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Effect of Silvicultural treatments on quantity and quality assessment of Tendu (*Diospyros melanoxylon* Roxb.) leaves

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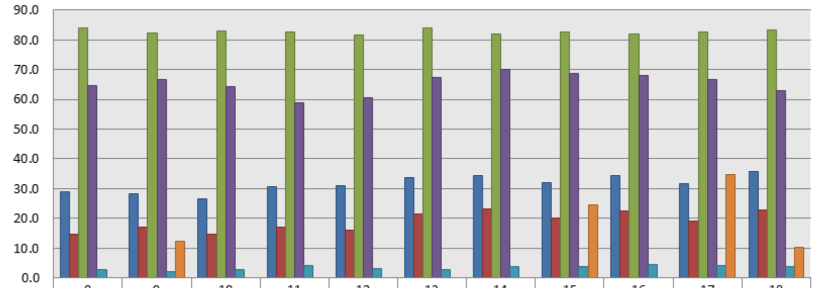
Abstract
Tendu (Diospyros melanoxylon Roxb.) is a common tree of mixed deciduous forest throughout India belongs to family Ebenaceae. The leaves play a vital role in the economic life of rural India. The species producing leaves is most common and preferably known as 'Tendu leaves' though, 'Beedi leaves' and 'Abnus leaves' are also used a synonyms at some places. In India, it largely occurs in the states of Madhya Pradesh, Orissa, Maharashtra, Andhra Pradesh, Jharkhand, Utter Pradesh, Rajasthan and Gujarat. It is not only an extremely important non-timber forest product that serves as a big revenue earner for the state government but is also an important economic resource to the indigenous tribes and local population during the summer months when they have no other form of employment. Due to its great economic value, Tendu leaf, also known as the 'golden leaf'. Tendu leaves are the most valuable and most important NTFP (Non-timber Forest Products) from the State's revenue point of view. It now accounts for 80-90% of the total revenue from the forests. The presence of women in non-agricultural activities particularly in Tendu leaves collection can be viewed from the various angles with judicious and scientific exploitation of the forest products in general. Field level experiment reveals that, both quantity and quality production of Tendu leaves can be enhanced by more than double with an average of 435800 leaves/ha i.e., 8.72 standard bags/ ha with proper silvicultural management if all factors remains positive.

Keywords: Silvicultural, *Diospyros melanoxylon* Roxb, Tendu leaves

Introduction
Diospyros melanoxylon Roxb. is an endemic plant of India is used in various ways. Besides being the source of Indian ebony, its wood is also utilized for making boxes, combs, ploughs and beams. The seeds are prescribed as cure for mental disorders, palpitation of heart and nervous breakdown. Above all, the leaves of this plant constitute one of the most important raw materials of the "*Bidi*" (Indian cheap smoke) industry. It is not only an extremely important non-timber forest product that serves as a big revenue earner for the state government but is also an important economic resource to the indigenous tribes and local population during the agricultural off-season summer months when they have no other form of employment (Dawar, 1994, Dhar *et al.*, 1989) [2, 3].
The annual national production of tendu leaves is 4.5 lakh tonnes/year (FSRI, 2010) [4]. Whereas the average annual production in Jharkhand is 4,74,900 standard bags/year which can be increased up to 7,95,875 standard bags (notified yield) per year. One of the biggest paradoxes of the *Tendu* leaves is that the largest growing areas are also the major food scarce zones in the State. It accounts for 75–80% of the total revenue from the forests. Despite immense potential of revenue generation and socio-economic upliftment of rural population residing in forest fringe areas limited efforts have been taken up to systematically assess *Tendu* leaf production and impact of silvicultural practices therein.

