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Effect of integrated nutrient management on some physical and chemical properties of soil in wheat crop (*Triticum aestivum* L.) on Mollisols of Uttarakhand under poplar based agroforestry

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Abstract

A field experiment was conducted to assess the “Effect of integrated nutrient management on some physical and chemical properties of soil in wheat (*Triticum aestivum* L.) crop on Mollisols of Uttarakhand under poplar based agroforestry” at Experimental site of Agroforestry Research Centre (old site) near Horticulture Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar during the month of November to April, 2017-18. The experiment was laid in Randomized Complete Block Design comprising of nine nutrient treatments (chemical fertilizers and its substitution with organics) replicated thrice. The different treatment combinations did not show any significant change on soil reaction, electrical conductivity but enhanced the available nutrient content of soil. Minimum pH values were observed under T9 (7.16) followed by T7 (7.22) while the highest was under T1 (7.33). An application of nutrients through fertilizer alone and along with FYM and with/ or VC had non-significant influence on soil EC at surface (0-15 cm). With integrated nutrient management program, soil physical properties were enhanced. Maximum available N in top soil was in T9 (254.10 kg ha⁻¹), available phosphorus (22.05 kg ha⁻¹) and available potassium (228.67 kg ha⁻¹) content of soil after harvest of wheat crop.

Keywords: Mollisol, agroforestry, poplar, wheat, vermicompost

Introduction

The exhaustive planting and usage of imbalanced and ineffective fertilizers, followed by restricted use of organic manure, has not only left the soil deficient in nutrients, but has also degraded soil quality. Integrated utilization of nutrients is very important, not just promoting increased crop growth over the years, but also increasing soil health and maintaining a sustainable ecosystem. Balanced handling of nutrient levels through the use of conventional, inorganic and bio-fertilizers encourages efficient and profitable crop production and also protects soil health (Singh *et al.*, 2004) [14]. In order to get the soil well supplied with all the necessary plant nutrients and to keep it in good health, it is appropriate to use organic sources such as farmyard, vermicompost and manure from poultry as a good source of nutrients needed by plants for quality production.

Integrated Nutrient Management (INM) applies to sustaining soil fertility and the availability of plant nutrients at the optimal level to ensure the optimal production by maximizing the advantages of all available sources of organic, inorganic and biological materials in an incorporated sense. Regulated nutrient supply for optimal crop growth and higher efficiency, soil fertility enhancement and conservation, and zero adverse effect on agro-ecosystem quality by controlled fertilization of organic manures, inorganic fertilizers, and bio-inoculants are the key principle of INM (Mahajan and Sharma, 2005) [9]. Integrated management of plant nutrients boosts crop yields and enhances the physical, chemical and biological properties of soil. The combination of inorganic fertilizers with organic manures and bio-fertilizers would not only help sustain crop production but would also be successful in increasing soil quality and maximizing the output of nutrient utilization (Pandey *et al.*, 2009) [11]. In view of above, the present research was conducted to evaluate the impact of application of FYM and/or vermicompost and inorganic fertilizer on physical and chemical soil properties and wheat yields in Mollisols under poplar agroforestry system.

Material and methods

The present investigation was conducted at Experimental site of Agroforestry Research Centre (old site) near Horticulture Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar during the month of November to April, 2017-18. Geographically the site was situated in *Tarai* region of Uttarakhand at latitude of 28.97° N, 79.41° E longitude and an altitude of 243.84 meter above mean sea level. Pantnagar had humid sub-tropical climate with heavy rains in monsoon season. Mean annual rainfall was 1400mm. The soils of *Tarai* region were poorly developed alluvial soils. These soils were developed from moderately coarse textured alluvial parent material under the influence of tree vegetation. The soil of the experimental site belonged to Makota-III clay loam as surface texture (Deshpandey *et al.*, 1971) [6]. Following nine treatments were compared in plot experiment on integrated nutrient management system in wheat under poplar agroforestry system using Randomized block design.

Treatment	Symbol
Open control (no poplar) (N ₀ P ₀ K ₀)	T1
Control under poplar stand (N ₀ P ₀ K ₀)	T2
100% RDF	T3
100% RDN through FYM	T4
100% RDN through VC	T5
50% RDN through FYM + 50% RDN through urea	T6
50% RDN through VC + 50% RDN through urea	T7
50% RDN through FYM + 50% RDN through VC	T8
50% RDN through organics (25% FYM + 25% VC) + 50% RDN through urea	T9

RDF- Recommended Dose of Fertilizer (N₁₂₀P₆₀K₄₀) of wheat

RDN- Recommended Dose of Nitrogen

Nitrogen application for FYM and VC were calculated on N equivalent basis of RDF. 100% phosphorus through Single Super Phosphate and potash through Muriate of Potash were applied as basal in T3. Well-decomposed FYM and VC were added to the plots as per treatment two weeks prior to sowing. The wheat variety HD 3086 was sown on 7th November 2017 at a seed rate of 125 kg ha⁻¹. Row spacing was kept at 20 cm. Wheat seeds were treated with captan 2 g kg⁻¹ of seeds to protect crop against seed borne diseases.

