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EFFECT OF PRUNING AND FERTILIZER APPLICATION ON THE QUALITY OF *Diospyros melanoxylon* LEAVES IN CHHATTISGARH (INDIA)

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ABSTRACT

Tendu (*Diospyros melanoxylon*) leaf is used to wrap 'Bidi' or Indian cigarette due to its texture, flavour and workability. Experiments were conducted in tendu during 2015-2017 to assess the impact of pruning and application on chemical- and bio-fertilizers on leaf quality of this plant in Korba, Korea and Raipur districts of Chhattisgarh (India). Various levels of nitrogen (25-100 kg N ha^{-1}) and phosphorus (250-1000g plot^{-1}), neem granules, vesicular arbuscular mycorrhizal (VAM) and foliar spray of N and P (0.5-2.0%) were tested in a factorial randomized block design experiment. Every year pruning of tendu bushes of 2-4 cm girth at ground level increased the leaf surface area. The application of 100 kg N ha^{-1} and 25 kg P ha^{-1} to rhizosphere soil after rainy season improved tendu leaf quality in terms of specific leaf area. Foliar spray of 2% N and 1% P on tendu bushes enhanced leaf size and were more effective than chemical fertilizer application to soil. Similarly, application of biofertilizers in the form of 500 g neem granules and 1000 g VAM plot^{-1}enhanced the leaf quality of tendu.

Keywords: Biofertlizer, chemical fertilizers, *Diospyros melanoxylon,* foliar spray, neem, pruning, tendu

INTRODUCTION

Tendu (*Diospyros melanoxylon*) occurs in the dry mixed deciduous forest of Peninsular India, extending northwards to Bihar and eastwards to Odisha. In India Chhattisgarh is the 2nd largest producer of tendu leaves after Madhya Pradesh because the agro-climatic conditions of these states are extremely conducive for the natural growth and propagation of plants (Sahu *et al.,* 2017). It is a conspicuous species in all three major types of forests i.e. teak, sal and mixed forests. The quality of tendu leaves plays a crucial role for obtaining better acceptability and economic return to the state forest departments. The quality characteristics of this species include odour, colour, tenderness, surface area, thickness and soft texture of leaves. The tendu flavour, flexibility and resistance to decay are the key factors in their use in bidi (Indian cigarette) industry.

In the entire *Diospyros* genus, only the leaves of *D. melanoxylon* are of commercial value due to their use in bidi industry. *D. melanoxylon* (vern.: Tendu or Kendu) leaf trade is one of the important tribal activities of India and a good source of revenue for the Government, besides providing gainful employment to several indigenous communities (George, 1952; Sastry, 1952). *D. tomentosa* leaves are also reported to be useful in bidi wrapping but they are not widely used.

Traditionally, tendu bushes are coppiced near the ground to induce new flush of leaves during February-March in each year, which gives good quality leaves after 40-50 days of coppicing. Over past few years, pruning of tendu bushes has been a debatable issue keeping in view the lack of scientific background on impact of pruning on quality and productivity of tendu leaves, different pathways of natural regeneration and availability of tendu fruits for wildlife. Similarly, the quality of leaves can also be achieved by pollarding, but it takes longer time for the leaves to regain and hence is not always preferable (Kerketta, 2016). A number of studies have been carried out on silvicultural management of this species to increase the productivity of quality leaves including the use of drip irrigation by the farmers (Boaz and Boaz, 2003) and coppicing (Kumar, 2001; Orwa *et al.*, 2009), still there is paucity on information regarding every year and alternate year pruning and use of chemical and biofertilizers. The present study was aimed to assess the impact of traditional practices of pruning of tendu bushes and application of chemical- and bio-fertilizers on yield and quality of its leaves in Katghora, Baikunthpur and East Raipur forest divisions of Chhattisgarh state (India).

MATERIALS AND METHODS

Selection of sites

Sites were selected in tendu bearing areas of three forest divisions of Chhattisgarh (India) after conducting surveys in the year 2015 and in consultation with the officers of Chhattisgarh State Forest Department. Sites selected in three forest divisions of Chhattisgarh were Morga (Katghora division), Kotadol (Baikunthpur division) and Litipara (East Raipur division) lying in the districts Korba, Korea and Raipur, respectively.