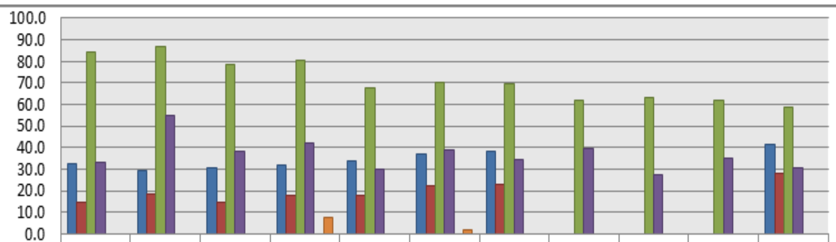
Material and Methods
The present experiment was conducted during the year 2015 in the different agro-climatic sub-zones of Jharkhand based on both primary as well as secondary data collected from various sources. The research work covers the whole Jharkhand state identified in all agro-climatic sub-zones of the state for field level experiment namely sub-zone IV, sub-zone V and sub-zone VI which falls under agro-climatic zone 7 i.e., Eastern Plateaus and Hill Region. The technical programme of work i.e. silvicultural treatments were conducted in all agro-climatic sub-zones of nearly 100 km or far away located at 22° 28'03.8"N latitude and 84° 32'07.6"E longitude, 22° 50'30.5"N latitude and 85° 59'43.7"E latitude & 23° 19'12.4"N latitude and 85° 33'25.3"E longitude of which the altitudes were 342 meters, 267 meters and 518 meters respectively from MSL.



	8	9	10	11	12	13	14	15	16	17	18
Max. Temperature	28.8	28.4	26.7	30.5	31.0	33.8	34.3	32.0	34.3	31.8	35.9
Min. Temperature	14.6	16.9	14.5	17.0	16.1	21.4	23.1	20.2	22.4	19.1	22.9
R.H.% (7:00 AM)	83.9	82.4	82.9	82.7	81.6	83.9	82.1	82.6	82.0	82.7	83.4
R.H.% (2.00 PM)	64.7	66.7	64.1	58.9	60.7	67.4	70.0	68.9	68.0	66.6	63.0
Wind Velocity Km/hr.	2.7	2.1	2.9	4.0	3.0	2.6	3.6	3.7	4.5	4.2	3.9
Rain (mm)	0.0	12.2	0.0	0.0	0.0	0.0	0.0	24.7	0.0	34.8	10.2

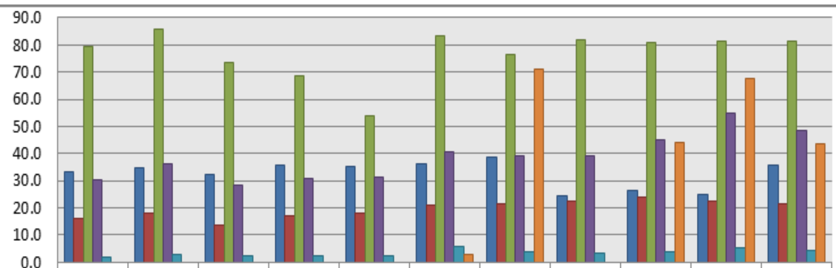
Fig 1a: Weekly Weather of Sub-zone IV [week 8 to 18, 2015 Weather Station Ranchi, Jharkhand]

The climate, in general is classified as sub-humid megathermal. Temperature generally decreases from September second week onwards to December. Rapid decline in temperature with occasional frost is also observed during late December till mid January followed by raising temperature afterwards and reaching its peak in April-May. Sunshine hour also vary from 1.6 hours day -1 in July to 8.8 hours day -1 in April. The variation in the amount of rainfall is very much (900 to 1500 mm) but comes at an average of 1400 mm annually of which 80-85 per cent is received during the month of June-September. The velocity of wind varies from 3.61 km/hr throughout the year. Generally, the monsoon breaks between 15th June and 20th June; and lasts up to second week of October. The weekly weather data during the experiment week 8 to 18 were recorded from the three meteorological observatories of Birsa Agricultural University, Ranchi situated in all the three agro-climatic sub-zones of Jharkhand during the year 2015 have been presented in Fig.1 (a, b and c).



