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Effect of rock phosphate enriched compost on yield and yield attributes of finger millet-cowpea cropping system in Cauvery command area, Karnataka

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Abstract
A field experiment was conducted at Zonal Agricultural Research Station, VC Farm, Mandya during *kharif* 2017, summer 2018, *kharif* 2018 and summer 2019 to study the effect of rock phosphate enriched compost on yield and yield attributes of finger millet-cowpea cropping system. Prior to initiation of the field experiment, three different composts *viz*., urban solid waste compost (USWC), vermicompost and farm yard manure (FYM) were enriched with rock phosphate at 5 per cent. Field experiment consisting of eleven treatment combinations comprising recommended N and K, and P through varied levels of enriched composts. The experiment was laid out in RCBD design with three replications and the test crops were finger millet and cowpea. The initial P_2O_5 of the experimental site was very high (133.58 kg ha^{-1}). The results revealed that application of recommended N and K + 75 per cent P supplied through enriched USWC (T_5) had significantly higher grain (45.15) and straw yield (60.36 q ha^{-1}) of finger millet and significantly higher grain (14.62) and haulm yield (29.98 q ha^{-1}) of residual cowpea in pooled analysis and found on par with recommended N and K + 75 per cent P supplied through enriched vermicompost (T_8). Yield attributes *viz*., number of ear heads hill^{-1} (4.30), number of fingers head^{-1} (6.43) and test weight (3.48 g) were recorded significantly in T_5 treatment of finger millet. Similarly, treatment T_5 noticed significantly higher number of pods plant^{-1} (27.34) and number of seed pod^{-1} (18.56) in residual cowpea.

Keywords: USWC, Vermicompost, FYM, Rock phosphate, Finger millet, Cowpea

Introduction
The continuous monocropping and over use of inorganic fertilizers without organic input degrade the soil quality and health of the soil and cause environmental pollution as well (Albiach *et al*., 2000) [2]. Soil quality could be restored by proper and careful soil management by different manurial practices. The application of organics along with inorganic fertilizers is an important practice in organic farming to improve soil quality, enhance microbial activity and nutrient recycle to produce high-quality crops. Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients turnover and many other related physical, chemical and biological parameters of the soil (Albiach *et al*., 2000) [2].
Phosphorus (P) is one of the major essential macronutrients required for the plant growth. Globally more than 5.7 billion hectares of land contain very low available P (Hinsinger, 2001) [12]. Recently, rock phosphate (RP), which is used as a raw material for phosphatic fertilizers, is appeared to be a potential source of plant P nutrition (Yu *et al*., 2012) [39]. Unfortunately, P in RP is not easily available in soils with an alkaline pH and even when conditions are optimal, plant yields are lower than those obtained with soluble phosphate (Khasawnech and Doll, 1978) [15]. Availability of P from relatively insoluble RP can be improved by integrating it with organic residues (Biswas and Narayanasamy, 2006) [3] and phosphate solubilizing microorganisms (Chi *et al*., 2007) [4]. Many studies have shown that the enriched compost improves physical and chemical properties of soils by increasing nutrient content, organic matter, water holding capacity and cation exchange capacity. Thus contributing to improvement of crop yield and quality (Mylavarapu and Zinati, 2009; Iovieno *et al*., 2009) [22, 13]. Keeping in view, the benefits of organic manuring as well as its inherent limitations such as analysis and slow action, a study was taken up to investigate the possibility of conversion of compost (USWC, vermicompost and FYM) into phosphate enriched compost through RP and to evaluate their nutritional quality of the crop.

Finger millet-cowpea is a major cereal-pulse based cropping system followed in southern dry zone of Karnataka. Finger millet (*Eleusine coracana* (L.) Gaertn) is an important cereal that belongs to the grass family *Poaceae*, sub family *Chloridoidae*. It is estimated that finger millet accounts for some 10 per cent of the 30 million tons of millet produced globally (Dida *et al.*, 2008) [5]. In India, it is cultivated on 1.8 m ha with average yields of 1.3 t ha^{-1}. In Karnataka, finger millet is grown in an area of 0.76 m ha producing 1.32 m t with a yield of 1715 kg ha^{-1} (FAO. Stat., 2014) [9]. Cowpea (*Vigna unguiculata* (L.) Walp.) is a legume mainly grown in tropical and subtropical regions in the world for vegetable and grains and to lesser extent as a fodder crop. It also serves as cover crop and improves soil fertility by fixing atmospheric nitrogen. In view of this, the present study was initiated with the objects of effect of varied levels of RP enriched USWC, vermicompost and FYM with N and K fertilizers on yield and yield attributes of finger millet-cowpea cropping system in Cauvery command area, Karnataka.

