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Effect of phospho enriched compost and zinc on soil properties and productivity of blackgram (*Vigna mungo*)

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ABSTRACT

A field experiment was conducted during *kharif* 2018 at Rajasthan College of Agriculture, Udaipur (Rajasthan), to study the effect of phospho enriched compost and zinc on soil properties and productivity of blackgram (*Vigna mungo* L.) in Typic Haplustepts soil of sub-humid southern plain of Rajasthan. The treatments comprised of four levels of phospho enriched compost (PEC), i.e. control, PEC @ 2, 4 and 6 t/ha and four levels of zinc i.e. control, Zn @ 2, 4 and 6 kg/ha.The experiment was laid out in a factorial randomized block design with three replications. Results revealed significant increase in soil available nitrogen, potassium and zinc content with increasing levels of phospho enriched compost and zinc up to 4 t/ha and 4 kg/ha, respectively and also significantly enhanced the crop yield, protein content and economics of blackgram. However, interactive effect of the seed and stover yield was found to be significantly higher in combined application of phospho enriched compost @ 6 t/ha and zinc @ 6 kg/ha as compared to other combinations of phospho enriched compost and zinc. The application of phospho enriched compost @ 4 t/ha and zinc @ 4 kg/ha along with the recommended dose of fertilizer results in significantly higher productivity, protein content and economics of blackgram under Typic Haplustepts soil.

Keywords: Blackgram, Phospho enriched compost, Productivity, Quality, Soil properties, Zinc

Blackgram (*Vigna mungo* L.) is one of the important pulse crops in India and it is also a main *kharif* pulse crop in Rajasthan. Blackgram is a rich source of protein, fat, mineral nutrients and phosphorus. In Rajasthan, blackgram is grown as a rainfed *kharif* crop in an area of around 5.40 lakh ha with production of around 3.37 lakh tonnes with productivity of around 559 kg/ha (DAC&FW 2018-19). The sub-optimal nutrition and low inherent fertility of soils in terms of organic matter and micronutrients are among the many reasons for low productivity of this crop. Organic matter addition into the soil in the form of compost of agricultural residues is a viable strategy for enhancing the soil fertility. Preparation of phospho enriched compost (PEC) by value-addition through cheap minerals like rock phosphate improves the soil fertility (Gaind *et al*. 2006), enhance the growth and yield of crops (Sreenivas *et al*. 2000) and saving in cost of chemical fertilizers (Erhart *et al*. 2005). Beside, PEC being a niche for beneficial microbes it enriches the soil with indigenous micro-flora and fauna (Paul 2007).

In India, zinc is considered as the third important yield limiting nutrient after the nitrogen and phosphorus (Takkar and Randhawa 1978). Zinc is an essential element for the activities of a number of antioxidant enzymes which are crucial for maintaining the membrane lipids, proteins and nucleic acids in plant cells (Cakmak 2008). Most of the soils of Rajasthan which are coarse textured, low in organic carbon and zinc deficient (Singh and Singh 1981). Hence, the optimal application of Zn in soil is essential for higher productivity and quality of crops. In coarse texture soils which are low in organic carbon, moisture retention and microbial activity the efficiency of native as well as applied micro-nutrients can be further improved when these are used in conjunction with organic manures. Hence, looking to the above facts the present investigation was carried out to study the effect of phospho enriched compost and zinc on soil properties and productivity of blackgram in sub-humid southern plain of Rajasthan.

MATERIALS AND METHODS

Experimental site and soil: The field experiment was conducted during *kharif* 2018 at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur

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situated at an altitude of 579.5 m amsl and at 24°34' latitude and 73°42' longitude. The region falls under Agro-climatic zone-IVa (Sub-humid Southern Plain and Aravalli Hills) of Rajasthan. Soil of the experimental site was clay loam in texture, alkaline in reaction, medium in organic carbon, low in available N, P, high in available K and low in available zinc.