	8	9	10	11	12	13	14	15	16	17	18
Max. Temperature	32.2	29.3	30.8	31.7	34.0	36.8	38.1	0.0	0.0	0.0	41.5
Min. Temperature	14.7	18.2	14.6	17.9	17.7	22.2	22.9	0.0	0.0	0.0	27.7
R.H.% (7:00 AM)	84.4	86.7	78.3	80.1	67.6	70.3	69.4	61.8	63.2	61.7	58.4
R.H.% (2.00 PM)	33.4	55.0	38.3	42.3	29.7	38.9	34.3	39.3	27.2	35.3	30.6
Wind Velocity Km/hr.	0	0	0	0	0	0	0	0	0	0	0
Rain (mm)	0.0	0.0	0.0	7.6	0.0	2.0	0.0	0.0	0.0	0.0	0.0

Fig 1b: Weekly Weather of Sub-zone V [week 8 to 18, 2015 Weather Station Chianki, Jharkhand]



	8	9	10	11	12	13	14	15	16	17	18
Max. Temperature	33.1	34.9	32.2	35.5	35.3	36.4	38.5	24.5	26.6	24.9	35.5
Min. Temperature	16.1	18.0	13.7	17.0	18.0	20.8	21.3	22.3	23.8	22.4	21.6
R.H.% (7:00 AM)	79.6	85.6	73.4	68.4	54.0	83.1	76.6	82.0	80.9	81.6	81.4
R.H.% (2.00 PM)	30.1	36.0	28.1	30.9	31.1	40.4	39.0	39.0	44.9	54.7	48.4
Wind Velocity Km/hr.	1.9	2.9	2.1	2.4	2.2	5.8	3.8	3.2	3.9	5.4	4.4
Rain (mm)	0.0	0.0	0.0	0.0	0.0	3.0	71.0	0.0	44.2	67.6	43.8

Fig 1c: Weekly Weather of Sub-zone VI [week 8 to 18, 2015 Weather Station Darisai, Jharkhand]

Red soils are common and found all over the granite and geneissic plateau surface. These soils are mostly observed in a catenary sequence. The soils of upland are usually, shallow to medium depth, reddish in colour, low base exchange capacity, acidic in reaction (5.0 to 5.6) poor in fertility status, well to excessively drained, prone to erosion with low water holding capacity and high permeability. The soils become heavier in texture down the catena and down the profile, colour changes from reddish yellow to yellow and yellowish grey. In lowland, soils are grey almost neutral in reaction, high clay content and high fertility status. Soils in about 49% of the total geographical area are highly acidic with pH <5.5; about 36% area suffering from moderate to slight soil acidity (pH 5.6 to 6.5). Neutral soils (pH 6.6 to 7.3) accounts for only about 8% (Agarwal *et al*., 2016) [1].

Experiments were carried out in each agro-climatic zone of Jharkhand and conducted from the last week of February, 2015 up to second week of May, 2015 by covering all (three) agro-climatic sub-zones of Jharkhand in which following three experiment points in good density of *Tendu* (*Diospyros melanoxylon* Roxb.) plants were selected which coordinates 22º 28’03.8”N latitude and 84º 32’07.6”E longitude, 22º 50’30.5”N latitude and 85º 59’43.7”E latitude & 23º 19’12.4”N latitude and 85º 33’25.3”E longitude. Following five treatments were employed in 4 replications in Randomized Block Design (RBD): Coppice, Coppice-cum-split, Control Burning, Pruning, and Control (Sole). Experiment field of having rich density of *Tendu* (*Diospyros melanoxylon* Roxb.) saplings of 1”-2” sized (collar diameter) were selected under each treatment i.e. at least 10 (ten) saplings in each treatment all three agro-climatic sub-zones of Jharkhand state. Blocks of 10m x 10m sized were made for each treatment (total five treatments) and replicated four times.

For the Coppice treatment, saplings in the marked block were cut with a very sharp axe or spade in a single stroke parallel to the ground level so that the cut portion or the collar region of the plant may not split. Whereas, for the Coppice-cum-split treatment, saplings were cut with a blunt axe or spade in two gentle strokes parallel to the ground level so that the cut portion or the collar region of the plant may split in two parts; otherwise, it was splitted into two parts with the help of axe or spade. For the Control Burning treatment, all dry leaves were collected with the help of brooms and bamboo bouquets from nearby and spread out in the defined treatment blocks. Precautionary measures for fire were taken till its completion so that it may not spread further for which, brooms were kept in hands to extinguish the fire by beating it just after completing the process. Sharp secateurs as a pruning tool was applied for removing all lateral branches of the *Tendu* plants in Pruning treatment with a view to left the single main stem. The cut of lateral branches were just near to the main stem. No leaves were left on the pruned plants. For these treatments including Control, observations related to number of leaves per plant after 60 days, leaf area of harvestable leaves, thickness of leaf by average measurement was taken from each and every big, medium and small single leaf by considering average of upper, middle and lower portion of a leaf, fresh weight of leaf by at least three harvested fresh leaves of big, medium and small sized each from 10 plants were taken and weigh for each treatment. For dry weight of leaf; sun dried up to a week of same three harvested green leaves of big, medium and small sized were taken and weigh for each treatment. Thereafter average weight was measured in a treatment.