Material and Methods

Site and experimental details

A field experiment was carried out to assess the effect of rock phosphate enriched compost on yield and yield attributes of finger millet-cowpea cropping system in high phosphorus build up soil at ZARS, Mandya in Southern Dry Zone (Zone 6) of Karnataka state lying between 12°-34'-03" North (latitude) and 76°-49'-08" East (longitude) with an altitude of 697 m above mean sea level. Finger millet (variety KMR 204) was taken as a main crop (*kharif*) and cowpea (variety C 152) was taken up as residual crop (summer) with a spacing of 30 x 10 cm.

The soil was sandy loam in texture with 87.42, 1.62, and 9.87 per cent sand, silt and clay, respectively and bulk density of 1.38 Mg m^{-3}. The soil was neutral in reaction (pH 7.12) and low in soluble salts (0.21 dS m^{-1}). The soil was low in organic carbon (0.48%) content, low in available N (210.80 kg ha^{-1}), K_2O (130.20 kg ha^{-1}) and high in available P_2O_5 (133.58 kg ha^{-1}). The exchangeable Ca and Mg content of soil was 2.57 and 1.08 C mol (P^+) kg^{-1}, respectively and available S was 8.85 mg kg^{-1}. The DTPA extractable micronutrient content *viz.*, Cu, Zn, Fe and Mn were 0.83, 1.21, 1.94 and 14.04 mg kg^{-1}, respectively.

The experiment was laid out in a randomized complete block design (RCBD) with eleven treatments and replicated thrice. The treatment combination include, T_1: Absolute control, T_2: Package of practice (100% NPK + FYM @ 10 t ha^{-1}), T_3: Recommended N and K + 25% P supplied through enriched USWC, T_4: Recommended N and K + 50% P supplied through enriched USWC, T_5: Recommended N and K + 75% P supplied through enriched USWC, T_6: Recommended N and K + 25% P supplied through enriched vermicompost, T_7: Recommended N and K + 50% P supplied through enriched vermicompost, T_8: Recommended N and K + 75% P supplied through enriched vermicompost, T_9: Recommended N and K + 25% P supplied through enriched FYM, T_{10}: Recommended N and K + 50% P supplied through enriched FYM and T_{11}: Recommended N and K + 75% P supplied through enriched FYM. FYM @ 10 t ha^{-1} was common for all the treatments except Absolute control (T_1). Recommended dose of fertilizer was 100:50:50 kg of N, P_2O_5 and K_2O per ha and net plot size was 12 m^2.

Yield and yield attributes

The above ground biomass (4 m x 3 m) harvested at physiological maturity of crop was separated into grain, straw and haulm. They were dried under shade and then weight was recorded. The grain, straw and haulm yields were expressed in q ha^{-1}. Five plants from net plot area of each treatment in all replications were harvested separately and counted for number of ear heads $hill^{-1}$, number of fingers $head^{-1}$ and number of pods $plant^{-1}$ (cowpea). Ten pods from each treatment in all replication were threshed separately and counted the number of seeds and took mean to get the number of seeds per plant in cowpea. One thousand grains (finger millet) and one hundred grains (cowpea) were counted from randomly selected five plants in each treatment and their weight was recorded and expressed in grams. The ratio of economic yield (grain yield) per ha to the biological yield (grain and straw/haulm yield) per ha was worked out as harvest index (Donald and Humblin, 1962) [7].

$$\text{Harvest index (HI) (\%)} = \frac{\text{Grain yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}} \times 100$$

Results and Discussion

Grain yield of finger millet

Treatment which received recommended N and K + 75 per cent P supplied through enriched USWC (T_5) had significantly higher grain yield (44.92 and 45.38 q ha^{-1}) compared to rest of the treatments but found at par with T_2 (POP: 100% NPK + FYM @ 10 t ha^{-1}) (42.89 and 43.22 q ha^{-1}), T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (43.97 and 43.97 q ha^{-1}), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (42.89 and 41.72 q ha^{-1}), T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (43.97 and 44.56 q ha^{-1}) and T_{10} (recommended N and K + 50 per cent P supplied through enriched FYM) (41.19 and 41.14 q ha^{-1}) in 2017 and 2018 season, respectively (Table 1 and Fig. 1). In 2018 season, T_5 was on par with T_{11} (recommended N and K + 75 per cent P supplied through enriched FYM) (41.52 q ha^{-1}) also. In pooled analysis, T_5 noticed significantly higher grain yield (45.15 q ha^{-1}) and was on par with T_2 (43.05 q ha^{-1}), T_4 (43.97 q ha^{-1}), T_7 (42.30 q ha^{-1}) and T_8 (44.26 q ha^{-1}). Grain yield increase in T_5 over T_1 (absolute control) and T_2 was 40.22 and 4.65 per cent, respectively in pooled data.

