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Research Article

# Integrated Application of Biofertilizers with different Fertilizers affects Soil Health in Pea Crop

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## Abstract

Nitrogen, phosphorus and potassium are key nutrients that play a major role in crop production on intensively cultivated soils. The soil fertility is directly influenced by the type of fertilizer inputs. The present experiment was laid down to study the effect of biofertilizers, organic and inorganic fertilizers on physico-chemical properties of rhizospheric soil in pea crop during the *rabi* season of 2015-16. Soil electrical conductivity, available nitrogen and available potassium were found significantly higher in treatments having 50% farm yard manure + 50% recommended dose of nitrogen and phosphorus + consortium while soil organic carbon and available phosphorus were significantly higher in treatments having 100% farm yard manure + consortium. The inoculation of biofertilizers in addition to organic and inorganic fertilizers resulted in higher residual soil nutrients.

**Keywords:** Consortium, FYM, nutrient availability, physico-chemical properties, rhizosphere

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## Introduction

Pea (*Pisum sativum* L.) is an important vegetable crop grown mainly as winter vegetable in the plains of North India [1]. It is highly nutritious and contains high quantity of proteins (7.2%) along with carbohydrates (15.9%) and minerals like calcium (20 mg/100 g) besides being a good source of vitamins. Chemical fertilizers are being used intensively to meet out the nutrient requirements of the crop but their prolonged use leaves toxic effect on soil ecosystem. Inorganic fertilizers are used primarily to increase nutrient availability to plants; however, the over exploitation has been the major concern of the hour [2].

Organic manures improve physical, chemical and biological properties of the soil which in turn improve fertility, productivity and water holding capacity of soil. Organic matter after decomposition releases macro and micronutrients to the soil solution which become available to the plants, resulting in their higher uptake [3]. Besides its capability for higher crop production, addition of organic amendments improves soil quality by manipulating the soil properties on long term basis. It has been reported that organic and low-input farming practices after 4 years led to an increase in the nutrient content and also the reserve pool of stored nutrients and maintained relativity stable EC level [4].

Biofertilizers are type of organic fertilizers which provide an ecologically safe means of fertilization. Biofertilizers are preparations of specific micro-organisms which, when applied to seed, plant surfaces (such as leaves), or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the availability of nutrients to the host. Commonly used microorganisms as biofertilizer are *Rhizobia*, *Azospirillum*, Phosphate Solubilizing Bacteria (PSB), Plant Growth Promoting Rhizobacteria (PGPR), *Azotobacter* and Arbuscular Mycorrhiza (AM). Biofertilizers act as an alternative which help to reduce the consumption of chemical fertilizers, to solve the environmental issues, reduce the damage to human health and enhance microbiological activity, physical and chemical properties of the soil [5].

## Experimental

### *Design and treatments*

A field experiment was conducted during winter season of 2015-16. The location of the experiment was in field of Department of Agronomy, Punjab Agricultural University (PAU), Ludhiana, India. The fields were subjected organic manures from long term. The experiment was laid in randomized blocked design using Punjab-88 variety. Treatments were applied in triplicate. The plot size was 7 × 2.5 $m^2$. A total of ten different fertilizer combinations were made as follows:

| Treatments | Fertilizer |
|---|---|
| **T1** | Without NPK |
| **T2** | N(100%) + P(100% of recommended dose) |
| **T3** | NP 50% from organic + 50% from inorganic |
| **T4** | NP 25% from organic + 75% from inorganic |
| **T5** | NP 100% from organic |
| **T6** | T1+ consortium biofertilizer |
| **T7** | T2+ consortium biofertilizer |
| **T8** | T3+ consortium biofertilizer |
| **T9** | T4+ consortium biofertilizer |
| **T10** | T5+ consortium biofertilizer |

The experiment was laid down by following the guidelines mentioned in package and practices of PAU (Punjab Agricultural University). All the treatments were inoculated with recommended dose of *Rhizobium* culture. The inorganic fertilizer viz. urea was applied @ 50 kg per acre, diammonium phosphate @ 80 kg per acre and organic fertilizer in the form of farm yard manure (FYM) @ 100 kg per acre. Consortium biofertilizer consisting of PSB and PGPR were used in combination with organic and inorganic fertilizers having different doses. The *Rhizbium* biofertilizer was purchased from Department of Microbiology, PAU, Ludhiana, India.