Raw material and preparation of PEC: Rock phosphate and mica were collected from mining sites in Udaipur district of Rajasthan, whereas maize stover and FYM were obtained from the farm section of Rajasthan College of Agriculture, Udaipur. Before compost preparation the raw materials were analyzed for chemical composition as per the standard laboratory procedures. For the preparation of PEC, 15 kg air dried maize stover chopped in to 5-6 cm size and soaked in water for 24 hr. After soaking, it was mixed thoroughly with required quantities of rock phosphate (RP) and waste mica. To reduce the C:N ratio of maize stover, urea solution @ 0.25 kg N per 100 kg of maize stover and fresh cow dung @ 10 kg per 100 kg of maize stover was added as natural inoculants. Phosphate solubilizing microorganism @ 50 g per 100 kg was also added to maize stover. After that the whole composting mass was mixed thoroughly and put in the cemented pits and covered with jute bag sheets for maintaining moisture. To provide adequate aeration turning was performed after 15, 30 and 60 days of composting and throughout the experiment moisture was maintained to 60% of water holding capacity. The composting process was followed up to 120 days for proper decomposition and nutrient enrichment in the PEC. The chemical composition of phospho enriched compost (N 0.845%, P 1.218% and K 1.159% and Zn 35.2 ppm) used in field experiment.

Experimental design and treatments: The experiment was laid out in factorial randomized block design and replicated thrice in the plot size of 4.0 m × 3.0 m (12 m^2). The treatments comprised of four levels of PEC, viz. control, 2.0, 4.0 and 6.0 t/ha PEC and four levels of zinc, viz. control, 2.0, 4.0 and 6.0 kg/ha of Zn.

Protein content: Protein content in seed was obtained by multiplying the per cent nitrogen (N) content by 6.25 (AOAC 1960).

$$\text{Protein content (\%)} = \text{N content (\%)} \times 6.25$$

Statistical analysis: The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique for a factorial randomized block design. The results are presented at 5% level of significance (P=0.05).

RESULTS AND DISCUSSION

Yield

Effect of phospho enriched compost level: The application of phospho enriched compost enhanced the seed and stover yield of blackgram significantly (Table 1). The maximum seed yield (1001 kg/ha) and stover yield (1632 kg/ha) was observed under PEC@ 6 t/ha. The seed and stover yield were increased significantly up to PEC@ 4 t/ha which was found to be statistically at par with PEC@ 6 t/ha. The increase in seed and stover yield was to the extent of 11.9, 30.0 and 35.7% and 13.2, 22.7 and 28.0% with the application of PEC@ 2, 4 and 6 t/ha, respectively as compared to control. The significant increase in seed and stover yield under the influence of PEC was largely a function of improved growth and yield attributes which eventually contributed in increased seed and stover yield.

Table 1 Effect of PEC and Zn levels on yield, quality, soil properties and economics of blackgram

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Protein content (%)	pH	EC (dS/m)	Organic carbon (%)	Available nitrogen (kg/ha)	Available phospho-rus (kg/ha)	Available potassi-um (kg/ha)	Avail-able zinc (mg/kg)	Net returns (₹/ha)
PEC levels (t/ha)											
Control	642^{a}	1175^{a}	18.09^{a}	8.27	0.672	0.622	273.12^{a}	15.92^{a}	357.11^{a}	0.592^{a}	15119^{a}
2	730^{b}	1353^{b}	19.87^{b}	8.22	0.631	0.664	299.45^{b}	17.32^{b}	385.01^{b}	0.731^{b}	19591^{b}
4	919^{cd}	1521^{cd}	20.54^{c}	8.19	0.590	0.701	321.72^{c}	19.29^{c}	409.58^{c}	0.914^{c}	25938^{c}
6	1001^{cd}	1632^{cd}	21.22^{cd}	8.10	0.548	0.745	339.04^{d}	22.15^{d}	431.29^{cd}	1.012^{d}	27182^{cd}
SEm ±	29.59	43.64	0.35	0.027	0.014	0.014	5.04	0.11	7.64	0.008	1539.4
CD (P=0.05)	85.47	126.04	1.02	0.078	0.040	0.040	14.58	0.32	22.07	0.023	4446.2
Zn levels (kg/ha)											
Control	640^{a}	1174^{a}	18.05^{a}	8.24	0.632	0.653	273.41^{a}	19.44^{a}	361.66^{a}	0.594^{a}	13312^{a}
2	732^{b}	1354^{b}	19.85^{b}	8.22	0.625	0.686	302.07^{b}	19.10^{b}	390.70^{b}	0.728^{b}	18264^{b}
4	917^{c}	1520^{c}	20.59^{c}	8.18	0.602	0.689	322.20^{c}	18.69^{c}	410.36^{c}	0.912^{c}	27323^{c}
6	1001^{cd}	1633^{cd}	21.22^{cd}	8.14	0.583	0.705	335.66^{cd}	17.45^{d}	420.26^{cd}	1.015^{d}	31590^{cd}
SEm ±	29.59	43.64	0.35	0.027	0.014	0.014	5.04	0.11	7.64	0.008	1539.4
CD (P=0.05)	85.47	126.04	1.02	NS	NS	NS	14.58	0.32	22.07	0.023	4446.2