Treatments which received 50 and 75 per cent P supplied through enriched USWC and vermicompost recorded higher grain yield. This may be ascribed to enough nutrients being provided to the crop and thus improving soil physical, microbial, chemical and nutritional properties, which encourages proliferous root system, resulting in better absorption of water and nutrient from soil and thus resulted in higher grain yield. The results are in conformity with Prakash *et al.* (2007) [24] and Dimambro *et al.* (2007) [6]. Improvement in yield component of wheat and maize with the application of urban compost and sewage sludge was reported by Kumar *et al.* (2002) [16], Gupta *et al.* (2002) [11] and Terman *et al.* (1973) [36]. Lima *et al.* (2004) [17] who concluded that the urban waste application contributes to increase the growth of corn plants. Wilson *et al.* (2004) [37] studied the use of compost in the production of four species of ornamental plants and it was found that the plants cultivated using urban solid waste compost improved all growth parameters. The earlier studies of Mishra *et al.* (1982) [21] also reveal the beneficial effects of phosphate enriched compost (13% P) to bring phenomenal increase in yield of green gram and wheat.

The phosphocompost was found to be comparable to single superphosphate.

Continuous and greater availability of soil nutrients throughout the crop growth under enriched compost along with NK and uptake of nutrients by crop as revealed by the increased growth parameters *viz*., plant height and number of tillers might have resulted in increased grain yield (Shanmugam and Veeraputhran, 2000) [30]. The advantages of using higher quality organic manures in terms of crop growth and yield have also been reported by many workers: Mishra *et al*. (1997) [20], Ramesh *et al*. (2007) [25], Manjunatha (2011) [18] and Jagadeesha (2015) [14].

Straw yield of finger millet

Significantly higher straw yield (60.14, 60.57 and 60.36 q ha^{-1}) was observed in season 1, season 2 and pooled data, respectively in T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) and was on par with T_2 (POP: 100% NPK + FYM @ 10 t ha^{-1}) (56.97, 57.40 and 57.19 q ha^{-1}), T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (60.08, 60.15 and 60.12 q ha^{-1}) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (60.00, 60.40 and 60.20 q ha^{-1}) in season 1, season 2 and pooled data, respectively. In season 1 (2017), treatment T_5 was on par with T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (58.75 q ha^{-1}) and T_{11} (recommended N and K + 75 per cent P supplied through enriched FYM) (56.17 q ha^{-1}) also (Table 1 and Fig. 1). Higher straw yield in these treatments could be explained as finger millet utilize higher N through the expression of better growth by accumulating more dry matter at higher levels of N and other nutrients (Yadav *et al*., 2010) [38]. Sharma and Sharma (1997) [31] reported that phosphocompost (2.5% P-enriched) applied @ 5 t ha^{-1} (on dry weight basis) was comparable with single superphosphate in terms of wheat grain and straw yields in an acidic soil. These results are in conformity with results obtained in present study.

Harvest index of finger millet

Treatment which received recommended N and K + 25 per cent P supplied through enriched vermicompost (T_6) had significantly higher harvest index in first season (49.10%) and pooled data (48.35%) compared to rest of the treatments (Table 1). In second season (2018), no significant differences were observed with respect to harvest index among the treatments. It varied from 42.23 to 47.60 per cent in T_4 and T_6, respectively. There was a proportionate increase in both grain and straw yields with increased level of enriched composts, thus resulting in non-significant harvest index. Similar results were also obtained by Patil and Shete (2008) [23].

Grain and haulm yield of cowpea

Irrespective of the treatments, significantly higher grain yield in residual cowpea was recorded in treatment which received recommended N and K + 75 per cent P supplied through enriched USWC (T_5) (14.32, 14.93 and 14.62 q ha^{-1}) in first, second season and pooled means, respectively (Table 2 and Fig. 2). This treatment was on par with T_2 (POP: 100% NPK + FYM @ 10 t ha^{-1}) (13.91, 14.52 and 14.22 q ha^{-1}), T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (14.09, 14.70 and 14.39 q ha^{-1}), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (14.00, 14.61 and 14.31 q ha^{-1}) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (14.20, 14.81 and 14.51 q ha^{-1}) in first, second season and pooled means, respectively. In first season, T_5 was on par with T_3 (recommended N and K + 25 per cent P supplied through enriched USWC) (13.20 q ha^{-1}), T_6 (recommended N and K + 25 per cent P supplied through enriched vermicompost) (12.99 q ha^{-1}) and T_{11} (recommended N and K + 75 per cent P supplied through enriched FYM) (13.41 q ha^{-1}) and in second season, T_5 was on par with T_{11} (14.02 q ha^{-1}) also. Grain yield increase in T_5 over T_1 (absolute control) and T_2 (Farmer's practice) was 30.09 and 2.74 per cent, respectively in pooled data.