Experiments on pruning practices

The experiments were conducted in the selected sites including time interval of pruning of tendu bushes, height at which the pruning was done and girth of pruned tendu bushes. Pruning was done either every year or alternate year and at 0, 15 or 30 cm from the ground level. Girth of pruned bushes included < 2 cm, 2-4 cm or > 4 cm. The experiments were conducted in a factorial randomized block design (RBD) with nine treatment combinations and each treatment having five replications at each site in every year (2015, 2016 and 2017) as well as alternate year (2015 and 2017). Each treatment-combination had 25 tendu bushes at each selected site. The total number of leaves on each bush was counted. Ten leaves from each bush were collected subject to the availability of required number of leaves on the bush at the time of harvesting, otherwise all the leaves available on the bush were harvested for the assessment of leaf area and weight, and thereby specific leaf area (SLA).

Experiments on chemical fertilizers

Different combinations of varying amounts of nitrogen (0, 25, 50 and 100 kg ha^{-1}) and phosphorus (0, 25, 50 and 100 kg ha^{-1}) were applied to the 5 m x 5 m size plots of tendu. In each plot, the number of plants differed due to irregular distribution of tendu bushes. Factorial RBD was followed and the experiment was replicated thrice. Thus, 48 plots of 5 m x 5 m size in each selected site were treated with chemical fertilizers as per the treatment-combinations mentioned above. Nitrogen was given in the form of urea and phosphorus in the form of single super phosphate (SSP) to the rhizosphere soil just after rainy season in the month of August. Thus, 0, 133.75, 267.50 and 535.0 g urea were applied to the plots having N_0, N_{25}, N_{50} and N_{100} treatments, respectively. Similarly, 0, 235.62, 471.24 and 942.48 g SSP plot^{-1} were given to P_{25}, P_{50} and P_{100} treatments, respectively. Basal doses of 250 g muriate of potash and 500 g farm yard manure were given to each plot. Ten leaves from each tendu bush were harvested for the estimation of leaf area and weight and SLA.

Experiments on foliar spray of chemicals

Different combinations of 0.5, 1.0 and 2.0% nitrogen and phosphorus were sprayed on tendu leaves to the selected plots of 5 m x 5 m size. In each plot, the number of bushes differed due to irregular distribution of tendu. Factorial RBD was followed with treatment replicated three times. Thus, 48 plots of 5 m x 5 m size in each selected site were treated with foliar spray of N and P as per the treatment-combination. N was given in the form of urea and P in the form of single super phosphate (SSP) during 2nd and 3rd week of April, when tendu leaves attained maximum size. Ten litre solution of each treatment-combination was prepared and used for 3 plots i.e. 3.33 L solution for each 5 m x 5 m plot. Urea 35.63, 71.26 and 142.52 g plot^{-1} were applied to 0.5, 1 and 2% N treatments, respectively. Similarly, 62.77, 125.54 and 251.08 g SSP were applied to 0.5, 1.0 and 2.0% P treatment plots, respectively. Ten leaves from each bush were collected for the estimating leaf area and weight and SLA.

Experiments on biofertilizers

Different combinations of varying amounts of neem granules procured from local market (250, 500 and 1000 g plot^{-1}) and vesicular arbuscular mycorrhizae (VAM) procured from Forest Pathology Laboratory of Tropical Forest Research Institute, Jabalpur (India) with species mix of *Glomus mosseae*, *Scutellospora* sp. and *Acaulospora* sp. (250, 500 and 1000 g plot^{-1}) were applied to the selected plots of tendu of 5 m x 5 m size. In each plot, the number of plants differed due to irregular distribution of tendu bushes. Factorial RBD was followed and the experiment was replicated thrice. Hence, 48 plots of 5 m x 5 m size in each selected site were treated in rhizosphere soil with neem granules and VAM biofertilizer just after rainy season in August as per the treatment-combinations mentioned above. Basal doses of 250 g muriate of potash and 500 g farm yard manure were given to each plot. Ten leaves from each tendu bush were harvested for the estimation of leaf area and weight, and SLA.

