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Note

Effect of poplar and eucalyptus based agroforestry system on soil biochemistry

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The field experiment was conducted during the winter season of 2016-17 at the experimental site of Agroforestry Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Poplar and eucalyptus were intercropped with different wheat varieties (UP-2526, UP-2565, UP-2628, and DPW-621-50). After harvesting the wheat crop, the soil sampling was performed to determine the soil parameters like electrical conductivity (EC), organic carbon and the minerals content. Nitrogen, phosphorus and potassium content and other biochemical constituents were higher in the agroforestry system as compared to the open farming system. A high soil pH (7.53) was found in an open farming system and lower pH in an agroforestry system. Soil EC in the agroforestry system was slightly higher than the open farming system. Organic carbon was maximum (1.33%) under the poplar agroforestry system compared to the eucalyptus based agroforestry system. Overall, this study determines the effect of poplar and eucalyptus based agroforestry systems on soil biochemistry.

Keywords: Electric conductivity, Eucalyptus, Organic carbon, pH

Eucalyptus and popular are among the most rewarding tree species when concerning the agroforestry systems of India[1]. Intercropping with short rotation higher density tree species like eucalyptus is taken to fulfil the demand of food and industrial raw matter for the same specified piece of land[2]. Whereas, poplar is an incredible timber-producing tree in northern India. This specific tree species is raised on field boundaries or in blocks with farming crops like wheat, sugarcane, fodders, turmeric and vegetables. It's standing together with other crops is by far a prominent outcome of its fast growth, improved market prices, less competition with other crops, along with its pruning tolerant nature. Poplar based agroforestry techniques are viable and more economically profitable than a lot of different harvest rotations in India[3].

Eucalyptus and poplar based agroforestry techniques adopted extensively by the farm owners more than a commercial scale will significantly fulfill the financial, social and environmental problems of the people[4,5]. Poplar-wheat is a right combination due to winter time deciduous dynamics of poplar (growing time of wheat crop) along with minimum procurement help selling price fixed by Government of India for the wheat. Nearly every harvest (cereals, pulses, veggies, forage, fruit/vegetable plants, *etc*.) can be grown under poplar. It is of all the world's fastest-growing manufacturing mild woods, which could be harvested in just a moderately short period of 5 to 8 years[6,7]. As compared to eucalyptus, poplar is a deciduous tree that sheds its fundamental element of leaves annually during November and December[8].

Litterfall enriches the soil's organic matter state, improves soil abilities, and discharge nourishment after decomposition. Litterfall improves the biochemical properties of the soil. Poplar based agroforestry unit is attainable, more useful and more business than the crop farming method[9,10]. Poplar based agroforestry unit is an enormous success in irrigated areas of northwestern India. Wheat might be correctly developed under block plantation of eucalyptus and poplar throughout its rotation. This is due to the ability of poplar to adapt to the wheat rivals by distorting its root system that improves complementary between trees and crops[11,12]. Eucalyptus and popular have a quick growth rate and a root system that can develop over a broad area, making it an ideal plant for cultivation for determining the soil nutrient balance[13]. In this work, the effect of poplar and eucalyptus-based agroforestry systems on soil properties was determined under the north Indian conditions.

Materials and Methods

After harvesting wheat harvest, the dirt sampling was conducted from each one of the treatments and every replication. On 27th April 2017, the experimental site was divided into different representative points to collect the soil samples from 0-30 cm profile depths. After that,

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dirt samples were grinded and air-dried with a wooden roller than components of soil was analysed. The pH was determined in 1:2.5 soils: water ratio, and after half an hour of equilibrium, the pH was determined with the help of a glass electrode on a microprocessor-based pH meter. Electrical conductivity of the soil was measured in 1:2.5 soils: water suspension at 25°C with a digital microprocessor-based conductivity meter. The organic carbon content in soil was determined by the following modified Walkley and Black method[14]. Available nitrogen in the soil was determined by the alkaline potassium permanganate method. Obtained distilled ammonia gas out of the distillation flask, gathered up in boric acid, was again titrated with 0.02 N requirements H_2SO_4. Available nitrogen was estimated by utilizing the following formula:

Available nitrogen (kg ha^{-1}) = (S-B) × 31.36

Where,

S = Sample titration (mL standard acid)

B = Blank titration (mL standard acid)

Available potassium was determined by the neutral ammonium acetate method in which 5.0 g of soil was taken in a 100 mL conical flask. Then, 25 mL of the neutral 1.0 N ammonium acetate solution was added and shaken for 5 min on mechanical shaker. Then contents were filtered through Whatman No.1 filter paper. The concentration of K in the filtrate was measured by using a flame photometer[15].