Among the treatments, T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) (29.76, 30.21 and 29.98 q ha^{-1}) registered significantly higher haulm yield compared to other treatments and was on par with T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (29.54, 29.99 and 29.76 q ha^{-1} in first, second season and pooled means, respectively) (Table 2 and Fig. 2).

Reddy and Krishnaiah (1999) [26] reported that one ton of organic manure on an average supplied about 5-8 kg of N and K and 2 kg of P. Further, they stated that that about one third of total N, half of total P were available to first crop and rest of N and P are available to the succeeding crop as residual effect. In general, higher grain and haulm yield of cowpea might be attributed to the beneficial effect of composts and FYM in supplying adequate nutrients as per crop requirement as a result of mineralization and their crop uptake resulting in higher dry matter production. These results are in line with the findings of Soumare *et al*. (2003) [35] and Adediran *et al*. (2004) [1] who indicated that residual effect of organic and inorganic fertilizer on cowpea showed greater advantage of organic fertilizer application. Sailaja and Ushakumari (2002) [28] reported slow release of nutrients from enriched vermicompost on residual cowpea which resulted in higher yield. Rostami *et al*. (2012) [27] observed higher yield in residual soybean on application of enriched municipal solid waste compost.

Harvest index of cowpea

There was a significant difference were observed with respect to harvest index in residual cowpea (Table 2). Treatment T_{10} (recommended N and K + 50 per cent P supplied through enriched FYM) (38.67, 39.24 and 38.96% in first, second season and pooled data, respectively) had significantly higher harvest index compared to rest of the treatments.

Yield attributes of finger millet

Number of ear heads hill^{-1}

Significantly higher number of ear heads hill^{-1} (4.27, 4.32 and 4.30) were observed in season 1 (2017), season 2 (2018) and pooled data, respectively with the application of recommended N and K + 75 per cent P supplied through enriched USWC (T_5) and was on par with application of recommended N and K + 50 per cent P supplied through enriched USWC (T_4) (4.20, 4.22 and 4.21) and recommended N and K + 75 per cent P supplied through enriched vermicompost (T_8) (4.00, 4.27 and 4.14) in season 1, season 2 and pooled data, respectively. In season 2 (2018), treatment T_5 was on par with recommended N and K + 50 per cent P supplied through enriched vermicompost (T_7) (3.92) also (Table 3). Significantly higher number of ear heads hill^{-1} were recorded in 50 and 75 per cent P supplied through enriched USWC and vermicompost treatments which could be ascribed to the slow and steady rate of nutrient release into the soil pool to match the adsorption pattern of finger millet crop. Gupta *et al*. (2002) [11] and Dimambro *et al*. (2007) [6] reported that an increased number of ears with the application of municipal solid waste compost and sewage sludge in wheat. Saunshi *et al*. (2014) [29] recorded an increased number of ear heads, ear head length and ear head weight in finger millet with the application of enriched liquid bio-digester manure.

Number of fingers head^{-1}

Treatment T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) (6.43) had significantly higher number of fingers head^{-1} and was on par with T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (6.30), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (6.16) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (6.34) in pooled analysis (Table 3). In 2017 season, T_5 (6.40) had significantly higher number of fingers head^{-1} and was on par with T_4 (6.27), T_7 (6.13) and T_8 (6.27) and in 2018, T_5 (6.46) had significantly higher number of fingers head^{-1} but at par with T_2 (POP: 100% NPK + FYM @ 10 t ha^{-1}) (6.06), T_4 (6.32), T_7 (6.19), T_8 (6.41) and T_{11} (recommended N and K + 75 per cent P supplied through enriched FYM) (6.04). Enriched organics had higher number of fingers head^{-1} and the present findings fall in line with the findings of Shivakumar (1999) [32] who reported that organic waste treatments recorded higher number of fingers head^{-1}.

Test weight (1000 grain weight)

In pooled analysis, treatment T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) (3.48 g) recorded significantly higher test weight compared to other treatments but at par with T_2 (POP: 100% NPK + FYM @ 10 t ha^{-1}) (3.36 g), T_3 (recommended N and K + 25 per cent P supplied through enriched USWC) (3.38 g), T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (3.44 g), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (3.38 g) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (3.47 g) (Table 3). In first season, T_4 (3.44 g) recorded significantly higher test weight and was on par with T_2 (3.34 g), T_3 (3.36 g), T_5 (3.43 g), T_7 (3.36 g) and T_8 (3.38 g) and in second season T_8 (3.55 g) had significantly higher test weight compared to rest of the treatments but at par with T_2 (3.38 g), T_3 (3.40 g), T_4 (3.44 g), T_5 (3.54 g) and T_7 (3.40 g). Application of higher levels of N and good quality enriched compost might have enhanced finger length by supplying higher N to the plant which in turn increased translocation of photosynthesis to sink. Further, by supplying higher N to plant which in turn increases the chlorophyll content leading to higher photosynthetic rate (Manzoor *et al*., 2006) [19] and thus might have resulted in improved test weight. Singh and Arya (1993) [34] also recorded a significant increase in the 1000 grain weight of barnyard millet with 15 kg P-enriched FYM applied @ 5 g ha^{-1} along with 30 kg N and 15 kg K per hectare. The better effectiveness of P-enriched manures appeared to be due to the solublization of rock phosphate during composting (Singh *et al*. 1993) [34].