Analysis of soil samples

Five surface (0-15 cm) and five sub-surface (15-30 cm) soil-samples were randomly collected from each study site and mixed with each other to form the composite sample. The collected soil samples were air dried and passed through 2 mm sieve. Standard analytical procedures were used for the estimation of different physicochemical parameters. Soil pH and electrical conductivity were determined in soil-water suspension (1.0: 2.5) (soil: water) using glass electrode (Piper, 1950). Organic carbon content was estimated by rapid titration method (Walkley and Black, 1934). Available nitrogen was determined by alkaline permanganate method while exchangeable cations (Ca, Mg, Na and K) were determined using ammonium acetate extract (Chopra and Kanwar, 1976). Available phosphorus and potassium were estimated by the methods described by Jackson (1973).

Statistical analysis

Statistical analysis of data was done using SPSS 16.0 software. The analysis of variance (ANOVA) table was drawn, critical difference (CD) observed at 5% significant levels and standard error mean calculated. Pairwise comparison among different treatments in chemical fertilizer, foliar spray of chemicals and biofertilizer experiments was done by Duncan multiple range test (DMRT).

RESULTS AND DISCUSSION

Tendu tree is usually kept reserved and is not felled, except in clear-felling or in the coppice-with-reserves working circles. The main source of production of bidi leaves is the bush arising through root suckers. Leaves of bigger trees are stiff and brittle, therefore are not capable of producing industry standard leaves for wrapping bidis. The objective of management of tendu bushes is the production of leaves; hence pruning is practiced in the field as this promotes vegetative growth and

Table 1: Number of leaves per tendu bush recorded in the selected sites of Chhattisgarh (India)

Pruning treatment*	Kotadol	Litipara	Morga
H_1G_1	8.47	8.20	11.87
H_2G_1	9.60	9.27	8.07
H_3G_1	8.87	10.73	8.87
H_1G_2	10.47	11.47	9.60
H_2G_2	12.60	8.80	10.93
H_3G_2	7.87	11.60	9.53
H_1G_3	8.84	11.13	14.60
H_2G_3	9.60	17.13	10.07
H_3G_3	9.53	18.53	11.33
SE$\pm$	3.266	2.806	1.887
$CD_{0.05}$	6.924	5.948	4.000

Height of pruning: H_1 - Ground; H_2 - 15 cm & H_3 - 30 cm; Girth of pruned bushes: G_1 - < 2 cm; G_2 - 2-4 cm & G_3 > 4 cm

the production of relatively large and thin leaves. Tendu bushes are cut near the ground to encourage sprouting of coppice shoots, which gives best quality leaves after 40-50 days of operation (Kerketta, 2016). In present study, the maximum number of leaves per tendu bush in Kotadol was recorded in the bushes of 2-4 cm girth pruned at 15 cm height (12.60), in Litipara in the bushes of > 4 cm girth pruned at 30 cm height (18.53) and in Morga in the bushes of >4 cm girth pruned at ground (14.60) [Table 1].

Effect of pruning on quality of leaves

Effect of annual and alternate year pruning on specific leaf area (SLA) of *Diospyros melanoxylon* is depicted in Table 2. SLA is the one-sided area of a fresh leaf, divided by its oven-dry mass. It can be used to estimate the reproductive strategy of a particular plant based upon light and moisture levels and is one of the most widely accepted key leaf characteristics used during the study of leaf traits (Kerketta *et al.*, 2018). SLA signifies the quality of tendu leaves because large and thin leaves are preferred for making higher number of good quality bidis. In annual pruning, the maximum SLA was found in 2-4 cm girth bushes pruned at ground level in all the three selected sites of Chhattisgarh. In Kotadol the maximum SLA was 13.45 $mm^2\ mg^{-1}$ while in Litipara and Morga it was 11.80 and 12.58 $mm^2\ mg^{-1}$. It shows that tendu leaves attain maximum area with minimum weight, when 2-4 cm girth bushes are pruned at ground level. Study on the impact of pruning on yield and quality of tendu leaves in Maharashtra (India) reported 5 times healthy leaves in pruned bushes than non-pruned poles with less gall infested, diseased and defoliated leaves in pruned bushes (Mehta *et al.*, 2020).

