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# Long term impacts of organic manures and chemical fertilizers on different chemical properties of soil in *Tarai* region of India

**Shiv Singh Meena, Ajay Srivastava, BR Meena, Vjay Kant Singh and Arvind Bishnoi**

**Abstract**
Agriculture has been the backbone of the Indian economy. In India around 70 per cent of the population earns its livelihood from agriculture. It fulfils the basic need of human beings and animals. It is an important source of raw materials for many agro-based industries. All chemical properties of the soil are the key factor of soil fertility. Different chemical properties in soil *viz*., N, P, K, EC pH affect due to the application of chemical fertilizers and organic manures. However the magnitudes of the impact at 0-15 and 15-30 cm soil depth are varies and alterations in the chemical properties of soil are not well defined. Therefore, the present trial was conducted on long term impacts of organic manures and chemical fertilizers on different chemical properties of a *Tarai* soil at the N.E. Borelog crop research centre, GB Pant University of Agriculture and Technology Pantnagar, Uttarakhand (India). The experiments plot comprising of six treatments were laid out in simple randomized block design with four replications. Treatments were i. Control, ii. 100% NPK (LTFE), iii. 100% NPK + FYM (LTFE), fallow field, poplar based agro-forestry system and eucalyptus based agro-forestry system. The pH of the soil was not significantly influenced by different treatments in both the surface and sub surface soil. The highest EC at surface and sub surface soil was found in poplar based agroforestry systems ($T_5$), followed by eucalyptus based agroforestry systems ($T_6$), 100% RD of NPK+FYM @ 15 t $ha^{-1}$($T_3$) and lowest EC was recorded in the control plot ($T_1$). The highest soil available nitrogen in surface soil was observed in 100% NPK + FYM @ 15 t $ha^{-1}$ treated plot ($T_3$), followed by $T_5$ and $T_4$ whereas, the lowest value was observed in control plot. The data obtained from this experiment enhanced the understanding of long term impacts of organic manures and chemical fertilizers on different chemical properties of soil in the *Tarai* region soil of UK in India.

**Keywords:** Nitrogen, phosphorus, potassium, EC, pH

## 1. Introduction

Agriculture has been the backbone of the Indian economy. In India around 70 per cent of the population earns its livelihood from agriculture. It fulfils the basic need of human beings and animals. It is an important source of raw materials for many agro-based industries. Indian geographical condition is unique for agriculture because it provides many favourable conditions. There are plains, fertile soil and long growing seasons and wide variations in climatic conditions *etc.* Apart from unique geographical conditions, India has been consistently making innovative efforts with the help of science and technology to increase production. In India, various types of farming and cropping patterns are used by farmers. India has one of the largest plain areas of the world in the form of Indo-Gangetic plain. Central part of India is dominated by plateau area. In the country, rice-wheat cropping system is very popular in Indo-Gangetic plains, occupies about 13.5 million hectares. Rice-wheat cropping system dominated mostly in Punjab, Haryana, Uttar Pradesh and Madhya Pradesh and contributes 75 per cent of the national food grain production (Sapkota *et al.*, 2017 and Jat *et al.*, 2014) [21, 12]. The intensive tillage in rice- wheat cropping systems requires much labour, water and energy, which are becoming more expensive, thus increasing the cost of production resulting in decreased profitability (Aryal *et al*., 2015). Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. (FAO, 2015) [15]. Agroforestry system interventions provide diversified range of product from a given area leading to higher income and improved standards of life, enhanced self-sufficiency and reduced risk from climatic, biological, and market impacts, better use of underutilized land enhance food and nutritional security and increased fulfilment of social and cultural needs through product sharing and exchange (Kumar and Nair, 2004) [13].

Soil organic matter (SOM) are intrinsic and essential components of soil which act as a storehouse for nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and all essential micro and trace nutrients. It also improves various other chemical properties such as cation exchange capacity and buffering capacity of soils and also improves soil physical properties *viz.* soil structure, porosity, water holding capacity and soil drainage.

Agroforestry has great potential for restoration of degraded lands and forests and mitigating the release of carbon as $CO_2$ in the atmosphere by increasing land based carbon sinks. Owing to all above points the present investigation ‘‘Long term impacts of organic manures and chemical fertilizers on different physical properties of soil in *Tarai* region of India” was carried out with the objective assessment of physical properties in rice- wheat cropping systems and poplar and eucalyptus based agroforestry systems under long term use of chemical fertilizers, organic manure (FYM).

