

Original Research Article

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Effect of Fertilization on Soil Properties under Different Poplar Species in Nursery under Temperate Conditions of Kashmir

T.A. Rather, S.A. Gangoo, M.A. Islam*, P.A. Sofi, G.M. Bhat and A.A. Mir

Faculty of Forestry, Sher-e- Kashmir University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal-191201, India

*Corresponding author

ABSTRACT

The study investigated the effect of fertilization on soil properties under different poplar species in nursery condition in Kashmir. The experiment was laid out in split plot design (SPT) in nursery beds of (3.60m²) at spacing of (60cm x 30cm) with 36 treatments, four poplar species (*Populus nigra*, *P. Ciliata*, *P. alba* and *P. balsamifera*), three levels of N (N₀, N₇₅, N₁₅₀ kg⁻¹) and three levels of P (P₀, P₆₀, P₁₂₀ kg⁻¹) replicated three times. The results indicated that the chemical constituents of soil decreased in first year from initial values in respect of pH, N, P, K, Ca and Mg but increased subsequently in second year except pH. The average available soil N, P, K, Ca and Mg was recorded maximum at T₉ (379.73, 383.51 kg ha⁻¹), (20.53, 21.68 kg ha⁻¹), (219.61, 220.90 kg ha⁻¹), (845.88, 850.08 ppm) and 262.87, 263.56 ppm followed by T₈ and T₆ but lowest at T₁ (373.00, 374.48 kg ha⁻¹), (18.62, 19.09 kg ha⁻¹), (217.09, 218.37 kg ha⁻¹), (835.81, 840.45 ppm) and (258.32, 258.93 ppm), respectively. Among the species mean maximum decrease in first year from initial values and increase in second year in respect of N, P, K, Ca and Mg was recorded in *P. balsamifera* followed by *P. nigra*, *P. ciliata* and *P. alba* in both years, respectively. Hence, T₉ (379.73, 383.51 kg ha⁻¹) has been recommended as the best treatment for ETps production of *P. nigra*, *P. ciliata*, *P. alba* and *P. balsamifera* through cuttings in nursery with regard to soil improvement in Kashmir.

Keywords

Poplar, Fertilization, nursery, *P. nigra*, *P. ciliata*, *P. alba*, *P. balsamifera*, Kashmir

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Introduction

Poplars occupy a unique and important position in the rural economy of North India (Kaushik *et al.*, 2012; Singh and Mavi, 2016). Poplar wood is white in colour having suitable density with an even texture, easy to saw and work, good carving quality indices and finishing quality (Bhardwaj *et al.*, 2001). They are known for their fast growth, easy vegetative propagation, capability to enrich

surface soil by adding leaf litter and the ability to provide substantial production 10 to 30m³/ha/yr on a short rotation of 6 to 12 years (Tewari, 1993). Poplars are grown as a cash crop generating employment in rural areas, raw material for wood based industries, revenue through taxation for the state government as well as meeting the objectives of National Forest Policy, 1988 and rehabilitation of river banks for their protection and averting soil erosion (Islam,

2016). Due to increasing demand for its wood, Poplar culture is likely to expand within the RIPC and also to new locations in northeastern states along the Himalayan range for the benefit of the people and the country (Dhiman, 2012).