Yield attributes of cowpea

Number of pods plant^{-1}

Significantly higher number of pods plant^{-1} were recorded in T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) (27.00, 27.68 and 27.34) in first, second season and pooled analysis, respectively (Table 4). This treatment was on par with T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (26.33 and 26.67), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (26.00 and 26.34) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (26.33 and 26.69) in first season and pooled data, respectively. And in second season, T_5 was on par with T_4 (27.01) and T_8 (27.04).

Number of seeds pod^{-1}

Treatment T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) (18.33, 18.79 and 18.56) registered significantly higher number of seeds pod^{-1} in first, second season and pooled data, respectively (Table 4). This T_5 treatment was on par with T_4 (recommended N and K + 50 per cent P supplied through enriched USWC) (18.46 and 18.23) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (18.51 and 18.26) in second season and pooled data, respectively. And in first season, T_5 was on par with T_2 (POP: 100% NPK + FYM @ 10 t ha^{-1}) (17.00), T_4 (18.00), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) (17.00) and T_8 (18.00).

Test weight (100 grain weight)

No significant differences were observed among the treatments in residual cowpea test weight (Table 4). But, in first season, treatment T_5 (recommended N and K + 75 per cent P supplied through enriched USWC) (9.69 g) had significantly higher test weight compared to other treatments except T_4 (recommended N and K + 50 per cent P supplied through enriched USWC), T_7 (recommended N and K + 50 per cent P supplied through enriched vermicompost) and T_8 (recommended N and K + 75 per cent P supplied through enriched vermicompost) (9.63, 9.63 and 9.66 g, respectively).

The yield attributes of residual cowpea *viz*., number of pods plant^{-1}, number of seeds pod^{-1}, test weight were higher in recommended NK along with 75 per cent P through enriched vermicompost and USWC which directly contributed to the enhanced phosphate solubilisation and N fixation which, further contribute to the increase in grain and haulm yield. The N from organic residues regardless of their initial content was probably used by the cowpea for its vegetative growth and development of rooting system. Gupta *et al*. (2006) [10] reported an increase in test weight, pods plant^{-1} and seeds pod^{-1} with the inoculation of P solubilizing bacteria in urdbean. Combined application of FYM and poultry manure with 50 per cent NPK significantly increased the grain and haulm yield of residual cowpea as documented by Dubey and Verma (1999) [8].

Table 1: Effect of phosphorus enriched composts on yield and harvest index of finger millet

Treatment	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Harvest index (%)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	26.28	27.70	26.99	34.64	36.74	35.69	42.96	42.99	42.97
T_2	42.89	43.22	43.05	56.97	57.40	57.19	42.77	42.92	42.85
T_3	40.14	40.06	40.10	50.78	51.15	50.97	43.71	43.93	43.82
T_4	43.97	43.97	43.97	60.08	60.15	60.12	42.28	42.23	42.25
T_5	44.92	45.38	45.15	60.14	60.57	60.36	42.85	42.86	42.85
T_6	39.08	39.81	39.45	40.61	43.65	42.13	49.10	47.60	48.35
T_7	42.89	41.72	42.30	58.75	54.15	56.45	42.69	43.44	43.07
T_8	43.97	44.56	44.26	60.00	60.40	60.20	42.26	42.42	42.34
T_9	31.33	34.35	32.84	36.05	41.15	38.60	46.04	45.48	45.76
T_{10}	41.19	41.14	41.17	51.11	51.48	51.30	44.21	44.38	44.30
T_{11}	40.56	41.52	41.04	56.17	53.57	54.87	41.95	43.66	42.80
S.Em±	1.42	1.79	1.02	1.38	1.57	1.08	0.22	1.29	0.63
CD at 5%	4.19	5.28	3.02	4.06	4.63	3.19	0.66	NS	1.84

Legend:

T_1: Absolute control	T_7: Recommended N & K + 50% P supplied through enriched vermicompost
T_2: POP (100% NPK + FYM @ 10 t ha^{-1})	T_8: Recommended N & K + 75% P supplied through enriched vermicompost
T_3: Recommended N & K + 25% P supplied through enriched USWC	T_9: Recommended N & K + 25% P supplied through enriched FYM
T_4: Recommended N & K + 50% P supplied through enriched USWC	T_{10}: Recommended N & K + 50% P supplied through enriched FYM
T_5: Recommended N & K + 75% P supplied through enriched USWC	T_{11}: Recommended N & K + 75% P supplied through enriched FYM
T_6: Recommended N & K + 25% P supplied through enriched vermicompost	

Table 2: Residual effect of phosphorus enriched composts on yield and harvest index of cowpea

Treatment	Grain yield (q ha^{-1})			Haulm yield (q ha^{-1})			Harvest index (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	9.92	10.53	10.22	18.81	19.26	19.03	34.52	35.35	34.93
T_2	13.91	14.52	14.22	24.15	24.60	24.37	36.56	37.12	36.84
T_3	13.20	13.81	13.51	23.33	23.78	23.55	36.14	36.74	36.44
T_4	14.09	14.70	14.39	28.51	28.96	28.73	33.08	33.67	33.37
T_5	14.32	14.93	14.62	29.76	30.21	29.98	32.48	33.07	32.78
T_6	12.99	13.60	13.29	22.22	22.67	22.44	36.89	37.49	37.19
T_7	14.00	14.61	14.31	27.64	28.09	27.86	33.63	34.21	33.92
T_8	14.20	14.81	14.51	29.54	29.99	29.76	32.47	33.05	32.76
T_9	11.57	12.18	11.88	19.94	20.39	20.16	36.73	37.39	37.06
T_{10}	12.84	13.45	13.15	20.37	20.82	20.59	38.67	39.24	38.96
T_{11}	13.41	14.02	13.71	25.19	25.64	25.41	34.74	35.33	35.03
S.Em±	0.47	0.36	0.30	0.38	0.33	0.26	0.16	0.50	0.27
CD at 5%	1.37	1.05	0.89	1.11	0.99	0.76	0.47	1.49	0.79

Legend:

T_1: Absolute control	T_7: Recommended N & K + 50% P supplied through enriched vermicompost
T_2: POP (100% NPK + FYM @ 10 t ha^{-1})	T_8: Recommended N & K + 75% P supplied through enriched vermicompost
T_3: Recommended N & K + 25% P supplied through enriched USWC	T_9: Recommended N & K + 25% P supplied through enriched FYM
T_4: Recommended N & K + 50% P supplied through enriched USWC	T_{10}: Recommended N & K + 50% P supplied through enriched FYM
T_5: Recommended N & K + 75% P supplied through enriched USWC	T_{11}: Recommended N & K + 75% P supplied through enriched FYM
T_6: Recommended N & K + 25% P supplied through enriched vermicompost	

Table 3: Effect of phosphorus enriched composts on yield attributes of finger millet

Treatment	Number of ear heads hill^{-1}			Number of fingers head^{-1}			Test weight (g)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	2.33	2.32	2.33	4.39	4.06	4.22	2.99	3.03	3.01
T_2	3.73	3.82	3.78	6.00	6.06	6.03	3.34	3.38	3.36
T_3	3.40	3.42	3.41	5.69	5.72	5.71	3.36	3.40	3.38
T_4	4.20	4.22	4.21	6.27	6.32	6.30	3.44	3.44	3.44
T_5	4.27	4.32	4.30	6.40	6.46	6.43	3.43	3.54	3.48
T_6	2.73	2.72	2.73	5.60	5.66	5.63	3.11	3.15	3.13
T_7	3.93	3.92	3.93	6.13	6.19	6.16	3.36	3.40	3.38
T_8	4.00	4.27	4.14	6.27	6.41	6.34	3.38	3.55	3.47
T_9	2.73	2.72	2.73	5.42	5.46	5.44	3.04	3.08	3.06
T_{10}	3.40	3.42	3.41	4.98	5.84	5.41	3.21	3.25	3.23
T_{11}	3.27	3.79	3.53	5.64	6.04	5.84	3.27	3.31	3.29
S.Em±	0.09	0.16	0.09	0.10	0.16	0.10	0.04	0.07	0.04
CD at 5%	0.28	0.46	0.26	0.31	0.48	0.29	0.13	0.21	0.13

Legend:

T_1: Absolute control	T_7: Recommended N & K + 50% P supplied through enriched vermicompost
T_2: POP (100% NPK + FYM @ 10 t ha^{-1})	T_8: Recommended N & K + 75% P supplied through enriched vermicompost
T_3: Recommended N & K + 25% P supplied through enriched USWC	T_9: Recommended N & K + 25% P supplied through enriched FYM
T_4: Recommended N & K + 50% P supplied through enriched USWC	T_{10}: Recommended N & K + 50% P supplied through enriched FYM
T_5: Recommended N & K + 75% P supplied through enriched USWC	T_{11}: Recommended N & K + 75% P supplied through enriched FYM
T_6: Recommended N & K + 25% P supplied through enriched vermicompost	