### *Biofertilizers application*

For the growth of consortium biofertilizer, Pikovaskaya's (PSB) and King's B (PGPR) media used were. Seeds of pea were inoculated with charcoal based biofertilizer having $10^8$ cells/ g @ 250g/ acre.

### *Soil sampling and analysis*

Soil samples were collected from rhizospheric soil (0-15 cm) of pea crop at harvest. The soil sampling was done from different treatments by collecting soil from 3-4 places in each plot with the aid of auger. Then the samples from same plot were mixed to get representative sample. The soil sample was dried, first in air then in oven, grounded with pestle and mortar and finally sieved for analysis of physico-chemical properties. Soil pH was determined by Beckman glass electrode pH meter. Other soil parameters including soil electrical conductivity [6], soil organic carbon content [7], available nitrogen [8], available phosphorus [9] and available potassium [10] were studied.

### *Statistical analysis*

A one-way analysis of variance (ANOVA) was performed to determine the effect of different fertilizer treatments on soil properties and plant nutrient status. Correlation was examined between soil microbial population and physico-chemical properties of soil. The level of significance referred in the results is $p < 0.05$.

## Results and Discussion

The results obtained showed that soil physico-chemical properties and plant nutrient status were significantly affected by biofertilizer inoculation. The initial soil properties before sowing of crop were observed. Soil pH was observed as 6.9; electrical conductivity was 0.20 dS/m; organic carbon content of the soil was 0.235; available nitrogen, phosphorus and potassium were 111.6 kg/ha, 20.3 kg/ha and 110.4 kg/ha respectively. Application of biofertilizers improved the overall nutrient status of the soil.

Soil pH is the deciding factor for the availability of essential plant nutrients. The results revealed that the initial soil pH before the sowing of crop was near to neutral (6.9) which increased significantly with the addition of organic manures and fertilizers. A slight decrease in soil pH was observed in treatment having sole application of consortium biofertilizer (7.24) as compared to treatment without any inoculations i.e. control (7.27) as shown in **Figure 1a**. The lowering of pH with addition of organic manures and biofertilizers may be attributed to the presence of organic acids in the manure and extracellular secretions made by microbes. Thus it helps in maintaining the buffering capacity of the soil.