Raising nursery plants of poplars through stem cuttings facilitate multiplication of superior genotypes which is an ultimate option for the cultivation of the species on large scale, thereby enhancing forest productivity (Masoodi *et al.*, 2014; Gangoo *et al.*, 2015). The ability of cutting to root and their subsequent growth in nursery is determined by a number of factors *viz.*, time at which cuttings are taken, age of the donor trees, position within the crown where cuttings are taken, treatment and status of rooting/growth regulators and condition under which cuttings are rooted (Puri, 1993; Sofi *et al.*, 2018). *P. deltoides*, *P. nigra*, *P. balsamifera*, *P. ciliata* and *P. alba* are the major poplar species cultivated mostly in Kashmir valley (Rather *et al.*, 2017). Among these poplars, *P. balsamifera*, *P. ciliata*, and *P. alba* are the indigenous species of the valley while *P. deltoides* has been introduced in the valley in 1950 which is cultivated and spread to every nook and corner of the valley due to its fast growth and adaptability (Rather *et al.*, 2018). Various clones of this species have been introduced into the valley but no record is available in the scientific journals. *P. nigra* is said to have been introduced by Mughal's during 18th century as an avenue tree. Now-a-days it is found along National highways and roads as an avenue tree and on boundaries of farmlands as an agro-forestry tree throughout Kashmir valley (Islam *et al.*, 2016). In an investigation (Gangoo *et al.*, 2011), carried out to screen promising clones of *P. nigra* significant inter-clonal variation has been found for various growth characters among the clones of *P. nigra* cultivated in various districts of Kashmir valley. The

cultivation of these species is diminishing day by day due to non-availability of information of their management practices and quality plant material (Kumar and Singh, 2012; Sofi *et al.*, 2016). For poplar growing as in case of all the plant species propagated through nursery raised seedlings healthy and vigorous nursery plants are a prerequisite (Islam *et al.*, 2015). The proper nutrition provided at nursery stage is of paramount importance to get healthy and vigorous planting stock. Keeping in view the multipurpose uses, rapid increase in growth, demand, capability to enrich surface soil by adding leaf litter and averting soil erosion, it became necessary to investigate the effect on chemical constituents of the soil through poplar cuttings with various doses of fertilizer in temperate conditions of Kashmir, so that results are expected to be useful for the farmers we would like to undertake cultivation of these poplar nurseries.

Materials and Methods

The study was carried out in Faculty of Forestry, Wadura, Sopore located at Latitude of 34°-17°N and Longitude 74°-3°E above an altitude of 1524 m msl. The mean maximum temperature was recorded in July (30.90⁰ C and 30.40⁰ C) and mean minimum in November (-0.35⁰ C and 0.16⁰ C) during the growing season. Rainfall was highest in the month of August (178.40 mm) and September (193.70 mm) whereas, minimum in November (17 mm and 19.60 mm), relative humidity was maximum in November (86.17% and October 92.29%) while minimum in July (48.13% and June 44.43%). The cuttings were taken from phenotypically superior trees already cultivated in Srinagar district. The fresh cuttings having 20cm length and 20mm diameter of uniform size were planted/ raised in the second fortnight of February in a well prepared nursery beds of (3.60 m²) with a spacing of (60cm x 30cm) in

three replicates employing split plot design. The total no. of cuttings planted per species was five hundred forty (540). The study was consisted of 36 treatments having four species *Populus nigra* (S₁), *P. alba* (S₂), *P. ciliata* (S₃) and *P. balsamifera* (S₄) with three levels of Nitrogen and Phosphorus each @ N₀, N₇₅, N₁₅₀ kg ha⁻¹ and P₀, P₆₀, P₁₂₀ kg ha⁻¹ applied into nine combinations *viz.*, T₁ = N₀P₀, T₂ = N₀P₆₀, T₃ = N₀P₁₂₀, T₄ = N₇₅P₀, T₅ = N₇₅P₆₀, T₆ = N₇₅P₁₂₀, T₇ = N₁₅₀P₀, T₈ = N₁₅₀P₆₀, and T₉ = N₁₅₀P₁₂₀. The fertilizer was applied in two split doses, first in the second fortnight of April after bud burst in cuttings and second dose in the second fortnight of June at the time of weeding/ hoeing in poplar cutting beds. The nitrogen was supplemented through urea and diamonium phosphate (DAP) while phosphorus was supplemented through single super phosphate (SSP) and DAP. The dosage was determined after calculating the percentage of N and P available in different fertilizers.