Table 4: Residual effect of phosphorus enriched composts on yield attributes of cowpea

Treatment	Number of pods $plant^{-1}$			Number of seeds pod^{-1}			Test weight (g)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	20.00	20.68	20.34	14.00	14.46	14.23	9.03	9.21	9.12
T_2	24.00	24.68	24.34	17.00	17.46	17.23	9.50	9.72	9.61
T_3	22.00	22.68	22.34	14.00	14.46	14.23	9.40	9.65	9.53
T_4	26.33	27.01	26.67	18.00	18.46	18.23	9.63	9.85	9.74
T_5	27.00	27.68	27.34	18.33	18.79	18.56	9.69	9.91	9.80
T_6	21.67	22.35	22.01	13.67	15.13	14.40	9.33	9.55	9.44
T_7	26.00	26.68	26.34	17.00	17.46	17.23	9.63	9.85	9.74
T_8	26.33	27.04	26.69	18.00	18.51	18.26	9.66	9.88	9.77
T_9	21.00	21.68	21.34	13.00	13.46	13.23	9.27	9.49	9.38
T_{10}	22.00	22.68	22.34	14.00	14.46	14.23	9.32	9.54	9.43
T_{11}	22.33	23.01	22.67	14.67	15.13	14.90	9.38	9.63	9.50
S.Em±	0.90	0.24	0.51	0.57	0.33	0.34	0.04	0.30	0.15
CD at 5%	2.66	0.71	1.50	1.68	0.96	1.00	0.11	NS	NS

Legend:

T_1: Absolute control	T_7: Recommended N & K + 50% P supplied through enriched vermicompost
T_2: POP (100% NPK + FYM @ 10 t ha^{-1})	T_8: Recommended N & K + 75% P supplied through enriched vermicompost
T_3: Recommended N & K + 25% P supplied through enriched USWC	T_9: Recommended N & K + 25% P supplied through enriched FYM
T_4: Recommended N & K + 50% P supplied through enriched USWC	T_{10}: Recommended N & K + 50% P supplied through enriched FYM
T_5: Recommended N & K + 75% P supplied through enriched USWC	T_{11}: Recommended N & K + 75% P supplied through enriched FYM
T_6: Recommended N & K + 25% P supplied through enriched vermicompost	

