



Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on plant growth and soil properties under pea (*Pisum sativum*) cropping

DEEPSHIKHA THAKUR¹, RAJESH KAUSHAL² and VINEET SHYAM³

Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230

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ABSTRACT

The field experiment was conducted to study the effect of conjoint use of bioactive phosphocompost and recommended dose of chemical fertilizers on various plant, soil and microbiological parameters under pea (*Pisum sativum* L.) crop. The bioactive phosphocompost (0.98%, 2.24%, 0.81% N, P, K respectively), was used in six different combinations with the chemical fertilizers. Out of the six treatment combinations, treatment T₃ (conjoint use of 75% recommended dose of chemical fertilizers and 25% phosphocompost) proved to be significantly superior in increasing the various plant parameters such as shoot length (76.25 cm), root length (22.25 cm), total plant biomass (40.78q/ha), green pod yield (219 q/ha) etc., over control. The significantly higher content of N (4.54%), P (0.55%) and K (2.39%) was also recorded in T₃ treatment. Although, significantly higher organic matter (1.32%), CEC (44.37 c mol (p+)/kg), available P (143.33 kg/h) and soil enzyme activities were recorded in T₆ treatment (100% phosphocompost). Various microbiological properties like microbial biomass, microbial activity, total microbial count, P solubilizer count, *Rhizobium* count and siderophore producers were also recorded highest in T₆ treatment. On the basis of results, it can be concluded that the conjoint use of 75 % recommended dose of chemical fertilizers and 25% phosphocompost, increased the yield of pea by 58% and is thus recommended to be used for higher yield, improved nutrient status, improved physico-chemical and microbiological properties of soil, directing towards sustainable farming.

Key words: Bioactive, Enzyme, Microbial, Pea, Phosphocompost, Soil.

With the advent of synthetic chemical fertilizers and their widespread adoption and use in farming, there has been less reliance upon organic residues as a source of nutrients for plant growth. Since fertilizer use in India is mostly subsidy driven, farmers often use fertilizers indiscriminately. Within few decades the bad effects of chemical fertilizer based agricultural practices on soil and environment have become evident. Current agricultural practices are responsible for soil impoverishment, leading to reduction of organic matter in the agro-ecosystem (Lal 1998). These degenerative effects of intensive agriculture have compelled the agricultural researchers to work on alternative sustainable production systems not only for sustained crop productivity but also for the soil health and soil quality. One of the most efficient viable strategies to control deterioration in soil quality is to add the organic matter in the form of compost (Zayed and Abdel 2005).

Organic materials such as crop residues and animal manures are not available in adequate amounts and cannot

by themselves improve soil fertility. Additionally, nutrient content of the organic resources are generally low and released at a rate determined by their chemical characteristics or their quality. Therefore, application of realistic levels of organic inputs seldom releases sufficient nutrients for optimum crop yield (Vanlauwe *et al.* 2010). Therefore, organic inputs can be applied conjointly with the chemical fertilizers. Combined strategy of organic and inorganic fertilizers for the improvement of soil fertility has also been supported by (Killham 2010). Fertilizers are better applied in combination with organic inputs (Alley and Vanlauwe 2009) in the long-term to sustain soil fertility and crop production.

Taking in to consideration the above mentioned facts, the present investigation was conducted under midhill conditions of Himachal Pradesh, to study the effect of conjoint use of phosphocompost and inorganic fertilizers on crop yield and soil health under pea (*Pisum sativum* L.) cropping.

MATERIALS AND METHODS

The field study was conducted in Soil Science and Water Management Farm, University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh in the year 2013 located at an altitude of 1270 meters above mean sea level with latitude of 30.15°N and longitude of 77.11°E,

¹Assistant Professor (e mail: deepshikhathakur212@gmail.com), Amity Institutes of Organic Agriculture, Amity University, Noida, Uttar Pradesh; ²Associate Professor (e mail: drkaushal@rediffmail.com), Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh; ³Food Safety and Standards Authority of India (e mail: vineet.shyam@gmail.com), Delhi.

falling under mid hill region. Pea (cv. Punjab 89) was used under Randomized Block Design (RBD), with number of treatments being six and number of replications being four. The plot sizes were 1.0 × 1.0 m with 60 cm × 7.5 cm spacing. The soil of the farm used for experiment is silty loam and belongs to order Entisols.