## 2. Materials and Methods

The field experiment was conducted during the crop season, 2016-17 at Norman E. Borlaug Crop Research Centre of GBPUA&T, Pantnagar, four treatments were taken in an ongoing Long Term Fertilizer Experiment, which is being carried out at since *Kharif* 1971 and Agroforestry Research Centre of GBPUA&T, Pantnagar in which two treatments were taken from Poplar and Eucalyptus based agroforestry systems. Experiment location represents the *Tarai* belt of Uttarakhand and is situated at 29˚N latitude, 79.5˚ E longitude and at an altitude of 243.83 m above mean sea level in the foot hills of *shivalik* range of the Himalayas. The soil of experimental area is fined loamy in texture. These soils are originated from alluvial sediments. The climate of the region is humid subtropical. The average annual precipitation is 1020 mm. During summer, maximum temperature exceeds $40^0$ C while in winters the minimum temperature occasionally touches $0^0$ C. the experimental treatments were laid out in RBD and replicated fourth times. Six treatments combination including two field conditions were (1) Long term fertility experiments; (a.) Control (no manures and fertilizers), (b.) 100% NPK to rice and wheat both (c.) 100% NPK to both crops + FYM @ 15 t $ha^{-1}$ (to wheat only) (d.) Fallow (without crop) (2) Agro-forestry system; (a.) 100% NPK to soybean-wheat and under Poplar trees (b.) 100% NPK to wheat under eucalyptus trees. The details of experiments are presented in Table 1.