Collection of soil samples

The initial soil samples as well as the samples after each growing season were taken randomly from each treatment plot of each species from each replicate at a depth of 0-20cm. The soil samples were composited stand wise, dried under shade, crushed and passed through 2mm sieve. The sieved samples were analyzed for different chemical properties in the Division of Soil Sciences, SKUAST-K, Shalimar. The methods employed for analysis of various chemical properties are as under:

pH, OC% and Ecdsm⁻¹

The pH of soil samples was measured at 20 °C with the help of a digital pH meter (model AP × 175 E/C) (Figure 1). Twenty five gram (25 g) of air dry soil sample was thoroughly mixed with 62.5 ml of distilled water (1:2.5

w/v) and the reading for pH of the soil samples was taken after 30 minutes. The pH meter was calibrated before use with Standard pH buffers (pH 4 and pH 7) (Jackson, 1973).

$$\text{Soil pH} = \log \frac{1}{\text{H}^+} = \log (\text{H}^+)$$

H⁺ is expressed as g ions ltr⁻¹.

After determining pH, soil suspension was kept overnight in undisturbed condition and EC was measured by conductivity meter (Digital CD-601) (Figure 2) (Jackson, 1973). Organic carbon (OC) was estimated by wet digestion method of Walkley and Black (1934). The known weight of soil was treated with excess standard K₂Cr₂O₇ in presence of concentrated Sulfuric acid. The excess K₂Cr₂O₇ not reduced by the organic matter of the soil, was determined by back titration with standard ferrous ammonium sulphate using diphenylamine indicator. Organic carbon percentage was calculated by using the following formula:

$$\text{Soil organic carbon (SOC)} = \frac{10}{\text{B}} \times \frac{0.003 \times 100}{\text{Weight of soil sample}} \times 1.3$$

Where,

B= Volume of titrant used for blank.

T= Volume of titrant used for sample.

Since it is assumed that organic carbon recovery by this method is only 77%, the values obtained were multiplied by a correction factor of 1.3.

Nitrogen (kg ha⁻¹)

Following procedure as described by Subbiah and Asija (1956) was used to determine

Nitrogen (kg ha⁻¹) (Figure 3).

$$\text{Available nitrogen (kg ha}^{-1}\text{)} = \frac{(\text{sample titre} - \text{titer-blank}) \times 0.02 \times 14 \times 2.24 \times 10^6}{\text{Weight of soil sample (g)} \times 1000}$$

Phosphorous and Potassium (kg ha⁻¹)

Available phosphorus was extracted by using 0.5 N NaHCO₃ at 8.5 pH and colour developed by using ammonium molybdate and stannous chloride (Figure 4). The transmittance was measured with the help of spectrophotometer at 660nm wave length (Olsen *et al.*, 1954). The concentrations of available phosphorus were calculated by reference to a calibration graph plotted from the standard phosphorus (KH₂PO₄) solution. Blanks were run in the same manner without soil. Potassium was estimated by Neutral normal ammonium acetate solution was used as extractant for available potassium from soil and determination was carried out on Digital Flame Photometer (Model CL 22D) (Figure 4) (Jackson, 1973).

Exchangeable Calcium and Magnesium

Exchangeable Ca⁺² and Mg⁺² were determined in NH₄OAC leachate with EDTA titration method using ammonium purpurate and eriochrome black (T) indicator as described by (Jackson, 1973) by AASFM (Atomic absorption spectrophotometer) (Figure 3).

Results and Discussion

Primary and Secondary Nutrients

The initial status of soil with respect to NPK was found in the range of medium with 380.24 kg ha⁻¹, 20.19 kg ha⁻¹ and 221.19 kg ha⁻¹ (Table 1) and sufficient in Ca (869.46

ppm) and Mg (276.09 ppm) (Table 2), respectively. The results obtained showed that during the first year the concentration of all the nutrients declined from the initial values with maximum decline in T₁ (control) and minimum decline at highest level of fertilizer dose either alone or in combination. However, in the second growing year there was substantial increase of all the nutrients with the increase in fertilizer dose. The maximum increase was recorded at T₆, T₈ and T₉ which were found at par with each other but differ significantly over all the treatments. Decrease in first year is due to the reason that short rotation forest species grow rapidly and bind a great amount of nutrients in their biomass and also the losses due to the leaching, denitrification and ammonification is high because urea takes some days for the hydrolysis of amide form and its conversion to ammonical form which gets converted into nitrate slowly and becomes available for plant use within a few days. While as in second growing year the increase in nutrients was probably due to leaf litter addition and subsequent decomposition and mineralization. Moscatelli *et al.*, (2008) reported that nitrogen fertilization did not modify soil capacity to accumulate organic matter although, a positive variation was observed at the beginning of the study.