The six treatment combinations of inorganic fertilizers and organic phosphocompost were used for the experiment. As a source of inorganic fertilizers, Calcium ammonium nitrate, Single super phosphate and Muriate of potash were used for N, P and K, respectively. Whereas the bioactive phosphocompost used for experiment was prepared from cellulolytic microbial consortia and was rich in beneficial plant growth promoting microflora such as nitrogen fixing bacteria and phosphate solubilizing microorganisms. Treatment details are as: T₁: Control; T₂: 50% recommended dose of chemical fertilizers (RDCF) + 50% phosphocompost (PC); T₃: 75% RDCF + 25% PC, T₄: 25% RDCF + 75% PC; T₅: Recommended dose of NPK* @ 100, 375, 100 kg/ha; T₆: 100% PC.

The cultural practices were done as per recommended package of practices. For determining the initial status, the soil samples were collected from experimental site, processed and physico-chemical properties of soils were measured with the prescribed standard procedure (Jackson 2005).

Plant parameters, viz. Shoot and root length (cm), total plant biomass (q/ha), green pod yield (q/ha), pod length (cm) and pod girth (mm), number of pods per plant and number of grains per pod, total soluble solids (° Brix) measured through Erma hand refractometer, nutrient content (NPK), Nutrient uptake (Kg/ha) were measured.

Soil physico-chemical parameters such as pH, electrical conductivity, bulk density, organic matter, available N, P and K status (Jackson 2005) were measured.

Microbiological and biochemical parameters of soil such as total microbial count, phosphorous solubilizer count, *Rhizobium* count, soil microbial activity (Parkin *et al.*), soil microbial biomass (Vance *et al.* 1987), soil enzyme activity [phosphatase (Tabatabai and Bremner 1969), dehydrogenase (Casida *et al.* 1964), urease (Hoffman 1965)].

The data on various microbial, soil and plant parameters under laboratory conditions was subjected to Completely Randomized Design (CRD), whereas, the data on field conditions was subjected to statistical analysis using randomized block design as outlined by Gomez and Gomez (1984). The critical difference at 5% level was used for testing the significant differences among the treated means.

RESULTS AND DISCUSSION

Due to long term and regular use of chemical fertilizers, the crops have become fertilizer responsive and so, the application of organic sources or compost alone cannot substitute the fertilizers for providing proper nutrition. The presented results report the effect of conjoint use of bioactive phosphocompost and chemical fertilizers on plant growth and soil properties under pea cropping.

Initial status of soil

Before the start of the experiment, the physico-chemical analysis of the soil showed that the pH, EC, bulk density (BD) and organic matter (OM) of the soil was 6.67, 0.41 (dS/m), 1.14 (Mg/m³) and 1.16% respectively. Whereas, the available nutrient status (kg/ha) N, P and K was determined to be 318.22, 78.40 and 278.41 respectively. The total microbial count was recorded as 98.34 × 10⁴ cfu/g.

Effect on plant growth parameters

The plant growth parameters such as maximum shoot length, root length, total plant biomass, green pod yield, pod length, pod girth, number of pods per plant and number of grains per pod (Table 1), was attained under treatment T₃ (75 % RDCF + 25 % PC), which is in conformity with the results of Banta and Dev (2009), who also reported that the application of 75% recommended dose of fertilizers and 25% phosphocompost recorded higher crop yield and nutrient uptake in wheat compared to other treatments. The conjoint application of organic and inorganic fertilizers have also been advocated by Kumaran *et al.* (1998) and Asmaa *et al.* (2013) for best results in terms of growth and yield. According to Mugwe *et al.* (2009), maize treated with organic materials plus inorganic fertilizer had higher grain yield compared to the recommended rate of inorganic fertilizer. Negassa *et al.* (2001) also reported an increase in maize grain yield when low doses of N and P fertilizers were applied with different organic materials such as farmyard and compost, as compared with the control treatment. The harvest index (Table 1) was not significantly influenced by any of the tried combinations of RDCF and PC. The order of the treatments based on the decreasing magnitude of harvest index was: T₄ > T₆ > T₃ > T₂ > T₅ > T₁.