### 2.1 Experimental Site

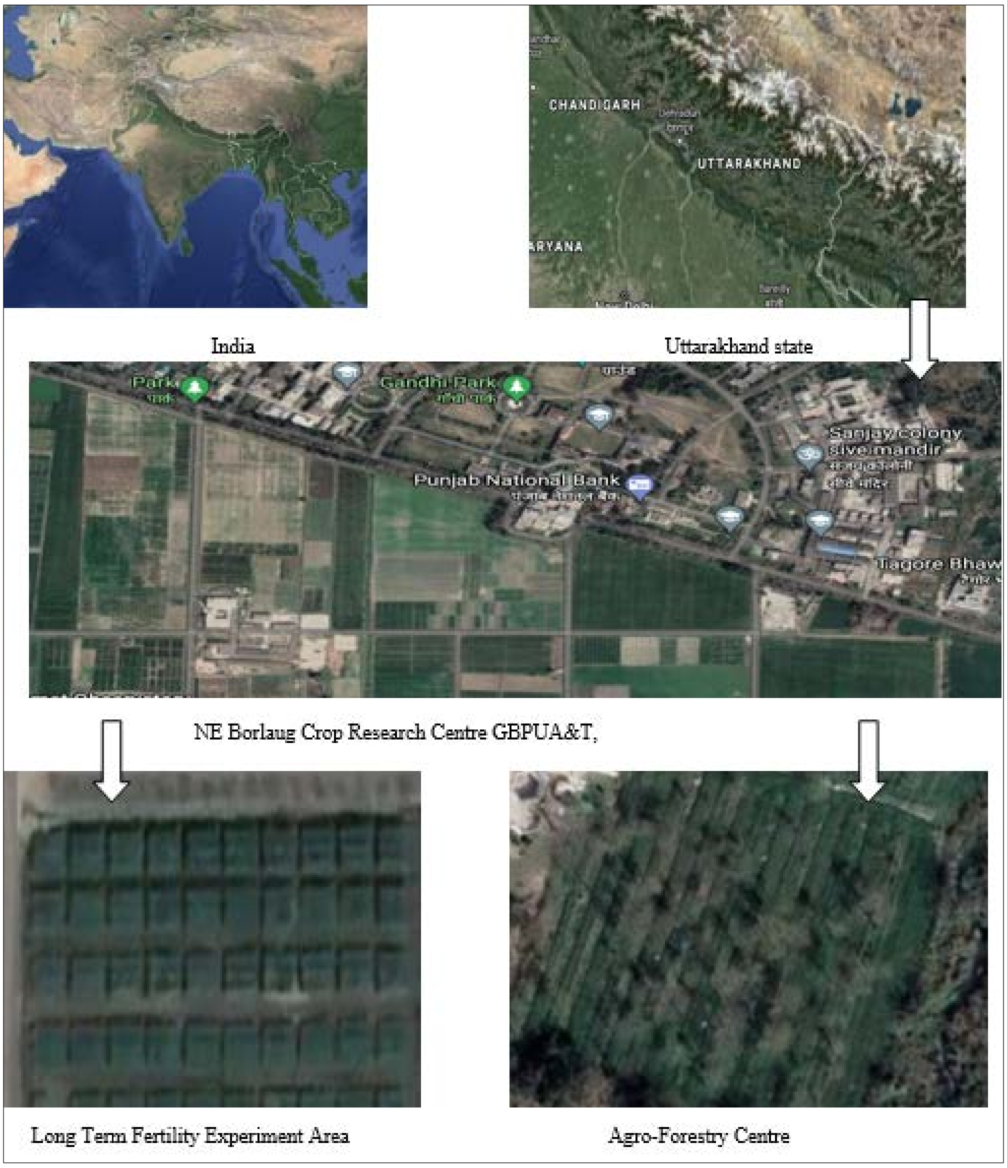

**Table 1:** Experimental details

| S. N. | Experimental site details | GB Pant University of Agriculture and Technology, Pantnagar, UK, India |
|---|---|---|
| 1 | Duration | 49 year of LTFE and 10 year of Agro-forestry |
| 2 | Tillage | Conventional tillage |
| 3 | Crop history | Rice-wheat cropping system follows from last 20 years in LTFE and Fallow-wheat cropping sysetm in AF |
| 4 | Types of soil | Fined loamy, High base saturation, developed from alluvial sediments |
| 5 | Experiment analysis design | Randomized block design (RBD) to test differences among the treatment means as described by Gomez and Gomez (1984). Correlation coefficients were computed using SPSS programme. |
| 6 | Replications | Four |
| 7 | Treatments | Six |

### 2.2 Observations
#### 2.2.1 Soil sampling
Soil samples were taken by the help of core sampler from two soil depths i.e. 0-15 and 15-30 cm to the experimental field after *Kharif* and *Rabi* seasons. The core and samples were weighed before and after drying in oven at 105ºC temperature for 25 hr (Gardner *et al.*, 2001).

Then the soil samples air dried, broken the clods and removed the roots and other material from the sample. Thereafter the soil samples were passed through 0.2 to 0.5 mm sieve for organic fractions and 2-mm sieve for other parameters. The sieved soil samples were stored in air tight plastic beg for further analysis of Physico-chemical and biological properties.

#### 2.2.2 Soil pH
A soil-water suspension was prepared in the ratio of 1:2.5 (10 g soil with 25 mL of distilled water) and pH was measured with the help of pH meter (Jackson, 1967) [11].

#### 2.2.3 Electrical conductivity
The soil water suspension prepared for determination of pH was used to estimate the electrical conductivity of soil. Soil suspension was allowed to settle till supernatant became clear. Electrical conductivity was measured with the help of EC meter and expressed as $dSm^{-1}$ (Bower and Wilcox, 1965) [5].

#### 2.2.4 Available N (Subbiah and Asija, 1956)
Available nitrogen was determined by alkaline potassium permanganate method. Almost 20 g of soil was treated with 100 mL of 0.32%alkaline KMnO4 solution. The organic matter present in the soil was oxidized by nascent oxygen liberated by KMnO4 in presence of sodium hydroxide (NaOH). Ammonia thus released was absorbed in known volume of standard acid (2% boric acid).

Titrate the distillate with standard alkali using methyl red against 0.02 $NH_2SO_4$ taken in burette until the pink colour appearing. Run a blank sample without soil with each set of five samples.

$$\text{Available N (kg/ha)} = \frac{(S - B) \times 0.00028}{20} \times 10^6 \times 2.24$$

Available N (kg/ha) = (S-B) × 31.36

Where, S and B stand for the volume of $H_2SO_4$ of sample and blank, respectively.