Significant changes were seen in the soil properties after second growing season. Savill (2004) who reported that the leaves of the deciduous broad leaved trees retain the major nutrient bases when they drop in the autumn. Thus, the litter under these forests is not as acidic as under evergreen forests. Also, the autumn leaf fall provides abundant and rich organic matter which begins to decay rapidly in following spring. While, as P concentration increases due to the addition of litter fall which results into formation of polyhumic substances and coating of Al and Fe ions, thus the higher content of P in soil in second year

may be attributed to the higher content of organic matter in the soil which prevents the fixation of P ions, which is line with the findings of Savill (2004). Ghosh and Kothandaraman (1996) showed that organic P fraction contributed 23.9 to 46.9 per cent P with their amount being high in higher organic carbon and gradually decreased with decrease in organic carbon content of soil. It is evident from the results (Table 3) that the available K in the soil for first and second year was found in the range of medium due to the reason that K is always in the exchangeable form in the soil. The Ca and Mg in the soil was recorded in the range of sufficient for both the years but maximum was found in treatment T₉ and minimum in T₁ but in 1st year it decreases but increased subsequently in the 2nd year. It may be due to the reason that N and P have synergetic effect for Ca and Mg which increases the percentage of nutrients in plant and maximum percentage is returned back at the time of abscised leaves into the soil which increased the nutrient concentration after decomposition.

These results are in line with the findings of Srivastava *et al.*, (1972) who reported that in moist deciduous forests leaf litter returns adds substantial amount of various nutrient elements to the soil. Baker and Blackman (1977) who revealed that there was 43.5, 4.7, 34.7 kg ha⁻¹ accumulation of N, P, K respectively just before the litter fall and approximately 26, 33 and 28% of these elements fell with abscised leaves. Thus from the above results it is clear that nutrient status of the soil is very important in short rotation forestry which is in conformity with the observations made by Hytonen (1996) who reported that besides climatic conditions different soil properties effect biomass production. In particular the nutrient status of the soil is very important in short rotation forestry as they grow rapidly and bind a great amount of nutrients in their biomass.

Soil pH and Organic carbon

The studies conducted on soil analysis revealed that the average soil pH decreased with the increase in fertilizer doses either individually or in combination of N and P. The maximum decrease was recorded at T₉ (6.28, 6.26) and minimum at T₁ (6.34, 6.33) from its initial values 6.36 in two consecutive years, respectively. The organic carbon increased from T₁ to T₉ and maximum OC% was recorded at T₉ (1.337, 1.495) and minimum at T₁ (1.290, 1.305) in two years, respectively. The change in pH from initial in two growing years recorded was not as much, however after change the pH was found suitable for the growth of poplar species. The increase in (SOC) soil organic carbon per cent compared to their initial values 1.252 increases during the two growing years.

The increase in SOC and decrease in pH was due to the reason that the growth of the poplar species was recorded maximum with the increase in level of fertilizer doses than control which was believed to be due to the effect of litter addition. Leaves of the deciduous trees decomposes readily, which increases the OC% and during decomposition of leaves the acids were released due to microbial oxidation of leaves and hydrolysis of urea and nitrification of products which consequently decreased the soil pH. These results are in agreement with the findings of Arsova (1995) reported decrease in soil pH with increase in fertilizer level while studying the effect of fertilizer application Savill (2004) who reported that the leaves of the deciduous broad leaved trees retain the major nutrient bases when they drop in the autumn. Thus, the litter under these forests is not as acidic as under evergreen forests. Also the autumn leaf fall provides abundant and rich organic matter which begins to decay rapidly in following spring. While as, pH obtained was suitable for the growth of poplar species

under test is in line with the findings of Sennerby and Forsse (1990) who reported that the suitable pH values of the soil for willow

cultivar is 5.5-6.5 and it is also reported by Cannell, (2004) that poplar and willows grow best on mildly acidic pH 6.0-7.0.