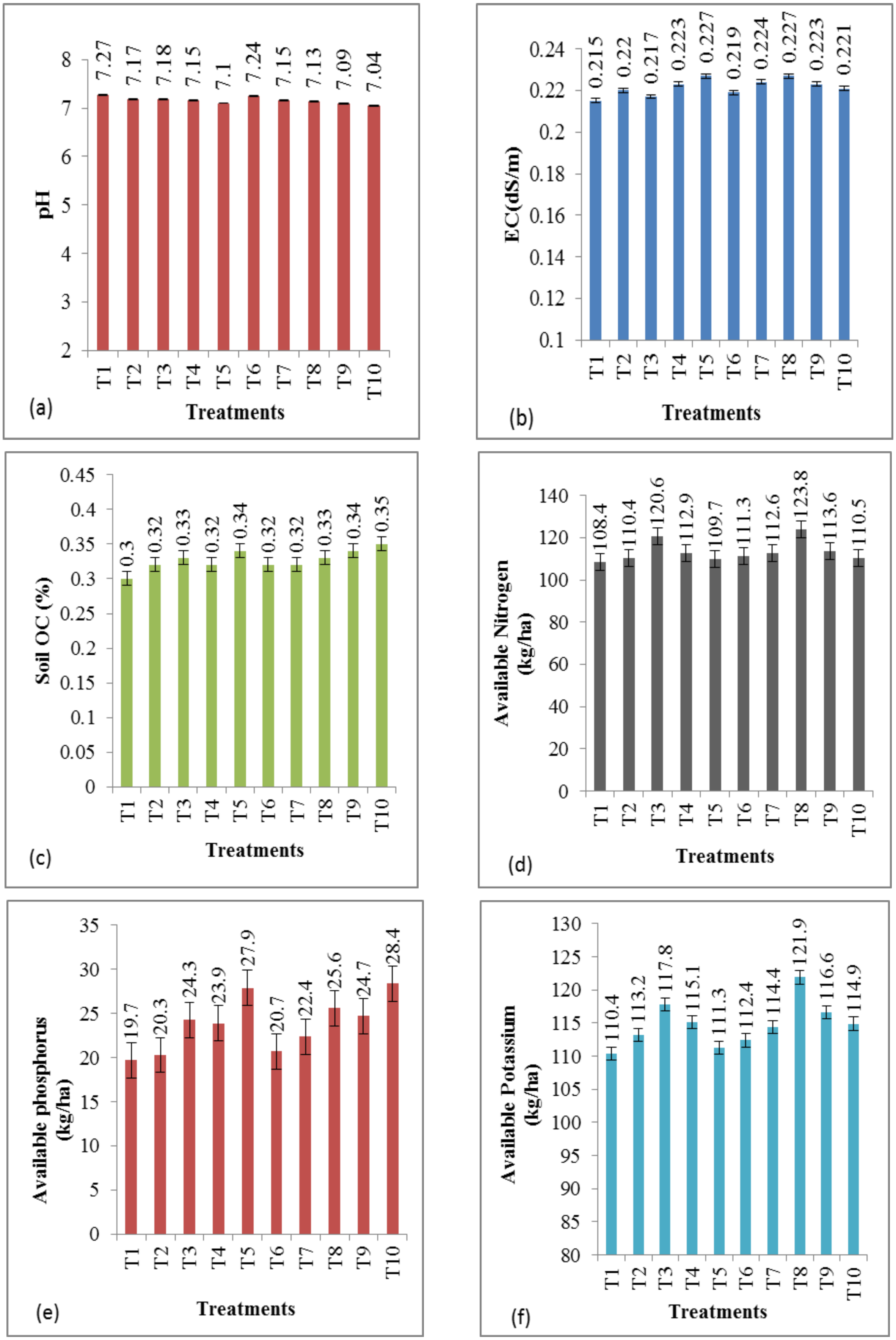


**Figure 1** Variation of physico-chemical properties at harvest in different treatments. (a) Soil pH, (b) Soil EC, (c) Soil organic carbon content, (d) Available nitrogen, (e) Available phosphorus, (f) Available potassium

Electrical conductivity (EC) increased with addition of inorganic, organic and biofertilizers. The EC of soil is directly related to the ions present in it; the probable reason being the production of acids or their intermediates through the decomposition of organic compounds, which reacted either with the partially soluble salts already present in the soil or converted them into soluble salts thereby increasing their solubility. The maximum EC (0.227 dS $m^{-1}$) was observed in treatment having 50% FYM + 50% recommended dose of nitrogen and phosphorus + consortium which was at par with treatment having 100% recommended dose of FYM (Figure 1b). According to studies of Khanday and Ali [11], increasing the dose of FYM decreases the EC of the soil. The results were in accordance with findings of Gopinath et al [12] and Jaipaul et al [13] who studied the positive effects of biofertilizers, organic manures and inorganic fertilizers on soil properties. They determined that addition of alternate fertility amendments such as biofertilizers improve the ion exchange capacity of the soil.

The addition of FYM and consortium biofertilizer significantly affected the soil organic carbon content. The organic carbon content of soil increased from 0.30% to 0.35% in control and treatment having 100% FYM + consortium respectively (Figure 1c). High microbial biomass production and high rhizodeposits of carbonaceous materials through root exudates may be one of the reasons for higher organic carbon in organically treated soils [14]. Similar results were reported by Kumar and Sharma [15] showing increase in organic carbon content of soil with the addition of organic manures and biofertilizers.