#### 2.2.5 Available Phosphorus (Olsen *et al.*, 1954) [18]
Available Phosphorus was extracted from soil with 0.5 M $NaHCO_3$ (pH 8.5) as described by Olsen *et al.* (1954) [18] and determined by Ammonium Molybdate Blue Colour method using Spectrophotometer at 882 nm.

$$\text{Available P (kg ha}^{-1}) = \frac{\text{R x Volume of extract}}{\text{Volume of aliqute}} x \frac{2.24 \times 10^6}{\text{wt. (g) of soil} \times 10^6}$$

Where, R = quantity of P in µg read on X- axis against a sample reading.

#### 2.2.6 Available Potassium
Available potassium was determined with neutral normal ammonium acetate solution (pH 7.0) by shaking for 30 minutes. Potassium content in the extract was determined flame-photometrically as given by Hanway and Heidel, 1952 [10].

$$\text{Available K (kg ha}^{-1}) = \frac{\text{R x Volume of extract x 2.24}}{\text{Weihgt of soil sample}}$$

Where R = ppm of K in the extract (obtained from the standard curve)

### 3. Result and Discussions
#### 3.1 Soil pH
The pH of the soil was not significantly influenced by different treatments in both the surface and sub surface soil both experimental sites during both the years presented in Table 2. The pH of the soil recorded at surface soil varied from 7.58 to 7.76. The highest pH was observed in poplar based agro forestry systems ($T_5$), followed by Eucalyptus based agroforestry systems ($T_6$), control ($T_1$), Fallow, 100% NPK + FYM ($T_3$) and lowest value in 100% NPK treated plot. The same trend as surface soil was observed in sub surface soil (15-30 cm), where pH ranged from 7.76 to 7.84. The highest pH was recorded in poplar based agroforestry systems ($T_5$), followed by Eucalyptus based agroforestry systems ($T_6$), control ($T_1$), Fallow, 100% NPK + FYM ($T_3$) and lowest value in 100% NPK treated plot. The soil pH was decrease with application of acid forming fertilizer i.e. ammonium sulphate, ammonium nitrate and urea. Similar findings were also reported by Uthappa *et al.* (2015) [23] observed that the maximum (8.55) and significantly higher soil pH was recorded in 30-60 cm soil depth, whereas than lower pH was recorded from 0-15cm (8.24) soil depth. Singh *et al.* (2017) [22] also evaluated that the continuous cropping and chemical fertilizer application over the years lower the soil pH, except the treatment involving the use of lime.

#### 3.2 Soil electrical conductivity (EC $dSm^{-1}$)
A glance of the data (Table 3) revealed that EC of the soil was significantly influenced by different treatments in both the surface and sub surface. The EC of the soil recorded at surface soil ranged from 0.29 to 0.40 $dSm^{-1}$. At surface layer the highest EC was observed in poplar based agroforestry systems ($T_5$) followed by Eucalyptus based agroforestry

systems ($T_6$), 100% RD of NPK+FYM @ 15 t $ha^{-1}$ ($T_3$). The lowest EC was observed in the control plot ($T_1$). In sub-surface soils, EC ranged between 0.27 to 0.37 $dSm^{-1}$. The highest EC was found in poplar based agroforestry systems ($T_5$), followed by Eucalyptus based agroforestry systems ($T_6$), 100% RD of NPK+FYM @ 15 t $ha^{-1}$ ($T_3$) and lowest EC was recorded in the control plot ($T_1$). In different chemical fertilizer treatments EC was slightly increased at both the surfaces except control plot whereas, EC was decreased. This might be due to addition of chemical fertilizer increases accumulation of salt in the soil which contributes increases in EC of soil. Similar results were observed by Bhatt *et al.* (2018) [3] and Uthappa *et al.* (2015) [23]. (Newaj *et al.*, 2007) [17] reported that the EC higher under poplar system may be due to production of organic acids from decomposition of litter and the effect of climatic variables *viz.* solar radiation, temperature, relative humidity, precipitation and wind velocity.