Nitrogen (kg ha^{-1})

Take 5 g soil in Kjeldhal tube
↓
Add a little distilled water and 25 ml KMnO_4
↓
Place a conical flask (250 ml) containing 25ml boric acid solution in such a way that the end of condenser tube dips into the boric acid solution.
↓
Connect the Kjeldhal tube to the distillation assembly and add about 25ml sodium hydroxide (2.5%)
↓
Set the process time 15-18 minutes (about 150ml distillation is collected in receiving flask) and Test with red litmus paper to ensure total distillation
↓
Titrate the distillate with standard 0.02N H_2SO_4 to wine red end point Run a blank in the same way



Figure 1: pH analysis



Figure 2: EC dsm^{-1} analysis



Figure 3: Soil nitrogen analysis



Figure 4: Soil P, K, Ca & Mg analysis

Table.1 Effect of various fertilizer dosages on soil properties in nursery

Initial value	380.24 (N kg ha ⁻¹)		20.19 (P kg ha ⁻¹)		221.14 (K kg ha ⁻¹)	
Treatments	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
N ₀ P ₀ (control)	373.00	374.48	18.62	19.09	217.09	218.37
N ₀ P ₁ (0, 60 kg ha ⁻¹)	375.21	378.23	19.39	20.29	217.68	218.97
N ₀ P ₂ (0, 120 kg ha ⁻¹)	376.21	379.24	19.70	20.74	217.85	219.14
N ₁ P ₀ (75, 0 kg ha ⁻¹)	377.75	381.51	19.05	19.96	218.79	220.08
N ₁ P ₁ (75, 60 kg ha ⁻¹)	378.31	382.34	19.95	21.14	219.21	220.50
N ₁ P ₂ (75, 120 kg ha ⁻¹)	379.63	383.34	20.45	21.44	219.50	220.79
N ₂ P ₀ (150 kg ha ⁻¹)	377.96	381.69	19.13	20.09	218.82	220.11
N ₂ P ₁ (150, 60 kg ha ⁻¹)	379.69	383.47	20.50	21.66	219.54	220.83
N ₂ P ₂ (150,120 kg ha ⁻¹)	379.73	383.51	20.53	21.68	219.61	220.90
CDP<0.05	0.40	0.80	0.14	0.24	0.14	0.19

Table.2 Effect of various fertilizer dosages on soil properties in nursery

Initial value	869.46 (Ca ppm)		276.09 (Mg ppm)		6.360 (pH)		1.252 (OC%)		0.156 (Ec dsm ⁻¹)	
Treatments	1 st year	2 nd year	1 st year	2 nd year						
N ₀ P ₀ (control)	835.81	840.45	258.32	258.93	6.340	6.331	1.290	1.305	0.157	0.160
N ₀ P ₁ (0, 60 kg ha ⁻¹)	837.38	842.08	260.48	261.08	6.332	6.315	1.297	1.341	0.158	0.163
N ₀ P ₂ (0, 120 kg ha ⁻¹)	838.95	843.65	260.90	261.51	6.329	6.314	1.305	1.376	0.159	0.164
N ₁ P ₀ (75, 0 kg ha ⁻¹)	840.52	845.23	259.28	259.89	6.317	6.297	1.316	1.411	0.161	0.166
N ₁ P ₁ (75, 60 kg ha ⁻¹)	842.45	847.20	261.75	262.36	6.305	6.287	1.326	1.449	0.163	0.170
N ₁ P ₂ (75, 120 kg ha ⁻¹)	845.24	849.51	262.62	263.27	6.294	6.266	1.335	1.484	0.164	0.175
N ₂ P ₀ (150 kg ha ⁻¹)	840.72	845.34	259.41	260.04	6.291	6.289	1.315	1.415	0.160	0.166
N ₂ P ₁ (150, 60 kg ha ⁻¹)	845.46	849.86	262.68	263.36	6.290	6.263	1.290	1.305	0.164	0.175
N ₂ P ₂ (150,120 kg ha ⁻¹)	845.88	850.08	262.87	263.56	6.289	6.260	1.297	1.341	0.164	0.176
CDP<0.05	1.41	1.54	0.61	0.62	0.004	0.008	0.004	0.031	N.S	N.S