Soil samples were collected after harvesting of wheat crop from each plot with the help of auger at 0-15 cm depth. Bulk density was calculated as the ratio of mass of soil to its total volume (Blake, 1986) and soil water holding capacity was determined using Hilgard apparatus. Air dry processed soil was uniformly packed in the keen box lined with filter paper. After filling the boxes, the dry weight was taken. Soil was saturated from below by water kept below these boxes on the tray for about 12 hrs. Then the moist weight was taken and the soil was dried in oven for 24 hrs at 105 °C. The pH and EC of soil was estimated by potentiometric and conductometric method as described by Jackson (1973) [7]. Available nitrogen content was determined by Alkaline potassium permanganate method as described by Subbaiah and Asija (1956), Available phosphorous content was determined by Bray's No. 1 method (Bray and Kurtz, 1945), available potassium content was determined by 1 N NH₄OAC (pH 7) extraction with flame photometry method as given by Jackson (1973) [7]. Bulk density was calculated as the ratio of mass of soil to its total volume (Blake, 1986) and soil water holding capacity was determined using Hilgard apparatus. Air dry processed soil was uniformly packed in the keen box lined with filter paper. After filling the boxes, the dry weight was taken. Soil was

saturated from below by water kept below these boxes on the tray for about 12 hrs. Then the moist weight was taken and the soil was dried in oven for 24 hrs at 105 °C.

Results and discussions

Bulk Density

Data pertaining to surface soil bulk density due to integrated nutrient management after harvest of wheat is presented in table 1. Study revealed that plots receiving T9 treatment had minimum soil bulk density (1.32 Mg m⁻³) when compared to the two controls T1 and T2 but the decrease was not significant. In the surface layer the decrease in bulk density of inorganically fertilized plots might be because applied fertilizers promoted the plant root and shoot growth that increased the plant biomass production (Selvi *et al.* 2005) [13]. Higher biomass resulted in increased soil organic matter, which act as cementing agent and reduced soil bulk density. Similarly, integrated application of organic and inorganic manures directly added the organic matter through applied organic source and indirectly through increased plant biomass production which promoted the soil aggregation and thus increased total porosity and decreased bulk density.

Soil water holding capacity (WHC)

Significantly highest water holding capacity was observed in treatment T9 followed by T7. Minimum WHC was recorded in control T1. T9 was significantly superior to all other treatments applied however; T7 was at par to T6, T3 and T8. Das (2007) [5] found that the impact of treatment on the water keeping power in both depth soils is statistically significant. Application of 50 percent, 100 percent and 150 percent NPK fertilizers culminated in enhanced water keeping capability suggesting better soil physical conditions with increased fertilizer application doses respectively. Application of FYM coupled with NPK fertilizers was substantially higher than control and all other fertilizer treatments in soils at both the depths.

Rasool *et al.* (2008) [12] also found that the soil's average capacity to hold water (WHC) during wheat was higher in FYM plots than in control plots. In monitor plots, the WHC of unbalanced fertilizer plots (100 per cent N) was not significantly different.

Table 1: Soil bulk density and water holding capacity after harvest of wheat

Treatment	soil bulk density	Soil water holding capacity
	(Mg m ⁻³)	(%)
	0-15 cm	0-15 cm
T1	1.39	59.37
T2	1.38	63.60
T3	1.34	67.07
T4	1.37	63.98
T5	1.37	65.85
T6	1.34	67.57
T7	1.33	67.68
T8	1.37	66.96
T9	1.32	70.53
SE(m) ±	0.02	3.41
C.D. (5%)	NS	1.13

Soil Reaction (pH)

The pH of surface soil (0-15 cm depth) was decreased as compared to control (in Table 2). The pH of surface soil ranged from 7.16 to 7.22 with a maximum pH under controlled plot T1 (7.33) and minimum pH was reported

under T9 (7.16). However the decrease was not significant. The decrement in pH was more pronounced with combined application of inorganic sources and organic sources in comparison to sole application of fertilizers. The significant decrement in soil pH on sole application of inorganic fertilizers might be due to acid producing nature of nitrogenous fertilizers. Nitrogenous fertilizers increase ammonium ion concentration in soil which can exchange the basic cations on soil exchange complex due to which leaching losses of basic cations were enhanced and it resulted in increased soil acidity or reduction in soil pH. The higher reduction in soil pH on integrated nutrient management might be due production of CO₂ and organic acids during microbial decomposition of applied organic manures complemented by residual acidity of nitrogen fertilizers (Yadav and Kumar, 2000)^[18].

