soil and water pollution while maintaining or increasing levels of production. Availability of FYM and other organic manures to apply to soil as per the recommendation is very difficult. Therefore, there is a need to develop viable technology to increase the efficiency of inorganic fertilizers through enriched organic manures. It has been proved that addition of P-enriched farmyard manure to the soil reduced the fixation and enhanced the availability of P to crops from the native and applied source. The huge amount of animal dung needed in the present situation which is difficult to manage for whole farming area, therefore demand of value addition technology in the area of composting and organic farming.

Materials and Methods

The field experiment was conducted during summer season, 2015 at research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.). The eleven treatment combinations comprised with rock phosphate enriched compost and ordinary compost with recommended dose of nitrogen and potassium in randomized block design replicated as thrice. The treatments were T_1- Control N,P,K (00,00,00), T_2- 100%RDF, T_3- 100% RDF+ 20 t FYM ha-1 (Standard Package of Practice), T_4-75% RDF + 4 t Ordinary Compost, T_5 -75% RDF + 6 t Ordinary Compost, T_6- 75% RDF + 4 t Enriched Compost, T_7 - 75% RDF + 6 t Enriched Compost,T_8 - 50% RDF + 4 t Ordinary Compost, T_9- 50% RDF + 6 t Ordinary Compost, T_{10} - 50% RDF + 4 t Enriched Compost, T_{11} -50% RDF + 6 t Enriched Compost. The variety HUM-16 was taken as a test crop. The initial and post harvest soil of Agriculture Research Farm, I.Ag.Sc., BHU, was analyzed through the methods like available nitrogen, phosphorus (Olsen *et al*. 1954) [9], potassium (Hanway and Heidal 1952) [2], sulphur (Chesnin and Yien 1950) [1], organic C (Walkley and Black 1934) [15], Soil pH and EC (Jackson 1973) [5] by electrical conductivity meterand found sandy loam in texture(piper, 1966) [10]. The initial soil was found low in organic carbon (0.28%), available nitrogen (145.52 kg ha^{-1}) and moderate in phosphorus(11.62 kg ha^{-1}), potassium content(162.65 kg ha^{-1}), sulphur (10.36 kg ha^{-1}) with slightly alkaline in reaction(7.6 pH) and safe electrical conductivity (0.22 dSm^{-1})were observed. Nitrogen in grain and stover was determined by modified Kjeldahl method. Oven dried grain and stover samples were digested in di-acid mixture and P, K and S were determined by adopting standard methods (Jeckson 1973).The fertilizers were applied as half dose of N and full doses of P and K at the time of sowing of summer greengram and remaining N fertilizer was applied in the two equal splits at 20 and 40 DOS. The recommended doses (100, 75 and 50% ha^{-1}) were applied through urea, DAP and Muriate of potash respectively.

Rock Phosphate Enriched Compost

In the present study, low-grade Rock Phosphate was taken from Rajasthan State Mines and Minerals Ltd., Udaipur, Rajasthan. The powder RP had 8.84% total P, 1.29% citrate soluble P. Rice straw was collected from the research farm of I.Ag.Sc, BHU, Varanasi. Six pits were prepared for composting. The pit size 4.0 m × 1.5 m × 1.0 m was managed and phosphorus enriched (three pits) and ordinary composts (three pits) were prepared. For carbon-rich compost, paddy straw was added with rock phosphate and gypsum in the ration of 5:1 in layers according to the size of pit separately.

Phosphate Solubilizing Bacteria (PSB) and cow dung concentrated solution was also mix in the pit of composting mixture to enhance the solubility of phosphorus and decomposition rate of plant materials. Water was added to keep the moisture level between 50- 60 percent at the interval of 3-4 days. The upper most layers were prepared by cow dung, worked as a lid of the pit; therefore, decomposition rate was also increased. The composting mixture was left to decompose. A fortnight turning of composting mixture was done to ensure the even distribution of the heat. The mixture of the composting was turned at every 2 weeks for about four months, until the compost is dark brown, crumbly and uniform. Chemical analysis was done of mature compost to assess the EC, pH, O.C., N, P, K & S status before conduct the experiment. The Rock Phosphate enriched compost was prepared using Rock Phosphate and rice straw as per the procedure outlined mentioned above. The matured compost (about 120 days old) was characterized as per the standard procedures. It had pH (compost : water 1:4) 6.92, electric conductivity (EC, compost : water 1:4) 3.18 dSm^{-1}, total organic C 28.3%, total N 2.24%, total P 2.58%, total K 1.44% and S 1.21%.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Yield

Rock phosphate enriched compost application realized spectacular improvement in seed and straw yield of green gram. The maximum grain yield (9.68 q ha^{-1}) and straw yield(39.23 q ha^{-1}) were recorded with treatment T_7 (75% RDF + 6 t E.C.) over control (T_1). The treatment T_3 (38.03 q ha^{-1}), and T_2 (37.22 q ha^{-1}) have shown an increase of 41 and 38%, respectively over control (26.91 q ha^{-1}), Mujahid and Gupta, (2010)[8]. This might be due to the role of phosphorus (rock phosphate enriched compost) on promotion of root growth and there by enhancement in renewable of nitrogen by the crop. The improvement in yield is attributed to increase in root nodulation due to phosphorus application through rock phosphate enriched compost. The results are in line with the findings of Indira *et al.* (2010) [4], Wagadre *et al*. (2010) [14], Rana *et al.* 2011 [11], Meena R.S. (2013) [7] and Tagore *et al.* (2013) [13].