Another qualitative character, total soluble solids (TSS), which is measure of carbohydrates, organic acids, proteins, fats and minerals of the fruit, was maximum in T₆ treatment (PC alone) as shown in Table 1. Increased total soluble solids content of the fruit with the application of different sources of organic manures has also been reported by Youssef *et al.* (2001) and Prabakaran and Pitachi (2002).

Effect on NPK content and their uptake by the plant

A perusal of data presented in Table 2 revealed that the maximum N, P and K content and their uptake was recorded under treatment T₃, i.e. 75% RDCF + 25% PC. The results were in conformity with Thenmozhi and Paulraj (2010) and Hellal *et al.* (2013), who reported that the conjoint application of enriched phosphocompost alongwith RDCF, recorded greatest influence on soil available nutrient (N, P and K) status compared to sole application of chemical fertilizers. Enriched composts provide all essential nutrients in readily plant usable forms, enhances uptake of these nutrients by the plants and play a major role in improving growth and yield of crops (Sreenivas *et al.* 2000). Studies have indicated that the combination of organic and inorganic fertilizers ensure greater synchrony between

Table 1 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on various plant growth parameters of pea

Treatment	Shoot length (cm)	Root length (cm)	Total biomass (q/ha)	Green pod yield (q/ha)	Harvest index	Pod length (cm)	Pod girth (mm)	No. of pods per plant	No. of grains per pod	Total soluble solids (°B)
T ₁ (Control)	54.15	16.37	23.23	128	2.94	6.86	11.11	35.25	5.0	16.87
T ₂ (50% RDCF + 50% PC)	69.95	21.15	34.47	193	3.53	9.73	13.54	41.75	7.5	19.51
T ₃ (75% RDCF + 25% PC)	76.25	22.25	40.78	219	3.60	11.10	13.82	45.50	8.7	19.19
T ₄ (25% RDCF + 75% PC)	67.45	20.42	29.62	184	3.70	8.87	12.11	40.00	6.7	19.97
T ₅ (100% RDCF)	74.25	21.47	37.34	202	3.52	10.81	13.07	45.00	8.7	18.06
T ₆ (100% PC)	66.25	20.25	31.66	192	3.66	9.83	12.56	41.75	7.5	21.11
CD _{0.05}	1.15	1.00	1.28	2.04	NS	0.90	0.65	1.60	1.62	1.22

RDCF, Recommended dose of chemical fertilizers; PC, Phosphocompost.

Table 2 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on total NPK content and their uptake by pea under mid hill conditions of Himachal Pradesh

Treatment	Total nutrient content (%) and their uptake (kg/ha)					
	N		P		K	
	Content	Uptake	Content	Uptake	Content	Uptake
T ₁ (Control)	4.12 (2.03)	95.70	0.42 (0.67)	9.75	1.81 (1.35)	42.04
T ₂ (50% RDCF + 50% PC)	4.46 (2.11)	153.78	0.47 (0.69)	16.20	2.21 (1.49)	76.20
T ₃ (75% RDCF + 25% PC)	4.54 (2.15)	185.14	0.55 (0.74)	22.42	2.39 (1.55)	97.45
T ₄ (25% RDCF + 75% PC)	4.39 (2.09)	130.03	0.46 (0.68)	13.62	2.11 (1.45)	62.49
T ₅ (100% RDCF)	4.52 (2.13)	168.77	0.51 (0.71)	19.04	2.36 (1.54)	88.12
T ₆ (100% PC)	4.40 (2.10)	139.30	0.45 (0.67)	14.24	2.13 (1.46)	67.43
CD _{0.05}	0.03	2.55	0.02	2.25	0.01	3.62

RDCF, Recommended dose of chemical fertilizers; PC, Phosphocompost. *Values in parenthesis are square root transformed values.

nutrient release and plant uptake and therefore increase crop yield (Mugwe *et al.* 2009, Omotayo and Chukwuka 2009). This explains why generally the integration of organic inputs with inorganic fertilizers gives higher benefits than the recommended rate of fertilizer.