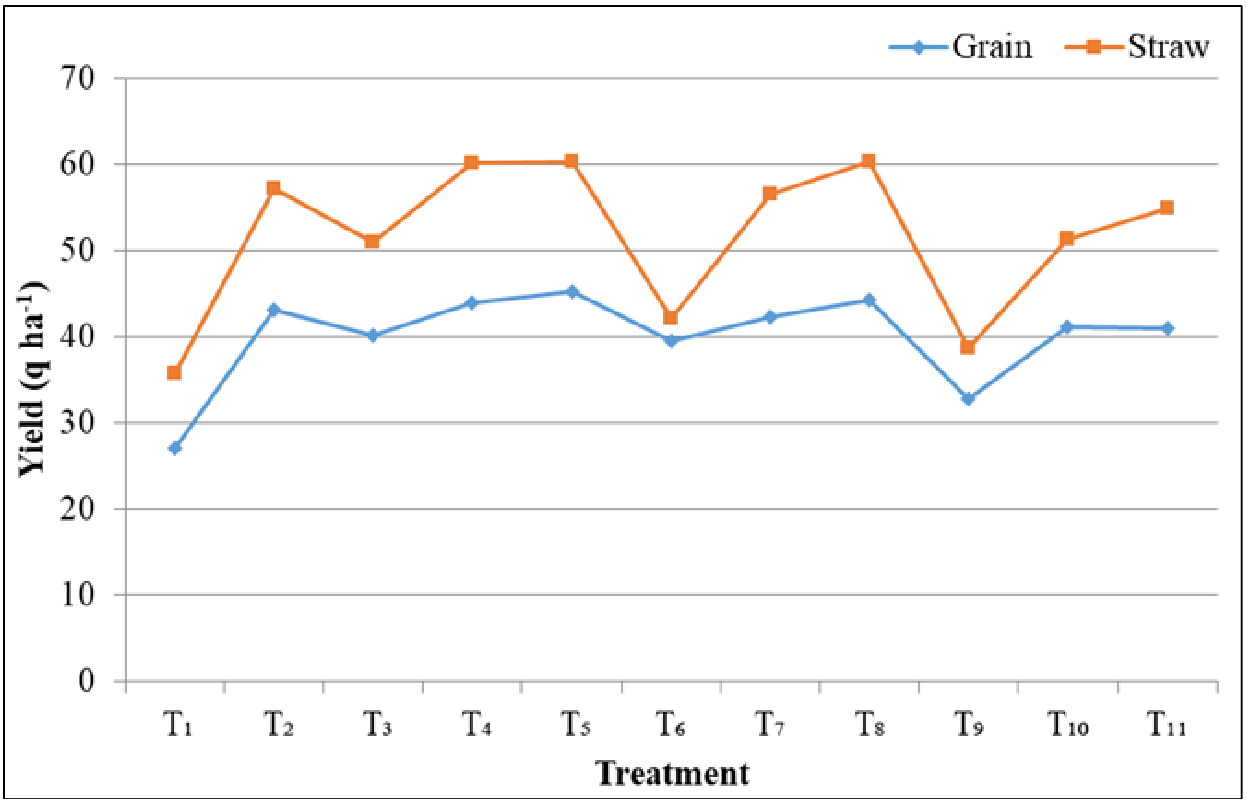

Fig 1: Effect of rock phosphate enriched composts on grain and straw yield of finger millet

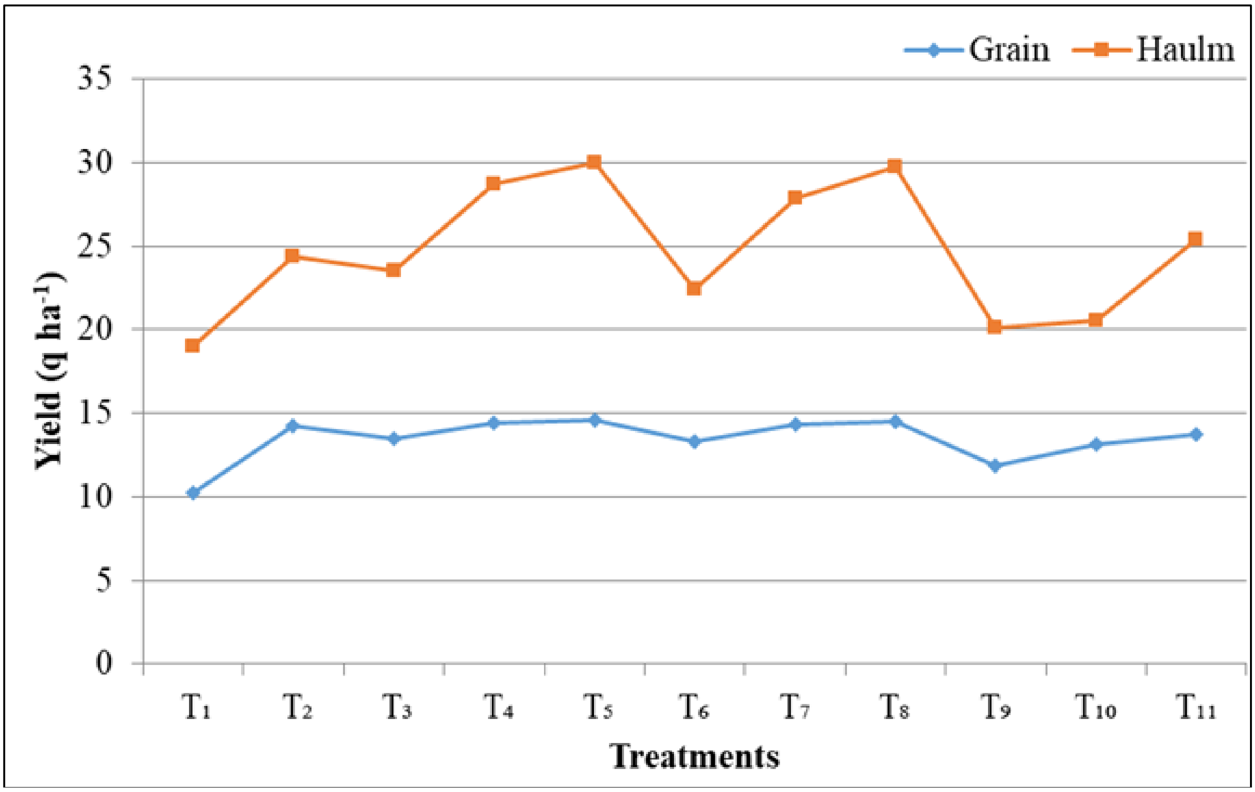

Fig 2: Residual effect of rock phosphate enriched composts on grain and haulm yield of cowpea

Conclusion

Under phosphorus rich soil condition, application of recommended N and K along with 50-75 per cent P through rock phosphate enriched USWC and vermicompost had beneficial effect on increasing grain, straw and haulm yield and yield attributes of finger millet-cowpea cropping system compared to control and package of practice.

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