Nitrogen, phosphorus, potassium and iron are key nutrients that play an indispensable role in crop production [16]. The maximum available nitrogen (123.8 kg $ha^{-1}$) was observed in treatment having 50% FYM + 50% recommended dose of nitrogen and phosphorus + consortium (Figure 1d). This may be due to various reasons such as slow mineralization of the nitrogen applied via manure, a higher application of nitrogen through organic sources and a sustained availability of nutrients through FYM into the soil [17]. Various studies have shown that long-term fertility trials through organic fertilizer applications increased the organic carbon stock and, thereby increased the cation exchange capacity. This effect has been attributed to the high negative charge of organic matter [18]. High cation exchange efficiency is important for retaining nutrients in the soil thereby making them available to plants. Available phosphorus of the soil (28.4 kg $ha^{-1}$) was observed to be the maximum in treatment having 100% FYM + consortium (Figure 1e). This can be attributed to the presence of PSB in the consortium biofertilizer which was effective in increasing the availability of phosphorus in soil by solubilization of native soil P [19]. Soil potassium (121.9 kg $ha^{-1}$) observed to be significantly higher in treatment having 50% FYM + 50% recommended dose of nitrogen and phosphorus + consortium (Figure 1f) which may be attributed to increase in the release of potassium from organic compounds and minerals present in soil via decomposition as well as solubilization by soil microorganism.

The correlation between different microbial population viz., bacteria, fungi, actinomycetes, PSB and PGPR and soil physico-chemical properties at harvest was carried out. Bacterial population was positively correlated with soil organic carbon ($r=0.455$, $p<0.05$), available nitrogen ($r=0.377$, $p<0.05$) and available potassium ($r=0.571$, $p<0.01$). On the contrary, fungal population was negatively correlated with available nitrogen ($r=-0.039$) and potassium ($r=-0.022$) but was positively correlated ($r=0.784$, $p<0.01$) with available phosphorus (**Table 1**). PGPR population had positive correlation with available nitrogen ($r=0.607$, $p<0.01$), phosphorus ($r=0.659$, $p<0.01$) and potassium ($r=0.628$, $p<0.01$).

**Table 1** Correlation between microbial population and soil properties at harvest

| | **pH** | **OC** | **EC** | **Soil N** | **Soil P** | **Soil K** |
|---|---|---|---|---|---|---|
| Bacteria | -0.275 | 0.455* | 0.232 | 0.377* | 0.346 | 0.571** |
| Fungi | -0.180 | 0.691** | 0.397* | -0.039 | 0.784** | -0.022 |
| Actinomycetes | 0.388* | -0.230 | -0.080 | -0.429* | -0.162 | -0.619** |
| Diazotrophs | -0.459* | 0.738** | 0.303 | 0.188 | 0.711** | 0.33 |
| PSB | -0.500** | 0.643** | 0.053 | 0.071 | 0.516** | 0.27 |
| PGPR | -0.339 | 0.554** | 0.308 | 0.607** | 0.659** | 0.628** |
| pH | 1 | -0.292 | 0.540** | 0.040 | -0.307 | -0.03 |
| Soil organic carbon | | 1 | 0.492** | 0.085 | 0.941** | 0.311 |
| EC | | | 1 | 0.234 | 0.491** | 0.376* |
| Available nitrogen | | | | 1 | 0.267 | 0.926** |
| Available phosphorus | | | | | 1 | 0.407* |
| Available potassium | | | | | | 1 |

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The results were in accordance with studies of Laldinthar and Dkhar [20] who studied the correlation between bacterial population and soil physico-chemical properties. They showed that bacterial population in the rhizospheric soil was positively correlated with organic matter content. Results were in confirmation with studies of Setiawati [21] who showed positive relationship between soil microbes and soil chemical properties as well as bacterial population was positively correlated with organic carbon. Similar results showing positive correlation of soil organic carbon and soil phosphorus were reported by Rezende et al [22].

## Conclusion

It is concluded that microbial inoculants had significant effect on physico-chemical properties of rhizospheric soil. The improvement in soil status for available nutrients with the application of biofertilizers could render profitable for the next crop in the cropping systems. Further, combined application of organic and inorganic fertilizers improves the soil properties. This characterizes the synergistic effect of inorganic and organic fertilizers thereby signifying that integrated use of inorganic, organic and biofertilizers helps in upgrading soil health.

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