*Means superscripted with same letters are statistically at par at P=0.05. NS = Non-significant

The incorporation of PEC in the soil ensures successive and almost continuous supply of macro and micro nutrients to the blackgram over the entire crop growth period (Biswas 2011). The inter relationship between yields attributes and its seed and stover yield had also been observed by Mali *et al.* (2017).

Effect of zinc level: The application of zinc enhanced the seed and stover yield of blackgram significantly (Table 1). The maximum seed yield (1001 kg/ha) and stover yield (1633 kg/ha) was observed under 6 kg Zn/ha. The seed and stover yield was increased significantly up to zinc @ 4 kg/ha and remained at par with 6 kg Zn/ha. The application 2, 4 and 6 kg Zn/ha increased the seed yield and stover yield to the extent of 12.5, 30.1 and 36.0% and 13.2, 22.7 and 28.0%, respectively as compared to control. This might be attributed to increase in yield attributes due to increased supply of available zinc in deficient soil. The significant increase in yield due to zinc fertilization could be attributed to the increased plant growth and biomass production, possibly as a result of the uptake of nutrients. These results are supported by findings of Mahilane and Singh (2018) in blackgram.

Quality

Effect of phospho enriched compost level: The application of increasing levels of phospho enriched compost increased significantly the protein content in blackgram seeds (Table 1). The maximum protein content in seed (21.22%) was observed under PEC@ 6 t/ha and the application of PEC@ 2, 4 and 6 t/ha increased the protein content in seed to the extent of 8.9, 11.9 and 14.7%, respectively as compared to control. However, the difference between PEC_2 and PEC_3 treatment were found to be statistically at par. The application of phospho enriched compost increase availability of N to the plant which was ultimately utilized for synthesis of protein and its translocation into seed. These results are in agreement with those of Mali *et al.* (2017).

Effect of zinc level: The application of Zn@ 6 kg/ha recorded maximum protein content in seed (21.22%) and the application of Zn @ 2, 4 and 6 kg/ha increased the protein content in seed to the extent of 9.1, 12.3 and 14.9%, respectively (Table 1). However, the difference between Zn_2 and Zn_3 treatment were found to be significantly at par.This is because of increased nitrogen content in seed which might be due to the increased availability of nitrogen to plants.Another reason for higher nitrogen content might be due to increased activity of nitrate reductase enzymes owing to zinc application. Similar, results have also been reported by Todawat *et al.* (2017).

Soil properties

Effect of phospho enriched compost level: The application of phospho enriched compost at increasing rates significantly decreased pH, electrical conductivity. However, organic carbon and available nutrient content in soil increased significantly after harvest of crop (Table 1). The decrease in pH and electrical conductivity of soil with the application of PEC is due to production of organic acids on decomposition of organic matter by the microorganisms and improvement in soil aggregation might have resulted in to lowering of soil pH and electrical conductivity (Nagar *et al.* 2016). The maximum soil organic carbon (0.745%) and nutrient contents, i.e. available N (339.04 kg/ha), P (22.15 kg/ha), K (431.29 kg/ha) and Zn (1.012 mg/kg) were observed under PEC_3 (phospho enriched compost @ 6 t/ha). However, in case of available potassium the difference between PEC_2 and PEC_3 treatment were also found to be statistically at par.The significant increase in organic carbon and available nutrients content of the soil after harvest of crop by application of phospho enriched compost may not only improves crop yield but also increases nutrient uptake besides improving the physical, chemical and biological properties of the soil, thereby provides better soil environment for growth and development (Biswas 2011 and Dsouza *et al*. 2018).