Table.3 Effect of various Poplar species on soil properties in nursery

Treatments	N kg ha ⁻¹		P kg ha ⁻¹		K kg ha ⁻¹	
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
S ₁ (<i>P. nigra</i>)	377.53	380.99	19.69	20.76	218.61	220.12
S ₂ (<i>P. ciliata</i>)	377.72	380.57	19.72	20.57	218.81	219.31
S ₃ (<i>P. alba</i>)	377.76	380.41	19.73	20.54	218.92	219.24
S ₄ (<i>P. balsamifera</i>)	377.00	381.50	19.67	20.83	218.37	221.20
CD P<0.05	0.13	0.15	N.S	0.17	0.22	0.34

Table.4 Effect of various Poplar species on soil properties in nursery

Treatments	Ca ppm		Mg ppm		pH		OC%		Ec dsm ⁻¹	
	1 st year	2 nd year								
S ₁ (<i>P. nigra</i>)	840.38	846.65	260.81	261.62	6.311	6.290	1.327	1.423	0.161	0.172
S ₂ (<i>P. ciliata</i>)	842.92	845.19	261.05	261.40	6.312	6.296	1.295	1.397	0.161	0.164
S ₃ (<i>P. alba</i>)	843.85	844.55	261.12	261.36	6.313	6.306	1.294	1.394	0.160	0.163
S ₄ (<i>P. balsamifera</i>)	838.36	847.35	260.72	261.85	6.303	6.274	1.353	1.460	0.161	0.174
CD P<0.05	0.18	0.19	0.06	0.02	0.005	0.009	0.006	0.018	N.S	N.S

Electrical conductivity

The ECdsm⁻¹ increases with the increase in fertilizer dose either individually or in combination of N and P application but it was found non-significant. The interaction among the fertilizer and among the species was also found non-significant. The electrical conductivity was maximum at T₉ (0.164, 0.176 dsm⁻¹) and minimum at T₁ (0.157, 0.160 dsm⁻¹) which was best for the growth and development of the family *Salicaceae*. These results are in agreement with the findings of Crouch and Honeyman (1986) who conducted experiment on 29 *Salix* species and cultivars of *P. nigra* var. italic grown in soil with salt solutions of electrical conductivity of 0.05, 1, 2 and 4 dsm⁻¹ and reported that the least tolerant were *Salix piperi*, *Salix purpurea* cultivar irtle and *Salix seringerna* and *P. nigra* var. italic were tolerant than other species. In our study among the species the

maximum mean electrical conductivity was recorded in *P. balsamifera* (1.353, 1.381) followed by *P. nigra* (1.327, 1.349), *P. Ciliata* (1.295, 1.307) and *P. alba* (1.294, 1.305) dsm⁻¹ (Table 4). It is due to the reason that different species have different genetic makeup with the result different species can tolerate different electrical conductivity. So our results collaborates with above findings that among the species the most tolerant was *P. balsamifera* followed by *P. nigra*, *P. Ciliata* and *P. alba*.

Conclusion

In order to produce high-quality nursery plants of *P. nigra*, *P. ciliata*, *P. alba* and *P. balsamifera*, cultivation of cuttings from phenotypically superior trees is a must. Treatment of the cuttings with a combination of N (75 kg ha⁻¹) and P (120 kg ha⁻¹) is the precondition to achieve tremendous survival

and growth of the nursery plants which is generally poorly understood and poorly practiced. Further, the propagation of nursery plants with these treatments improves soil properties overwhelmingly as depicted by the findings of the study.

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