Results and Discussion

As depicted in the Fig.2, the notified yield potential is 7, 95,875 standard bags of Tendu leaf in Jharkhand. The highest collection of *Tendu* leaf was 7,62,003 standard bags during the year 2012 which was 95.74% followed by 7,47,944 standard bags and was 93.98% against the notified yield. Lowest collection of *Tendu* leaf was 2,87,847 standard bags in the year 2014 which was only 36.17% of the notified yield. Whereas, the highest revenue generated from Tendu leaf was Rs.38, 643, 1683/- during the year 2012 followed by Rs.28,905,3012/- during the year 2011. Lowest revenue from Tendu leaf was Rs.5,513,3837/- during the year 2005 (JSFDC, 2015).

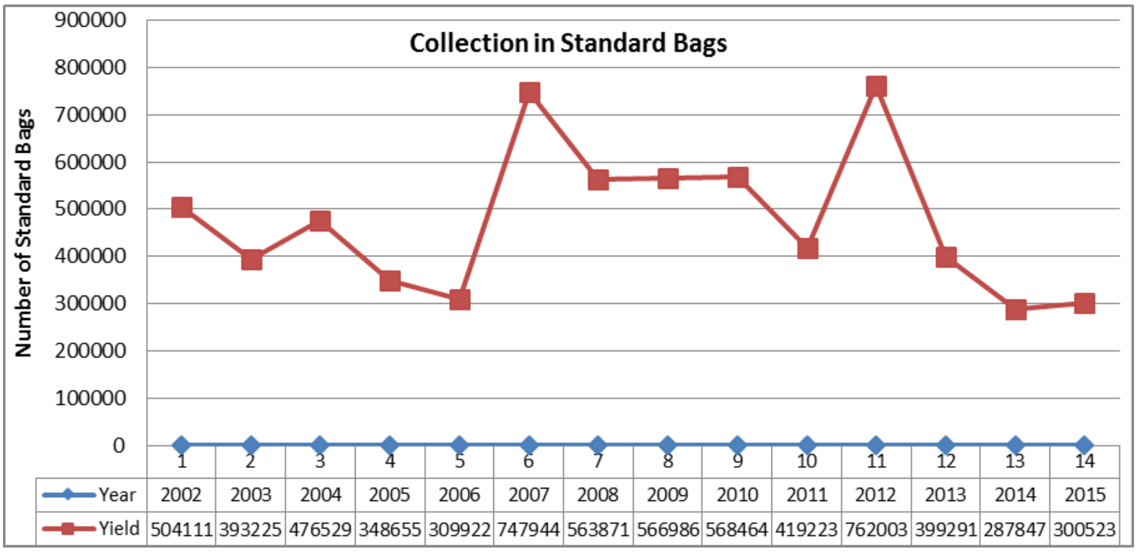


Fig 2: Average Collection of Tendu leaf in Jharkhand

The maximum and average production was 2,76,657 (76.24%) standard bags in sub-zone V followed by 60,067 (58.66%) standard bags in sub-zone VI, lowest was 1,38,176 (41.80%) standard bags in sub-zone IV against the sub-zone wise separated and calculated notified standard bags of 362875, 102400 and 330600 respectively (Fig.3).