In alternate year pruning, the maximum SLA was recorded in tendu bushes pruned at ground level, followed by bushes pruned at 15 cm height from ground surface and 30 cm height from the ground surface in all three selected sites of Chhattisgarh. Maximum SLA was observed in bushes with < 2 cm girth pruned at ground level (11.54 $mm^2\ mg^{-1}$), followed by the bushes with < 2 cm girth pruned at 15 cm height (11.24 $mm^2\ mg^{-1}$) and bushes with < 2 cm girth pruned at 30 cm height

Table 2: Effect of pruning of tendu bushes on specific leaf area ($mm^2\ mg^{-1}$) at three locations in Chhattisgarh (India)

Pruning treatment*	Kotadol		Litipara		Morga		Overall mean	
	Every year	Alternate year	Every year	Alternate year	Every year	Alternate year	Every year	Alternate year
H_1G_1	12.75	11.54	11.10	12.06	11.24	12.77	11.70	12.12
H_2G_1	13.07	11.24	11.16	12.02	11.08	11.75	11.77	11.67
H_3G_1	12.79	11.03	11.02	11.41	10.96	12.12	11.59	11.52
H_1G_2	13.45	10.67	11.80	11.35	12.58	12.02	12.61	11.35
H_2G_2	12.93	10.94	10.78	12.81	11.70	10.96	11.80	11.57
H_3G_2	13.13	10.58	11.78	11.41	11.52	11.10	12.14	11.03
H_1G_3	9.52	10.73	11.18	13.19	11.42	10.67	10.71	11.53
H_2G_3	10.34	9.85	11.11	11.66	11.21	12.37	10.89	11.29
H_3G_3	11.10	9.49	11.21	12.61	11.02	12.02	11.11	11.37
Mean	12.12	10.67	11.24	12.06	11.41	11.75	11.59	11.50
SE$\pm$	0.51	0.72	0.57	1.35	0.28	1.22	-	-
$CD_{0.05}$	1.04	1.54	1.17	2.87	0.56	2.59	-	-

(11.03 mm^2 mg^{-1}) in Kotadol; bushes with > 4 cm girth pruned at ground level (13.19 mm^2 mg^{-1}), followed by bushes with 2-4 cm girth pruned at 15 cm height (12.81 mm^2 mg^{-1}) and bushes with > 4 cm girth pruned at 30 cm height (12.61 mm^2 mg^{-1}) in Litipara; bushes with < 2 cm girth pruned at ground level (12.77 mm^2 mg^{-1}), followed by bushes with > 4 cm girth pruned at 15 cm height (12.37 mm^2 mg^{-1}) and bushes with < 2 cm girth pruned at 30 cm height (12.12 mm^2 mg^{-1}) in Morga. With the increase in height of pruning from the ground surface, the SLA showed decrease. The thickness of tendu bushes did not affect leaf area and weight in alternate year pruning experiments.

SLA was found more (13.45 mm^2 mg^{-1}) in every year pruning than alternate year pruning (11.54 mm^2 mg^{-1}) in Kotadol among their maximum values, while the reverse trend was observed in Litipara and Morga i.e. more in alternate year pruning and less in every year pruning. Among average values, SLA was found more in every year pruning in Kotadol and Morga and less in Litipara, when compared with alternate year pruning. Irrespective of sites, average value of SLA was found more in every year pruning (11.59 mm^2 mg^{-1}) than alternate year pruning (11.05 mm^2 mg^{-1}).