Effect on soil parameters

Physical, chemical and biochemical properties at the end of the experiment: Composts contains organic matter, plethora of microflora, macro and micronutrients, which helps in improving the nutrient status, physico-chemical and biological properties of soil (Zorpas *et al.* 2002, Zhao *et al.* 2011 and Ingelmo *et al.* 2012). In the present study, the effect of all the six treatments on the physico-chemical properties of the soil was recorded as presented in Table 3. The data indicated that none of the tried combinations of phosphocompost and chemical fertilizers influenced the soil pH, EC and BD significantly over the control.

The Cation exchange capacity (CEC), i.e. total exchangeable cations in the soil was recorded to be maximum in the plots treated with 100% phosphocompost (T₆) as compared to sole and conjoint applications of

chemical fertilizers and phosphocompost. The increased cation exchange capacity of soil amended with compost has also been reported by Epstein *et al.* (1976), Giusquiani *et al.* (1995) and Sarwar *et al.* (2008). In a 5 year experiment with biowaste-compost conducted by Mwitimutege *et al.* (2012), the CEC increased linearly with the amount of OM added through compost.

The addition of the compost to the soil is known to increase the Soil organic matter (SOM), improving physical, chemical and biological functions of the soil (Savala *et al.* 2003). Complying with the above statement, in the present study, the highest organic matter content (1.32%) was recorded in treatment T₆ i.e. 100% phosphocompost. An increase in the soil organic matter through the application of compost was also reported by Albiach *et al.* (2001) and Manna and Ganguly (2000).

The highest available nutrient status (kg/ha) N, P and K was determined to be 386.31, 142.54 and 319.25.41 respectively in treatment T₃. The results were in conformity with Thenmozhi and Paulraj (2010) and Hellal *et al.* (2013), who reported that the conjoint application of enriched phosphocompost along with RDCF, recorded greatest

Table 3 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on the physico-chemical properties and nutrient status of soil in pea under mid hill conditions of Himachal Pradesh

Treatment	pH	EC (dS/m)	OM (%)	Bulk density (Mg/m)	CEC (c mol (p+)/kg)	Available nutrients (kg/ha)		
						N	P	K
T ₁ (Control)	6.54	0.40	1.17 (1.47)	1.14	12.80	323.78	74.43	279.64
T ₂ (50% RDCF + 50% PC)	6.52	0.38	1.24 (1.49)	1.13	29.07	352.32	131.11	309.06
T ₃ (75% RDCF + 25% PC)	6.54	0.41	1.28 (1.51)	1.13	19.85	386.31	142.54	319.25
T ₄ (25% RDCF + 75% PC)	6.57	0.40	1.20 (1.48)	1.12	34.37	344.54	113.56	304.12
T ₅ (100% RDCF)	6.54	0.39	1.18 (1.47)	1.14	15.38	366.27	134.54	312.19
T ₆ (100% PC)	6.49	0.41	1.32 (1.52)	1.10	44.37	346.11	143.33	299.52
CD _{0.05}	NS	NS	0.01	NS	3.01	2.53	3.42	2.19

RDCF, Recommended dose of chemical fertilizers; PC, Phosphocompost.

Table 4 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on the soil enzyme activity of pea under mid hill conditions of Himachal Pradesh.

Treatment	Soil enzymes		
	Phosphatase (μ mole PNP released/h/g soil)	Dehydrogenase (mg TPF formed/h/g soil)	Urease (mg NH ₄ ⁺ released/g soil)
T ₁ (Control)	18.98	2.15	0.17
T ₂ (50% RDCF + 50% PC)	23.63	3.57	0.22
T ₃ (75% RDCF + 25% PC)	23.52	2.63	0.22
T ₄ (25% RDCF + 75% PC)	28.97	5.27	0.25
T ₅ (100% RDCF)	22.54	2.81	0.21
T ₆ (100% PC)	31.14	5.28	0.29
CD _{0.05}	1.14	0.33	0.03

RDCF, Recommended dose of chemical fertilizers; PC, Phosphocompost.

influence on soil available nutrient (N, P and K) status compared to sole application of chemical fertilizers.

Soil enzyme activities are considered as indicators of the biological status of soil and are incredibly important as they are direct linkage of soil microbial community to metabolic requirements and available nutrients. The addition of organic inputs to the soil is known to improve the enzymatic activities of the soil (Isabel *et al.* 2010). The application of phosphocompost alone (T₆) showed the maximum phosphatase activity, dehydrogenase activity and urease activity and the minimum of all enzyme activities was found in control (Table 4). In agreement to present findings, the increase in the phosphatase, dehydrogenase and urease enzyme activity by the long term application of compost was also reported by Albiach *et al.* (2000) and Nayak *et al.* (2007).