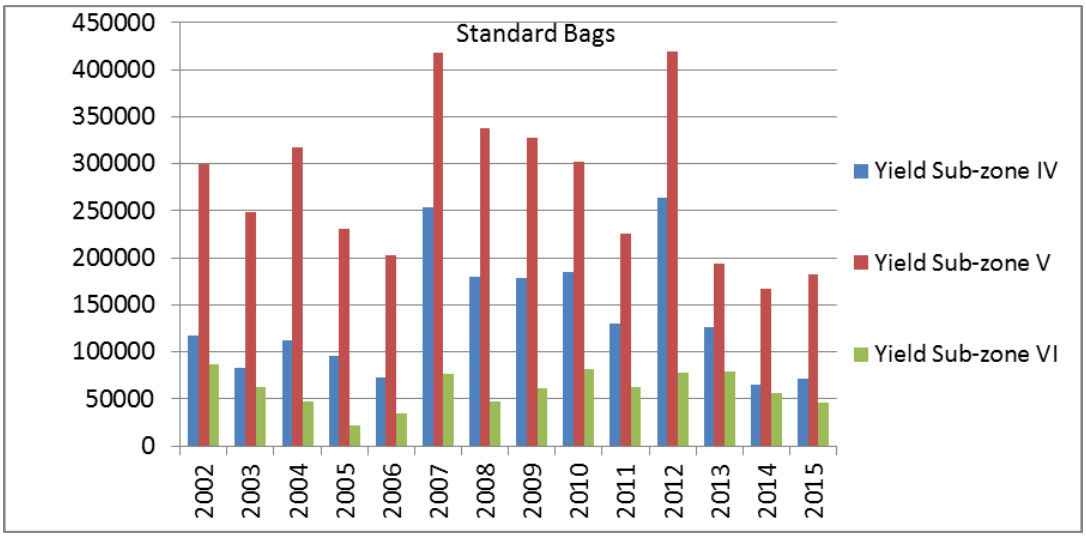


Fig 3: Sub-zone wise Average Production of Tendu leaf in Jharkhand

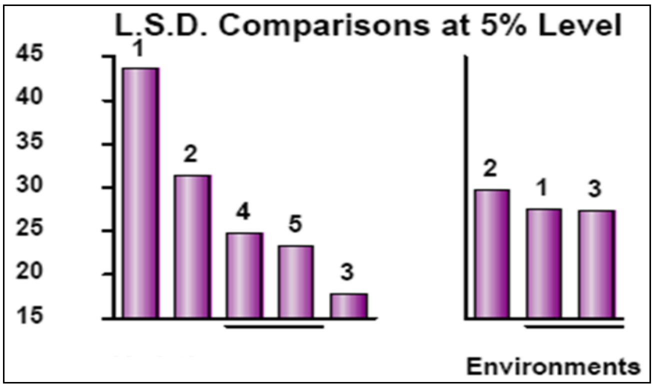
Number of leaves per plant

It is evident from the data (Table 1) that, both the treatments and climates had influence upon the above parameter. As per the pooled data, the numbers of leaves per plant were maximum in coppice with the production of 44 leaves followed by coppice-cum-split (31 leaves). Twenty five leaves were recorded with pruned whereas, 23 leaves were recorded with control; both were statistically noted at par to each other. Minimum number of leaves i.e. 18 leaves per plant were recorded with control burning. The number of leaves in coppice was found nearly double to the control.

As far interaction between treatments and agro-climatic sub-zones/environments was concerned, maximum 45 number of leaves were recorded in coppice with sub-zone V followed by coppice-cum-split by producing 34 leaves; 27 leaves in pruned; 25 leaves in control and minimum 18 leaves were produced in control burning. Sub-zone V always showed superior performance taking with all treatments. Sub-zone IV and VI were statistically at par to each other but, significantly different to sub-zone V. From the observation it is clear that *Diospyros melanoxylon* was much influenced by the various silvicultural treatments and by the climate in regard to number of leaves per plant. The same has earlier been observed by Neelay and Sah (1980) [7], Ghosh *et al.*, (1976) [5].