Effect of chemical fertilizers on SLA

That data on the effect of chemical fertilizers on SLA of *Diospyros melanoxylon* is presented in Table 3. In Kotadol the maximum SLA (11.04 mm^2 mg^{-1}) was found in $N_{100}P_{25}$ treatment- combination, which is in agreement with the results of soil analysis (Table 5). When values of nitrogen of all collected soil samples were averaged then nitrogen content in Kotadol soil samples was found in the low range (118.44 kg ha^{-1}). Similarly, when values of phosphorus of all collected soil samples were averaged the phosphorus content in soil samples was found in low range (13.48 kg ha^{-1}). The results showed that the soil samples collected from Kotadol are nitrogen and phosphorus deficient, that is why the addition of 100 kg N ha^{-1} and 25 kg P ha^{-1} to the soil enhanced SLA. Similar results were obtained from Morga, where maximum SLA (15.73 mm^2 mg^{-1}) was observed in $N_{100}P_{25}$ treatment-combination. The soil of Morga was found deficient in nitrogen (152.01 kg ha^{-1}) and phosphorus (11.24 kg ha^{-1}) and the addition of 100 kg N ha^{-1} and 25 kg P ha^{-1} to the soil enhanced SLA. In Litipara, the maximum SLA (12.22 mm^2 mg^{-1}) was recorded in $N_{100}P_0$ treatment, which may be due to the very low range of nitrogen (60.22 kg ha^{-1}) recorded in the soil of this region hence the addition of 100 kg N ha^{-1} to soil enhanced SLA. Although average phosphorus content (19.26 kg P ha^{-1}) was also in low range but was higher than the soil samples collected from Kotadol (13.48 kg P ha^{-1}) and Morga (11.24 kg P ha^{-1}). Pairwise comparison of average values of SLA among different treatments in the selected sites showed three distinct groups. $N_{50}P_0$ with minimum SLA and $N_{100}P_{25}$ with maximum SLA were found in two different groups and the rest of all treatments in the third group. Increase in production of large sized thin textured tendu leaves was observed when quality IV bushes

Table 3: Effect of chemical fertilizers on specific leaf area (mm^2 mg^{-1}) of *Diospyros melanoxylon*

Treatments*	Kotadol	Litipara	Morga	Mean
N_0P_0	9.70	10.60	12.57	10.96^{ab}
N_0P_{25}	9.87	11.24	12.39	11.17^{ab}
N_0P_{50}	9.78	11.50	12.35	11.21^{ab}
N_0P_{100}	10.80	11.31	11.69	11.27^{ab}
$N_{25}P_0$	10.24	11.52	12.37	11.38^{ab}
$N_{25}P_{25}$	10.86	11.43	14.02	12.10^{ab}
$N_{25}P_{50}$	10.98	10.39	11.74	11.04^{ab}
$N_{25}P_{100}$	9.83	11.56	15.21	12.20^{ab}
$N_{50}P_0$	10.39	11.11	10.69	10.73^{b}
$N_{50}P_{25}$	9.78	11.21	11.72	10.90^{ab}
$N_{50}P_{50}$	10.97	10.77	11.15	10.96^{ab}
$N_{50}P_{100}$	10.10	11.21	12.09	11.13^{ab}
$N_{100}P_0$	10.39	12.22	11.67	11.43^{ab}
$N_{100}P_{25}$	11.04	11.20	15.73	12.66^{a}
$N_{100}P_{50}$	9.37	11.37	13.62	11.45^{ab}
$N_{100}P_{100}$	10.23	11.04	13.02	11.43^{ab}
SE $\pm$	0.85	1.10	1.54	
$CD_{0.05}$	1.74	2.10	3.15	

N_0 - No nitrogen (N), N_{25} - 25 kg N ha^{-1}, N_{50} - 50 kg N ha^{-1}, N_{100} - 100 kg N ha^{-1}; P_0 - No Phosphorus (P), P_{25} - 25 kg P ha^{-1}, P_{50} - 50 kg P ha^{-1}and P_{100} - 100 kg P ha^{-1}
Mean with the same alphabets in columns are not significantly different ($p \leq 0.05$) from each other as per DMRT test.