Electrical Conductivity (EC)

Combined application of fertilizers and organic manures led to a increase in soil EC over sole application of fertilizers (in Table 2). The EC of soil was ranged from 0.33 to 0.37dSm⁻¹ and lowest EC was recorded in control T1 (0.33dSm⁻¹) which was about 12.1% lower. Maximum EC value of 0.37 dSm⁻¹ was observed in T9 which was similar to T3, T6 and T7. The increase in the soil EC on fertilization may be due to presence of soluble salts in these chemical fertilizers (Kumar and Shivay, 2010)^[8]. The increase in soil EC with application of organic manures might be due to release of soluble salts through decomposition of organic manures. The results of present study are in strong line with results reported by Nagar *et al.* (2016)^[10] and Balloli *et al.* (2000)^[11].

Table 2: Soil pH and EC after harvest of wheat

Treatment	soil pH	soil EC (dS m ⁻¹)
	0-15 cm	0-15 cm
T1	7.33	0.33
T2	7.31	0.35
T3	7.29	0.37
T4	7.27	0.36
T5	7.26	0.36
T6	7.24	0.37
T7	7.22	0.37
T8	7.25	0.36
T9	7.16	0.37
C.D. (5%)	NS	NS
SE(m) ±	0.08	0.005

Available Nitrogen

The fertilizer treatments had significant influence on available nitrogen after harvest of wheat crop (Table 3). Study revealed that significant and maximum available nitrogen was obtained by application of T9 which was followed by T3. However, T9 was statistically at par to T3 and T7 and increased N availability over T1 by 17.5% and over T2 by 13.9% in surface soils. The rise in soil usable nitrogen over fertilization regulation could be ascribed to direct applying nitrogen to soil

mineral types. In comparison, the higher rise in advanced nutrient control is due to the fact that applied fertilizers facilitated the mineralization of applied manures, decreased immobilisation, resulting in higher nitrogen added to the field. The rise in the usable nitrogen in the surface of the transformed soil could also be related to an increased rate of decomposition of organic material and the mineralization / ammonization due to production of organic forms of nitrogen (Bharadwaj and Omanwar, 1994)^[2].

Table 3: Soil available nutrients after wheat harvest

Treatment	soil available nitrogen (kg ha ⁻¹)	soil available phosphorus (kg ha ⁻¹)	soil available potassium (kg ha ⁻¹)
	0-15 cm	0-15 cm	0-15 cm
T1	216.17	17.86	180.30
T2	223.27	18.22	189.00
T3	248.25	19.07	225.67
T4	230.57	18.74	214.67
T5	231.94	18.85	216.33
T6	241.58	18.96	220.36
T7	246.67	18.99	223.74
T8	235.32	18.94	218.67
T9	254.10	22.05	228.67
C.D. (5%)	21.72	NS	15.13
SE(m) ±	7.18	0.75	5.00

Available Phosphorus

The highest status of available phosphorus (22.05 kg ha⁻¹) was observed in the treatment (T9) which was followed by T3 however, the increase was statistically insignificant (Table 2). T2 had an increase over T1 by 2% which might be due to poplar leaf litter incorporation. The decline in control plot phosphorus level was attributed to crop depletion of usable soil phosphorus which, in effect, was not applied to soil by fertilizers or manure. The improvement in soil usable P after

fertilizer application can be due to direct introduction of small quantities of P by applied fertilizers and their residual effect. The more significant improvement in soil accessible P on integrated nutrient control could be due to accumulation of cations such as Al⁺³, Fe⁺³, and Ca⁺³ by organic acids produced during organic matter processing, triggering fixation of usable P (Chesti *et al.*, 2013)^[4]. During the transition of organic matter, many anions (e.g. humate ion) were released which triggers the de-sorption of adsorbed phosphate ion by anion

exchange. Apart from this rise in accessible P, direct release of P from organic matter or the production of soluble P chelates by organic acids produced during decomposition of organic matter could also be related (Singh *et al.*, 2014)^[15].

Available Potassium

The data presented in Table 2 when studied revealed that the available potassium status was observed to be the lowest in the control treatment T1 (180.30 kg ha⁻¹) and it was found to be significantly highest (228.67 kg ha⁻¹) in T9 with an increase of 27 percent over T1. Treatments T9, T6, T3 and T7 were remained statistically at par with each other. The higher availability of potassium in soil might be attributed to the beneficial effect of organic manures in the reduction of potassium fixation; added organic matter interacted with potassium clay to release potassium from non-exchangeable fraction to the available pool. The lowest soil amount accessible in control plot was attributed to constant removal of significant amounts of K due to extensive cropping without any introduction of nutrients. The small decline in usable K in inorganically fertilized parcels over initial could be attributed to the lower addition of K by fertilizers than crop demands and different losses (Singh and Kumar, 2010)^[16].

Conclusion

In view of the above results, it can be concluded that use of different nutrient sources did not produce any significant changes in soil bulk density, pH and EC but conjoined use of organic and inorganic nutrients were found to be beneficial in enhancing the water holding capacity, available nitrogen, phosphorus and potassium contents due to improvement in soil physical structure and increasing microbial activities.

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