Microbiological properties at the end of experiment: Enriched composts, besides supplying plant nutrients, add a sufficient amount of organic matter to the soil, which helps in improving the physico-chemical and microbiological properties of the soil. It also acts as a niche for microbes and enriches the soil with a variety of the indigenous microflora and fauna (Postma *et al.* 2003 and Paul 2007).

Cropping practices and soil fertilization of the soil affect the microbiological parameters of the soil (Goyal *et al.* 1992). The highest total bacterial count (Fig 1), beneficial bacterial count of phosphate solubilizers, siderophore producers, *Rhizobium* count (Fig 2), microbial biomass (Fig 3) and microbial activity (Fig 4) were recorded in the plots treated with 100% phosphocompost, followed by treatment T₄ (25% RDCF+ 75% PC). The increase in population could be attributed to the addition of microbial consortia in compost as well as organic carbon source. Microbial communities in the soil are enhanced and stimulated by the addition of organic waste, especially due to the presence of readily available nutrients and C compounds (Isabele *et al.* 2010). The increase in microbial biomass carbon by the additions of organic amendments was also reported by Goyal *et al.* (1992), Kukreja *et al.* (1991) and Gaid and Lata (2007). Increase in soil microbial activity due to oxidation of organic matter in treated spent wash applied soil was reported by Kavitha and Subramanian (2007).

The present study concluded that treatment T₃, i.e. 75% recommended dose of chemical fertilizers and 25% phosphocompost was recorded as the best treatment in context to the tested parameters. The postulation behind

the results is that 75% RDCF provided the readily available nutrients whereas; the 25% phosphocompost provided the slow releasing nutrients. Phosphocompost may also have increased the water holding capacity and beneficial microbial count in the soil and may also have helped in suppressing the leaching of chemical fertilizers.

Organic inputs are not available in adequate amounts and cannot by themselves improve soil fertility as the nutrient content of the organic resources are generally low and released at a rate determined by their chemical characteristics or their quality. Therefore, application of realistic levels of organic inputs seldom releases sufficient nutrients for optimum crop yield. This study has indicated that the combined application of compost and inorganic fertilizer has beneficial effects on soil properties, plant growth and yield. The conjoint use of 75% recommended dose of chemical fertilizers and 25% phosphocompost, increased the yield by 58% over the control. Besides saving 6.3, 14.9 and 14.4 kg /ha N, P₂O₅ and K₂O, respectively, the application of phosphocompost along with chemical fertilizers further improved the available nutrient status, physico-chemical properties, cation exchange capacity, soil enzyme activity and other microbiological properties of soil. Thus the study recommends the conjoint use inorganic

fertilizers and phosphocompost to be used for fertilization of pea for higher yield, improved nutrient status, improved physico-chemical and microbiological properties of soil, directing towards sustainable farming.

As the organic inputs solely cannot improve soil fertility due to low nutrient content and released at a rate determined by their chemical characteristics or their quality, the conjoint use of organic and inorganic fertilizers is preferable. In the present study, the field experiment was conducted to study the effect of conjoint use of bioactive phosphocompost and recommended dose of chemical fertilizers on various plant, soil and microbiological parameters under pea crop. The bioactive phosphocompost (0.98%, 2.24%, 0.81% N, P, K respectively), was used in six different combinations with the chemical fertilizers. Out of the six treatment combinations, treatment T₃ (conjoint use of 75% recommended dose of chemical fertilizers and 25% phosphocompost) proved to be significantly superior in increasing the various plant parameters, improving the soil physicochemical and biological properties. The conjoint use of 75% recommended dose of chemical fertilizers and 25% phosphocompost, increased the yield by 58% over the control. Besides saving 6.3, 14.9 and 14.4 kg /ha N, P₂O₅ and K₂O, respectively,