Uptake of nutrients

Distinct variation in N, P, K, and S The maximum value of nitrogen uptake by grain (34.09 kg ha^{-1}) and straw (91.14 kg ha^{-1}) were recorded with application of phosphorus through75% RDF + 6 t E.C. (T_7) over control. In case of straw nitrogen uptake varied from 49.61 to 91.14 kg ha^{-1}. The similar trend was shown in case of nitrogen uptake by straw (table 1). There was a concomitant increase in nitrogen uptake with increasing organic manure as well as inorganic fertilizer. The similar findings also observed by Wagadre *et al*. (2010) [14], Rana *et al.* 2011[11]. Phosphorus application through rock phosphate enriched compost had shown remarkable improvement on uptake of phosphorus by grain varied from 1.58 to 5.33 kg ha^{-1} and straw varied from 3.71 to 16.58 kg ha^{-1}. The maximum P uptake by grain (5.33 kg ha^{-1}) and straw (10.59 kg ha^{-1}) were recorded with treatment T_7(75% RDF + 6 t E.C) over control. Similar response has been observed by Kumari and Ushakumari (2002) [6].

It is apparent that the uptake of potassium was higher in straw than grain. Potassium uptake by grain varied from 10.16 to 17.66 kg ha^{-1}. The maximum uptake of potassium by grain and straw (17.66 kg ha^{-1}) and (27.85 kg ha^{-1}) were recorded with T_7(75% RDF + 6 t E.C) respectively (table 1). The minimum uptake (10.16 kg ha^{-1}) was recorded in control. Potassium uptake by straw varied from 14.80 to 27.85 kg ha^{-1}. The uptake of sulphur by grain varied from 1.32 to 2.29 kg ha^{-1}. The maximum sulphur uptake by grain (2.29 kg ha^{-1}) (5.52 kg ha^{-1}) were recorded with the application of 75% RDF + 6 t E.C(T_7) over control (1.32 kg ha^{-1}) and(3.35 kg ha^{-1}) respectively.

Fertility status of post-harvest soil

Spectacular improvement in N, P, K and S status of soil (kg ha^{-1}) was found due to application of rock phosphate enriched compost. The maximum pH (7.57) observed in treatment T_2 (100% RDF) and the Minimum pH (7.33) was observed in treatments T_3 (100% RDF + 20 t FYM ha^{-1}). Decreasing of soil pH due to addition of organic sources of nutrients towards neutrality (table 2).It is evident that EC of post-harvest soil ranged between 0.22 to 0.28 dSm^{-1}. The minimum value of EC (0.22 dSm^{-1}) was recorded in T_1 (Control) while maximum E.C. (0.28 dSm^{-1}) was observed in treatment T_7 (75% RDF + 6 t E.C.) which was safe in terms of crop production. This might be due to more soluble salts present in the enriched compost by the addition of rock phosphate and gypsum. It is evident that there was a significant increase in organic carbon content of soil with application of organic sources of plant nutrients. The percent organic carbon content in soil ranged from 0.35 to 0.60%. The maximum organic carbon content (0.60%) was observed in T_3 (100% RDF + 20 t FYM ha^{-1}) followed by 0.57% in T_7 (75% RDF + 6 t E.C.) which showed a respective increase of 71 and 63%, over treatment T_1(0.22%). This might be due to application of high amount of organic manure (FYM).

The available nitrogen content of soil ranged between 211.66 to 245.13 kg ha^{-1} in treatment T_1(control) and treatment T_3 (100% RDF + 20 t FYM ha^{-1}), respectively (table 2). Maximum availability of nitrogen was found in treatment T_3 (100% RDF + 20 t FYM ha^{-1}). Its might be due to application of 100% RDF with higher amount of organic manure (FYM).In the present study application of rock phosphate enriched compostT_7 (75% RDF + 6 t E.C.) brought marked improvement in phosphorus availability. Available phosphorus in soil was balanced only 13.19kg ha^{-1} in control (T_1) but the application of organic and inorganic sources of plant nutrients, increased significantly up to 22.66 kg ha^{-1} in T_7 (75% RDF + 6 t E.C.). The available K content in soil ranged between 183.54 to 253.69 kg ha^{-1}.Maximumpotassium (253.69 kg ha^{-1}) was found in treatment T_3 (100% RDF + 20 t FYM ha^{-1}) over control (183.54 kg ha^{-1}). The available potassium observed in post-harvest soil 248.49, 245.06 and 244.78 kg $ha^{-1}$with treatment T_7, T_6 and T_2, respectively which were 35, 34 and 33% higher over control (T_1). This gradually increased of available potassium may be due to application of enriched compost and ordinary compost with farm yard manure. The available sulphur in post-harvest soil varied from 10.91 to 19.26 kg ha^{-1}. The minimum being is treatment T_1 (10.91 kg ha^{-1}) while maximum availability of S content (19.26 kg ha^{-1}) was observed in treatment T_7 (75% RDF + 6 t E.C.) (table 2). The magnitude of increase in the status of sulphur was under T_7 (75% RDF + 6 t E.C.) due to addition of gypsum in rock phosphate enriched compost.