Table 4: Effect of foliar spray of chemical fertilizers on specific leaf area ($mm^2\ mg^{-1}$) of *Diospyros melanoxylon*

Treatments*	Kotadol	Litipara	Morga	Mean
N_0P_0	10.07	10.74	10.55	10.45^{d}
N_0P_{50}	10.67	12.80	11.61	11.69^{abc}
N_0P_{100}	12.00	11.68	10.47	11.38^{abcd}
N_0P_{200}	11.61	12.01	10.89	11.50^{abcd}
$N_{50}P_0$	11.50	12.03	11.37	11.63^{abc}
$N_{50}P_{50}$	10.65	11.73	10.48	10.95^{bcd}
$N_{50}P_{100}$	10.76	12.43	10.45	11.21^{abcd}
$N_{50}P_{200}$	10.45	11.24	10.47	10.72^{cd}
$N_{100}P_0$	11.39	11.41	11.60	11.47^{abcd}
$N_{100}P_{50}$	11.33	12.46	10.45	11.41^{abcd}
$N_{100}P_{100}$	12.20	12.19	10.46	11.62^{abc}
$N_{100}P_{200}$	11.32	11.85	10.46	11.21^{abcd}
$N_{200}P_0$	11.29	13.00	11.35	11.88^{ab}
$N_{200}P_{50}$	10.01	12.94	10.45	11.13^{bcd}
$N_{200}P_{100}$	12.71	12.67	11.64	12.34^{a}
$N_{200}P_{200}$	10.40	12.85	10.50	11.25^{abcd}
SE $\pm$	0.87	0.57	0.26	-
$CD_{0.05}$	1.78	1.17	0.53	-

N_0 - No N, N_{50} - 0.5% N, N_{100} - 1% N, N_{200} - 2% N; P_0 - No P, P_{50} - 0.5% P, P_{100} - 1% P, P_{200} - 2% P
Mean with same superscripted alphabets in columns do not differ significantly ($p \leq 0.05$) from each other.

Table 5: Effect of biofertilizers on specific leaf area ($mm^2\ mg^{-1}$) of *Diospyros melanoxylon*

Treatments*	Kotadol	Litipara	Morga	Mean
n_0v_0	10.40	10.37	12.89	11.22^{a}
n_0v_1	10.37	11.84	14.21	12.14^{a}
n_0v_2	10.59	10.85	13.30	11.58^{a}
n_0v_3	10.22	11.10	12.29	11.20^{a}
n_1v_0	11.18	10.98	14.37	12.18^{a}
n_1v_1	10.82	10.72	12.97	11.50^{a}
n_1v_2	10.25	10.45	13.12	11.27^{a}
n_1v_3	10.85	11.42	12.58	11.62^{a}
n_2v_0	11.31	12.73	12.55	12.20^{a}
n_2v_1	9.76	12.29	12.97	11.67^{a}
n_2v_2	10.47	11.10	14.29	11.95^{a}
n_2v_3	9.73	11.73	15.06	12.17^{a}
n_3v_0	10.19	10.63	12.14	10.99^{a}
n_3v_1	10.70	10.08	11.81	10.86^{a}
n_3v_2	10.00	11.28	12.04	11.11^{a}
n_3v_3	10.09	11.21	12.18	11.16^{a}
SE $\pm$	0.72	0.75	0.18	-
$CD_{0.05}$	1.48	1.52	3.75	-

n_0, n_1, n_2 and n_3 are 0, 250, 500 and 1000 g neem granule $plot^{-1}$ treatments, respectively; v_0, v_1, v_2 and v_3 are 0, 250, 500 & 1000 g VAM $plot^{-1}$ treatments, respectively;
Mean with same superscripted alphabets in columns do not differ significantly from each other.

were fertilized with calcium ammonium nitrate, single super phosphate and muriate of potash during monsoon period in Dhenkanal district of Odisha (Udgate, 1997).

The effect of foliar spray of chemical fertilizers on SLA of leaves is given in Table 4. The results of foliar spray were similar to the soil application of chemical fertilizers, describing maximum SLA with $N_{200}P_{100}$ treatment-combination in N and P deficient soils of Kotadol and Morga; while with $N_{200}P_0$ treatment-combination in N deficient soil of Litipara. SLA enhanced maximum (19.20%) in foliar spray experiments as compared to the chemical fertilizers (18.08%), depicting more effectiveness and feasibility of former one. Pairwise comparison through DMRT showed 7 groups, with largest group accommodating 7 treatments *viz.*, N_0P_{100}, N_0P_{200}, $N_{50}P_{100}$, $N_{100}P_0$, $N_{100}P_{50}$, $N_{100}P_{200}$ and $N_{200}P_{200}$. N_0P_0, $N_{50}P_{200}$, $N_{200}P_0$ and $N_{200}P_{100}$. Each were found in separate group showing that SLA in these treat-ments differ significantly from each other.