### 3.3 Available nitrogen (N kg $ha^{-1}$)
The data on available nitrogen is presented in Table showed that the soil available nitrogen was significantly influenced by the different treatments in the surface and sub surface (0-15 and 15-30 cm) soil. Soil available N observed at surface soil ranged from 188.15 to 359.58 kg $ha^{-1}$. The soil available nitrogen in sub surface soil (15-30 cm) varied from 125.42 to 259.24 kg $ha^{-1}$. The highest N content was recorded in 100% NPK +15 t FYM $ha^{-1}$ treated plot ($T_3$), followed by $T_5$ and $T_4$ whereas, the lowest N content was observed in the control. The soil available nitrogen was decreased with increase in soil depth which may be assigned to the addition of FYM and crop residues on the soil surface. It was also surprising to notice that available nitrogen increased in all the treatments except control and 100% NPK treated plots at both the surface and sub surface soil. This might be attributed to the fact that the nitrogen present in N fertilizer and FYM could be converted into plant available form by biochemical reaction. These results were in agreement with the findings of Yadav and Kumar (2009) [24] and Kumar *et al.* (2008) [14]. Trees can also enhance soil chemical, physical, and biological properties of soil by adding organic matter and releasing nutrients in agro-forestry systems (Antonio and Gama-Rodrigues, 2011) [1] and (Chaudhry *et al.*, 2007) [7].

### 3.4 Available phosphorus (P kg $ha^{-1}$)
From the data presented in Table showed that the soil available phosphorus was significantly influenced by the different treatments in the surface and sub surface (0-15 and 15-30 cm) soil at both experimental sites. Soil available phosphorus noticed at surface soil ranged from 8.48 to 33.83 kg $ha^{-1}$. All the treatments showed significantly increased in soil available phosphorus as compared to control. However, the highest soil available phosphorus in surface soil was observed in 100% NPK +15 t FYM $ha^{-1}$ treated plot ($T_3$), followed by poplar based agroforestry systems ($T_5$) and fallow plot ($T_4$) whereas, the lowest value was observed in control plot. The soil available phosphorus in sub surface soil (15-30 cm) varied from 4.88 to 30.65 kg $ha^{-1}$. The maximum value was recorded in 100% NPK + FYM @ 15 t $ha^{-1}$ treated plot ($T_3$), followed by $T_5$ and $T_4$ whereas, the minimum value was observed in the control. It was also noticed that available phosphorus increased in all the treatments except in control plot at both the surface and sub surface soil. The soil available phosphorus was decreased with increase in soil depth. Application of FYM with 100% NPK enhance the availability of P might be due to release of organic acid that bind aluminium and iron, thereby reducing P fixation and increasing its availability. Similar findings were observed by (Manjhi *et al.*, 2014) [16]. Soil organic matter on the soil surface favored the solubilization of insoluble P releasing much more quantity to the surface (Chaudhary *et al.*, 2006) [6] and also due to the imprisonment of crop cultivation to the rhizosphere and inosculate of the depleted P through external sources i.e., chemical fertilizers (Kumari *et al.*, 2010) [15] and (Rajeswar and Aariff khan, 2007) [19].

### 3.5 Available potassium (K kg $ha^{-1}$)
The available potassium data in surface and sub surface layer was statistically analyzed and furnished in table. Soil available potassium was significantly influenced by the different treatments in the surface and sub surface layer (0-15 and 15-30 cm) soil at both experimental sites. Soil available potassium at surface soil ranged from 108.54 to 182.42 kg $ha^{-1}$.All the treatments showed significantly increased in soil available potassium as compared to control plot. The soil available potassium in sub surface soil (15-30 cm) varied from 95.24 to 158.20 kg $ha^{-1}$. The highest value was recorded in 100% NPK +15 t FYM $ha^{-1}$ treated plot ($T_3$) and the lowest value was recorded in the control. An overall increase in available K was observed in the present study under all the treatments as compared to the control plot at both the surface and sub surface. Surface soil had higher available K content as compared to sub-surface soil. This could be due to more intense weathering of K bearing minerals, release of K from crop residues, application of potassium fertilizers and upward translocation of K from lower depth along with capillary rise of ground water. Similar results were observed by (Basavaraju *et al.*, 2005) [2] and (Rao *et al.*, 2013) [20]. The beneficial effect of 100% NPK RD along with FYM on available K could be ascribed to the reduction of K fixation, solubilisation and release due to the interaction of organic matter with clay particle besides the direct K addition to the K pool of soil. Shri Ram *et al.* (2016) found that the long term application of chemical fertilizer, FYM for 41 years significantly rise available K was recorded under the FYM treated plots followed by the super-optimal dose of NPK fertilizers. Respectively, the minimum value of available potassium recorded in control. Bora *et al.* (2018) [4] observed that the significantly highest content of available K was noticed in the treatments where manure was incorporated along with N and $P_2O_5$ as compared to the treatments where no organic manure was applied.