Table 1: Effect of rock phosphate enriched compost with fertilizers on yield and uptake of N, P, K and S (kg ha^{-1}) by grain and straw of green gram.

Treatment	Yield (q ha^{-1})		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	6.52	26.91	13.88	49.61	1.58	4.75	10.16	14.8	1.32	3.35
T_2	8.62	37.22	30.07	85.6	4.06	9.18	15.44	25.31	1.91	4.88
T_3	9.31	38.03	33.01	88.86	4.72	9.89	16.97	26.75	2.09	5.02
T_4	8.1	32.11	26.43	69.03	3.24	6.96	13.82	19.91	1.8	4.15
T_5	8.39	32.49	28.02	70.83	3.5	7.15	14.49	20.9	1.9	4.28
T_6	9.19	36.05	32.09	81.58	4.44	8.77	16.32	24.51	2.14	4.94
T_7	9.68	39.23	34.09	91.14	5.33	10.59	17.66	27.85	2.29	5.52
T_8	7.62	30.9	22.97	65.61	2.77	6.49	12.46	18.54	1.64	3.91
T_9	8.05	31.39	25.28	66.86	3.06	6.91	13.5	18.62	1.76	4
T_{10}	8.61	33.8	29.15	75.16	3.7	7.55	15.01	22.08	1.95	4.52
T_{11}	8.95	34.48	30.64	78.49	4.06	8.27	15.82	23.44	2.07	4.7
SE m±	0.17	0.22	0.606	0.487	0.1	0.16	0.31	0.26	0.04	0.04
CD (P=0.05)	0.48	0.62	1.746	1.403	0.28	0.47	0.89	0.75	0.11	0.1

T_1- Control N,P,K (00,00,00), T_2- 100% RDF, T_3- 100% RDF+ 20 t FYM ha^{-1}, T_4-75% RDF + 4 t Ordinary Compost, T_5 -75% RDF + 6 t Ordinary Compost, T_6- 75% RDF + 4 t Enriched Compost, T_7 - 75% RDF + 6 t Enriched Compost,T_8 - 50% RDF + 4 t Ordinary Compost, T_9- 50% RDF + 6 t Ordinary Compost, T_{10} - 50% RDF + 4 t Enriched Compost, T_{11} -50% RDF + 6 t Enriched Compost.

Table 2: Effect of rock phosphate enriched compost and fertilizers application on soil pH, EC, OC, available N, P, K, and S of post-harvest soil.

Treatment	pH	EC (dSm^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})
T_1	7.53	0.22	0.35	211.66	13.19	183.54	10.91
T_2	7.57	0.26	0.41	240.15	15.24	244.78	11.90
T_3	7.33	0.27	0.60	245.13	16.20	253.69	14.30
T_4	7.53	0.26	0.52	237.62	17.19	240.25	15.24
T_5	7.47	0.27	0.56	239.00	18.17	241.01	15.50
T_6	7.43	0.27	0.54	235.72	21.13	245.06	16.89
T_7	7.43	0.28	0.57	238.74	22.66	248.49	19.26
T_8	7.47	0.25	0.51	230.77	16.88	236.01	16.29
T_9	7.47	0.25	0.56	232.13	17.86	238.59	16.38
T_{10}	7.47	0.26	0.52	230.10	18.88	244.47	16.63
T_{11}	7.43	0.27	0.55	233.54	19.73	245.70	18.12
SE m±	0.043	0.005	0.005	24.14	0.26	0.36	0.30
CD (P=0.05)	0.123	0.013	0.015	69.53	0.74	1.02	0.87

T_1- Control N,P,K (00,00,00), T_2- 100% RDF, T_3- 100% RDF+ 20 t FYM ha^{-1} (Standard Package of Practice), T_4-75% RDF + 4 t Ordinary Compost, T_5 -75% RDF + 6 t Ordinary Compost, T_6- 75% RDF + 4 t Enriched Compost, T_7 - 75% RDF + 6 t Enriched Compost,T_8 - 50% RDF + 4 t Ordinary Compost, T_9- 50% RDF + 6 t Ordinary Compost, T_{10} - 50% RDF + 4 t Enriched Compost, T_{11} -50% RDF + 6 t Enriched Compost.

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