Effect of biofertilizers on SLA

The effect of biofertilizers on SLA of *D. melanoxylon* is given in Table 5. In Kotadol and Litipara, the maximum SLA was recorded in n_2v_0 treatment, describing the application of 500 g neem granules per 5 m x 5 m size plot having tendu bushes in nitrogen deficient rhizosphere soil after rainy season. Neem cake or neem granules lower nitrogen losses by inhibiting nitrification (Lokanadhan *et al.*, 2012). Hence, the addition of neem granules to the rhizosphere soil might have reduced the nitrogen loss but helped in enhancing leaf surface area and thereby SLA. In Morga, the maximum SLA was observed in n_2v_3 treatment, which means that the addition of 500 g neem granules in combination with 1000 g VAM $plot^{-1}$ in nitrogen and phosphorus deficient rhizosphere soil enhanced leaf surface area or quality of tendu leaves. No significant variation in SLA was observed among different treatments during pairwise comparison.

Table 6: Physicochemical characteristics of soil samples collected from Chhattisgarh (India)

Sites	Surface/ Subsurface	pH	EC (µs cm^{-1})	Organic carbon (%)	Available nutrients (kg ha^{-1})			Exchangeable cations (meq 100 g^{-1})			
					N	P	K	Ca	Mg	Na	K
Kotadol	Surface	5.52	8.39	0.19*	130.45*	12.16**	90.31*	0.73	0.10	2.03	0.45
	Sub surface	5.61	6.63	0.14*	108.43*	15.38**	100.50*	0.60	0.10	2.06	0.45
Litipara	Surface	5.37	13.03	0.59**	79.90*	13.20**	245.96**	1.22	0.28	1.15	0.52
	Sub surface	6.03	6.40	0.40*	40.53*	25.32***	192.12**	3.03	0.76	1.30	0.54
Morga	Surface	5.31	13.78	0.61**	164.02*	10.78**	252.25**	1.14	0.41	0.13	0.44
	Sub surface	5.64	6.75	0.49*	140.01*	11.70**	190.13**	1.54	0.35	0.13	0.42

* Low; ** Medium; *** High

VAM absorb and accumulate more phosphorus and enhance phosphate uptake from less soluble sources of phosphorus promoting growth of plants (Gray and Gerdemann, 1969). Physicochemical and biological properties are influenced in the soils inoculated with biofertlizers exhibiting a higher population of bacteria, fungi and actinomycetes (Ramalakshmi *et al*., 2008).

Physicochemical characteristics of soil samples indicated low to high content of available nitrogen, available phosphorus and organic carbon content (Table 6). Therefore, the application of chemical- and bio-fertilizers supplement the nitrogen and phosphorus to the rhizosphere soil. Although, the application of chemical- and bio-fertilizers is practically difficult in the natural conditions due to non-uniform distribution and large area covered under this species, but increasing land degradation and reduction in quality tendu leaf production, it becomes necessary to sustain the quality and tendu leaf production through scientific means.

Conclusion: Every year pruning of tendu bushes of medium girth (2-4 cm) at ground level maximize the leaf surface area and minimize the leaf weight thus increases the quality of leaves. Application of 100 kg N ha^{-1} and 25 kg P ha^{-1} to the nitrogen and phosphorus deficient soil after rainy season (having high moisture content) can increase the size of tendu leaves. Foliar spray of 2% N plus 1% P on tendu bushes in 2nd to 3rd week of April, when tendu leaves attain maximum size, enhanced leaf size, which was more effective than the soil application of chemical fertilizers. Moreover, the application of 500 g neem granules per 5 m x 5 m size plot in nitrogen deficient rhizosphere soil and 500 g neem granules plus 1000 g VAM plot^{-1} in nitrogen and phosphorus deficient soil increase the quality of tendu leaves.

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