Results and Discussion

Soil pH

Data related to observations are presented in (Table 1). Soil pH under open farming and agroforestry was found to be non-significant. Maximum soil pH (7. 53) was found in the available farming system and lower pH in an agroforestry system. Under eucalyptus agroforestry pH was recorded 7.48 and minimum in poplar based agroforestry system. Soil pH under different wheat varieties was found to be significant. Maximum soil pH found under UP-2526 (7.56) and DPW-621-50 (7.44) and Minimum soil pH under UP-2628 (7.40). Earlier it was determined that the soil pH was decreased with increased age of poplar[16,17].

Soil EC

The observation regarding soil EC (Electrical Conductivity) is presented in (Table 1). Soil EC under open farming and agroforestry system was found to be non-significant. Soil EC in the agroforestry system was slightly higher than the open farming system. Under poplar agroforestry system EC (0.38 dSm^{-1}) was higher over the eucalyptus (0.37 dSm^{-1}) agroforestry system. Among wheat varieties, higher EC in UP-2628 and remained superior overall varieties. Interaction between types, wide-open agriculture, agroforestry was discovered to be non-significant. EC was top under increased age of poplar plantation as opposed to the sole cropping[17].

Soil organic carbon

Data related to soil organic carbon is presented in (Table 1). Soil organic carbon was significantly influenced under the open farming system and agroforestry system. Organic carbon was maximum under the agroforestry system than the open farming system. Organic carbon was higher (1.33%) under poplar agroforestry system than the others. Even Organic carbon under eucalyptus was higher than the open farming system. Organic carbon was more elevated between different wheat varieties in UP-2526 (1.42%), and minimum organic carbon was recorded in DPW-621-50 and UP-2628. Interaction between wheat varieties, open farming and agroforestry was found to be non-significant. Soil organic carbon decreased with increasing depth of soil, and soil organic carbon under trees increased significantly[18]. Soil organic carbon was remarkably higher in the soil surface. Organic carbon under trees was more as compared to the control[19].

Table 1 — Effect of different wheat varieties, agroforestry system and open farming system on available soil pH, EC (dSm^{-1}) and organic carbon (%) at a depth of 0-30 cm

Treatment	pH	EC (dSm^{-1})	Organic Carbon (%)
Open (without trees)	7.53	0.35	1.02
Poplar	7.40	0.38	1.33
Eucalyptus	7.46	0.37	1.03
S.E.M ±	0.30	0.003	0.53
C.D. (P= 0.05)	NS	NS	0.21
C.V. (%)	1.1	2.5	4.2
Wheat Varieties			
UP-2526	7.59	0.37	1.42
UP-2565	7.42	0.38	1.04
UP-2628	7.40	0.38	1.03
DPW 621-50	7.44	0.37	1.03
S.E.M ±	0.02	0.004	0.05
C.D. (P= 0.05)	0.08	NS	0.17
C.V. (%)	1.5	3.4	5.7
Interaction (A×B)	NS	NS	NS

Available soil nitrogen (N)

Data related to soil nitrogen is presented in (Table 2). Soil nitrogen was found to be statistically significant in open farming systems and agroforestry system. Soil available nitrogen under eucalyptus agroforestry was significantly higher than open farming system and poplar agroforestry system. Soil nitrogen under the open farming system was less as compared to the agroforestry system. Maximum nitrogen was recorded in eucalyptus based agroforestry (239 kg/ha) than the open farming system. Under poplar based agroforestry system, soil nitrogen was 230.2 kg /ha. Available soil nitrogen was not significantly differing in wheat varieties. Maximum available nitrogen was found in UP-2526 (255.6 kg/ha), and UP-2565 was at par from UP-2628 and DPW-621-50. Minimum soil nitrogen was recorded in DPW-1621-50.

Interaction between wheat varieties, open farming and agroforestry system in respect of soil nitrogen was found to be non-significant. Continuous increase in soil organic matter under trees helped to increase soil nitrogen. Available nitrogen under agroforestry was higher due to the presence of organic matter as compared to sole cropping. There is decreased in soil nitrogen with increased depth of soil[15]. Available nitrogen in 0-15 cm and 15-30 cm depth was higher under trees than open farming system[19].