Effect of zinc level: The application of zinc significantly enhanced the available nitrogen, potassium and zinc content in soil and available phosphorus in soil decreased whereas, the pH, electrical conductivity and organic carbon were found to be non-significant at harvest stage of crop (Table 1). The maximum available N content (335.66 kg/ha), available potassium (420.26 kg/ha) and available zinc (1.015 mg/kg) in soil was observed under treatment Zn_3 (Zn @ 6 kg/ha) and the minimum under Zn_0 (control).The application of 6 kg Zn/ha increased the available N, K and Zn content in soil to the extent of 18.55, 13.94 and 41.48%, respectively as compared to control. However, in case of available nitrogen and potassium the difference between Zn_2 and Zn_3 treatment were found to be significantly at par. It might be due to effect of zinc on microbial nitrogen fixation in soil which was also indicated by Hemalatha and Chellamuthu (2013). The experimental soil being low in available zinc might have resulted in increased available zinc with the increasing level of zinc application. The result was in conformity to those of reported by Todawat *et al.* (2017).On the other hand, application of zinc significantly decreased the availability of phosphorus the cause behind this can be ascribed to antagonistic effect of zinc on availability of phosphorus, due to formation of insoluble zinc phosphate at higher concentration of zinc which reduces the availability of phosphorus. Such finding was reported by Todawat *et al.* (2017).

Economics

Effect of phospho enriched compost level: The increasing levels of phospho enriched compost application significantly increased the net return of blackgram (Table 1). The maximum net return (₹ 27182/ha) was observed under the treatment PEC_3 (phospho enriched compost @ 6 t/ha) and the minimum (₹ 15119/ha) under control (PEC_0). However, the difference between PEC_2 and PEC_3 treatment were found to be statistically at par. The net return significantly increased due to consequence of increase in seed and stover yield (Todawat *et al.* 2017).

Table 2 Interactive effect of PEC and zinc on seed yield and stover yield of blackgram

Treatment	Control	PEC@2.0 t/ha	PEC @ 4.0 t/ha	PEC@6.0 t/ha
	Seed yield (kg/ha)			
Control	1170	1653	2309	2555
Zn@ 2.0 kg/ha	1747	2028	2386	2632
Zn@ 4.0 kg/ha	2328	2401	3018	3263
Zn @ 6.0 kg/ha	2469	2676	3315	3561
SEm ±		59.18		
CD (P=0.05)		170.94		
	Stover yield (kg/ha)			
Control	2481	3340	3969	4305
Zn@ 2.0 kg/ha	3456	4021	4218	4553
Zn@ 4.0 kg/ha	3995	4257	4831	5165
Zn @ 6.0 kg/ha	4170	4628	5234	5568
SEm ±		87.28		
CD (P=0.05)		252.08		

Effect of zinc: The application of zinc significantly increased the net returns as compared to control (Zn_0). The significantly maximum net return was obtained under the treatment Zn 6 kg/ha (₹ 31590/ha) and the minimum under control (₹ 13312/ha). However, the increase was significant up to Zn_2 which was also found to be statistically at par with Zn_3 (Table 1). It is clear that the treatment there was significant increase in seed and stover yield which ultimately gave more net return for the input cost incurred in these treatments (Todawat *et al.* 2017).

Interaction effect of PEC and zinc on seed and stover yield: A significant interactive effect of PEC and zinc on seed yield and stover yield of blackgram ware observed (Table 2). Although, all the combinations of PEC and zinc levels recorded significantly higher yield over control, However, the maximum seed yield (3561 kg/ha) and stover yield (5568 kg/ha) was obtained under PEC @ 6 t/ha and Zn@ 6 kg/ha combination and the lowest under control. The increase in seed and stover yield might be due to the fact that PEC and zinc had an additive effect. Since the experimental soil was deficient in nutrients especially Zn the supplementation of Zn with PEC incorporation improved the availability of both nutrients as well as water by increased water and nutrient retention in the root zone by reducing infiltration and percolation. These findings are in agreement with those of Todawat *et al.* (2017) on greengram.

On the basis of experimental finding, it can be concluded that the application of PEC @4 t/ha + Zn @ 4 kg/ha alongwith the recommended dose of fertilizer results in significantly higher yield and protein content of blackgram under Typic Haplustepts soil of sub-humid southern plain of Rajasthan.

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