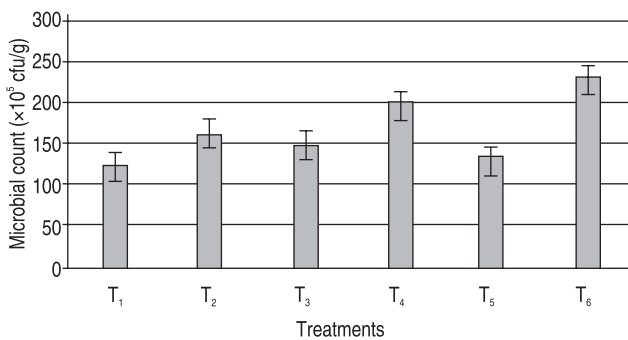


Fig 1 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on total microbial count in soil under pea crop.

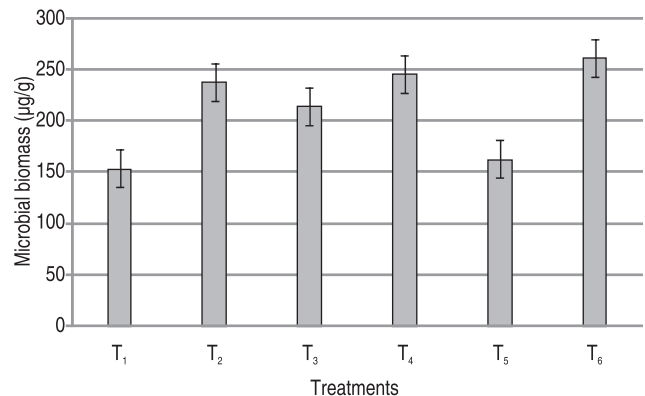


Fig 3 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on microbial biomass (µg/g) in soil under pea crop.

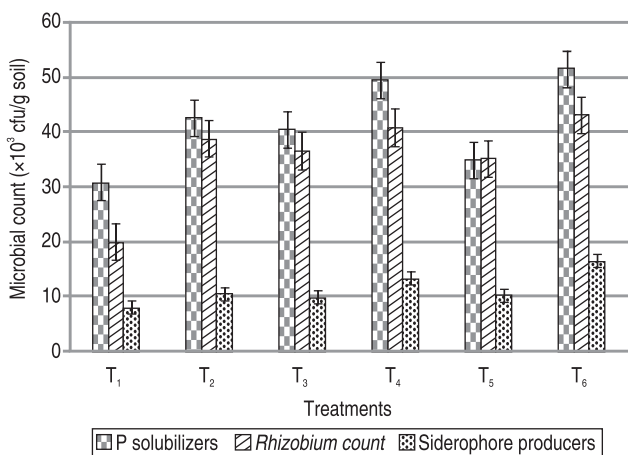


Fig 2 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on beneficial bacterial count in soil under pea crop.

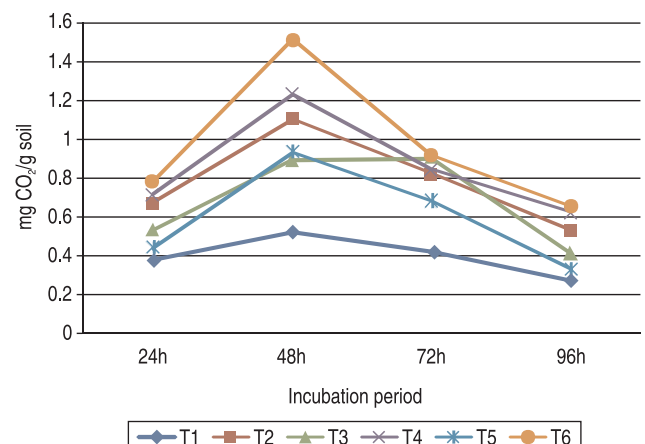


Fig 4 Effect of conjoint use of bioactive phosphocompost and chemical fertilizers on microbial activity (mg CO₂/g soil) in soil under pea crop.

the application of phosphocompost along with chemical fertilizers further improved the available nutrient status, physico-chemical properties, cation exchange capacity, soil enzyme activity and other microbiological properties of soil. Thus the study recommends the conjoint use inorganic fertilizers and phosphocompost to be used for fertilization of pea for higher yield, improved nutrient status, improved physico-chemical and microbiological properties of soil, directing towards sustainable farming.

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