Available soil phosphorus (P_2O_5)

Observations regarding available soil phosphorus are presented in (Table 2). Soil phosphorus in open farming and agroforestry was found to be non-significant. Phosphorus was higher in agroforestry system than the open farming system. Maximum phosphorus was found in eucalyptus based agroforestry (20.2 kg/ha) and minimum in the open farming system (17.7 kg/ha). Under poplar based agroforestry, available phosphorus was 19.6 Kg/ha. Phosphorus among wheat varieties was found to be non-significant. Higher phosphorus was recorded in DPW-621-50 (19. 64 Kg/ha) and minimum under UP-2628. Phosphorus in UP-2565 (19.15 kg/ha) was higher than the UP-2628 (kg/ha). Interaction among wheat varieties, open farming and agroforestry was found to be statistically non-significant. Phosphorus was decreased with increasing soil depth, and it was higher under poplar agroforestry[20]. Phosphorus under trees was increased as compared to the open farming system[21].

Table 2 — Effect of agroforestry system and open farming system on available soil available nitrogen, phosphorus, potassium (Kg ha^{-1}) at a depth of 0-30 cm

Treatment	Available N (Kg ha^{-1})	P_2O_5 (Kg ha^{-1})	K_2O (Kg ha^{-1})
Open (without trees)	209.5	17.7	153.0
Poplar	230.2	19.6	174.0
Eucalyptus	239.0	20.2	176.5
S. E. M ±	1.8	0.2	1.0
C. D. (P= 0.05)	6.5	NS	4.3
C. V. (%)	2.5	4.2	2.2
Wheat Varieties			
UP-2526	255.6	19. 11	167.9
UP-2565	228.1	19.15	165.8
UP-2628	225.8	18.90	170.7
DPW 621-50	225.3	19.64	167.0
S. E. M ±	1.67	0.3	0.6
C. D. (P= 0.05)	NS	NS	2.0
C. V. (%)	2.2	5.7	1.2
Interaction (A×B)	NS	NS	NS

Available soil potassium (K_2O)

Data regarding available soil potassium is presented in (Table 2). Available soil potassium in open farming and agroforestry was found to be significant. Available soil potassium was higher in agroforestry systems than in the open farming system. Potassium was more elevated in the eucalyptus based agroforestry system (176.5 kg/ha) than open farming and poplar based agroforestry system. Potassium under eucalyptus based agroforestry system was significantly superior over open farming system. Among wheat varieties, potassium was found to be significant. Potassium in UP-2628 (170.7 kg ha^{-1}) was found to be significantly higher overall varieties. UP-2526 (167.9 Kg ha^{-1}) showed higher soil potassium than the UP-2565 (165.8 kg ha^{-1}) and DPW-621-50 (167.0 kg ha^{-1}). Interaction among wheat varieties was found to be non-significant. Potassium regulates transpiration respiration and affected the enzymatic activity and synthesis of proteins and carbohydrates. Available soil potassium has significantly differed in the various depth of soil under the agroforestry system[16].

Poplar based agroforestry methods are economically viable are much more sustainable than many other crop rotations common in northern India. Poplar can further improve the soil organic material (SOM) contents in arable soils[22]. Nevertheless, little is determined on the SOM quality under poplar cultivation so far. Moreover, soil organic C, total N, total P were determined to be more prominent under the agroforestry system. Soil organic N and C were maximum at 0 to 10 cm and declined with the depth of soil. P is consistent at all depths[14]. Agroforestry system resulted in a higher

organic matter status of the soil and is more significant to boost the microbial activity and nutrients status, as well biochemical composition of plant[23,24]. Under more mature forests, soil organic carbon was drastically higher as compared to the young plantation. In moderately alkaline soils organic carbon elevated by 11 to 52% because of the presence of trees in a method for 6-7 years. Overall, under the agroforestry system, a quick growth rate along with a root system is in a position to develop in a broad area, and also it's able to cultivate in poor nutrient soil and resist high levels of metal in soil.

Conclusion

From the above investigation it may be concluded that Soil Ph was higher under was higher in the open farming system than the agroforestry system. Higher pH among wheat varieties was recorded in UP-2526 which was significantly higher overall varieties. Soil EC and Soil organic carbon was significantly higher in the agroforestry system over the open farming system. Higher EC was found in UP-2628 and UP-2565 than the other wheat varieties. Soil organic carbon was higher under poplar based agroforestry system than the open farming and eucalyptus agroforestry system. Available soil nitrogen was significantly higher in the agroforestry system over open farming. Among wheat varieties available soil nitrogen in UP-2526 was substantially higher than overall varieties. Among intercrops, available phosphorus was more elevated in DPW-621-50, and minimum phosphorus was recorded in UP-2526. Soil parameters were significantly superior in agroforestry systems than open farming systems except soil pH, which was higher in the open farming system.

Conflict of interest

All authors declare no conflict of interest.

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