**Table 1:** Effect of long term use of organic manure manures and inorganic fertilizers on pH and EC ($dSm^{-1}$) under different cropping systems

| S. No. | Treatments | pH | | EC ($dSm^{-1}$) | |
|---|---|---|---|---|---|
| | | Depth (0-15 cm) | Depth (0-15 cm) | Depth (0-15 cm) | Depth (0-15 cm) |
| T1 | Control | 7.66$^a$ | 7.81$^a$ | 0.29$^e$ | 0.27$^e$ |
| T2 | 100% NPK (LTFE) | 7.58$^a$ | 7.76$^a$ | 0.32$^d$ | 0.30$^d$ |
| T3 | 100% NPK+FYM (LTFE) | 7.62$^a$ | 7.78$^a$ | 0.35$^c$ | 0.33b$^c$ |

| | | | | | |
|---|---|---|---|---|---|
| T4 | Fallow (LTFE) | 7.64[a] | 7.80[a] | 0.33[d] | 0.31[cd] |
| T5 | Poplar (Agroforestry) | 7.76[a] | 7.84[a] | 0.40[a] | 0.37[a] |
| T6 | Eucalyptus (Agroforestry) | 7.68[a] | 7.82[a] | 0.37[b] | 0.35[b] |
| | S.Em± | 0.06 | 0.08 | 0.00 | 0.01 |
| | CD at 5% | 0.19 | 0.23 | 0.01 | 0.02 |
| | CV % | 1.66 | 1.99 | 2.70 | 4.42 |

**Table 2:** Effect of long term use of organic manure manures and inorganic fertilizers on available nitrogen (kg $ha^{-1}$), available phosphorus (kg $ha^{-1}$) and available potassium (kg $ha^{-1}$**)** under different cropping systems

| S. No. | Treatments | Available nitrogen (kg $ha^{-1}$) | | Available phosphorus (kg $ha^{-1}$) | | Available potassium (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|
| | | Depth (0-15 cm) | Depth (0-15 cm) | Depth (0-15 cm) | Depth (0-15 cm) | Depth (0-15 cm) | Depth (0-15 cm) |
| T1 | Control | 188.15[e] | 125.42[e] | 8.48[d] | 4.88[e] | 108.54[e] | 95.24[e] |
| T2 | 100% NPK (LTFE) | 242.51[cd] | 196.52[d] | 21.18[c] | 15.24[d] | 138.66[d] | 126.78[d] |
| T3 | 100% NPK+FYM (LTFE) | 359.58[a] | 259.24[a] | 33.83[a] | 30.65[a] | 182.42[a] | 158.20[a] |
| T4 | Fallow (LTFE) | 250.88[bc] | 213.27[c] | 22.65[c] | 18.74[bc] | 160.22[c] | 138.56[bc] |
| T5 | Poplar (Agroforestry) | 263.67[b] | 234.15[b] | 25.64[b] | 20.18[b] | 170.84[b] | 148.26[ab] |
| T6 | Eucalyptus (Agroforestry) | 229.79[d] | 200.70[d] | 21.35[c] | 17.34[c] | 148.92[d] | 130.88[cd] |
| | S.Em± | 5.54 | 3.68 | 0.67 | 0.55 | 3.42 | 3.42 |
| | CD at 5% | 16.70 | 11.09 | 2.00 | 1.66 | 10.29 | 10.31 |
| | CV % | 4.33 | 3.59 | 6.00 | 6.17 | 4.51 | 5.14 |

## 4. Conclusion

Different chemical properties in soil *viz*., N, P, K, EC pH affect due to the application of chemical fertilizers and organic manures. However the magnitudes of the impact at 0-15 and 15-30 cm soil depth are varies. The pH of the soil was not significantly influenced by different treatments in both the surface and sub surface soil. The highest EC at surface and sub surface soil was found in poplar based agroforestry systems ($T_5$), followed by eucalyptus based agroforestry systems ($T_6$), 100% RD of NPK+FYM @ 15 t $ha^{-1}$($T_3$) and lowest EC was recorded in the control plot ($T_1$). The highest soil available nitrogen in surface soil was observed in 100% NPK + FYM @ 15 t $ha^{-1}$ treated plot ($T_3$), followed by $T_5$ and $T_4$ whereas, the lowest value was observed in control plot.

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