Table 1: Number of leaves per plant

Treatments	Number of leaves per plant			
	Sub-zone IV	Sub-zone V	Sub-zone VI	Pooled
Coppice	43.00	45.25	42.50	43.58
Coppice-cum-split	30.50	33.75	30.00	31.41
Control Burning	17.75	18.25	17.25	17.75
Pruned	23.25	27.00	24.00	24.75
Control	23.00	24.50	22.50	23.33
S.Ed±	*1.711*	*2.469*	*1.557*	S.Ed ± C.D. 5%
C.D. 5%	*3.729*	*5.379*	*3.393*	
C.V.%	*8.801*	*11.737*	*8.082*	
Treatments				1.0507, 2.1176
Environments				0.8139, 1.6403
Treatment x Environments				1.8199, 3.6678
C.V.%				9.81



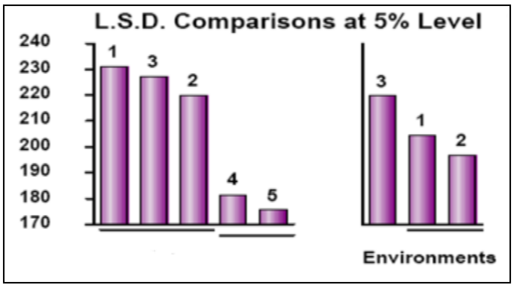
The probable reason for the number of leaves per plant might be due to production of prolific number of shoots in case of coppicing. The number of leaves was found minimum in control burning might be due to severe injury to the plant which might had badly affected the physiology of the plant in making them weak. Pruning and control treatments behaved similar with regard to number of leaves per plant might be due to physiology on emergence of new leaves being same as after leaf fall in control.

Leaf area

A perusal of pooled data in the Table 2 revealed that maximum leaf area (231.08 cm^2) was recorded with coppice followed by control burning and coppice-cum-split all above were statistically at par with each other. With the above treatments, pruned and control were found highly significant difference. Pruned showed 181.50 cm^2 leaf area whereas control showed minimum 175.50 cm^2 leaf area.

Table 2: Leaf area

Treatments	Leaf area (cm²)			
	Sub-zone IV	**Sub-zone V**	**Sub-zone VI**	**Pooled**
Coppice	229.50	215.75	248.00	231.08
Coppice-cum-split	212.75	208.00	238.50	219.75
Control Burning	225.25	213.50	242.75	227.16
Pruned	180.50	177.75	186.25	181.50
Control	175.00	168.50	183.00	175.50
S.Ed±	11.275	10.013	9.000	S.Ed ± C.D. 5%
C.D. 5%	24.566	21.816	19.609	
C.V.%	*7.793*	*7.199*	*5.793*	
Treatments				5.6721, 11.4313
Environments				4.3936, 8.8547
Treatment x Environments				9.8244, 19.7997
C.V.%				6.71



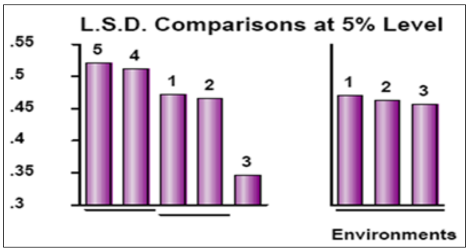
Interactions shows that 248 cm² leaf area with coppice in sub-zone VI showed the best followed by 229.50 cm² and 215.75 cm² in the rest sub-zone IV and V. Minimum leaf area observed in the control of sub-zone V. Sub-zone IV and V were statistically at par to each other but significantly different to sub-zone VI which was having marked difference in climatic conditions. The findings comply with the findings of Oraon (2016) [8]. The probable reason for the maximum leaf area in coppice might be due to efficient regulation of protein synthesis and their mobilization in leaves due to appropriate climatic conditions for the growth of the species in case of sub-zone VI. The rainfall during the experimental week might have also helped as evident from the data presented in the Fig.1c. Increased root formation and nutrient uptake by roots are positively associated with formation of leaves and increase of leaf area.

Thickness of leaf

Treatments had clear-cut influence upon the thickness of leaf (Table 3). Control burning produced most thin (0.347 mm) leaves and was significantly different with the other treatments followed by coppice-cum-split and coppice with the thickness of 0.466 mm and 0.472 mm respectively. Pruned got fourth position and control got last position with a thickness of 0.521 mm; both were also statistically at par. Minimum thickness was observed in control burning with a thickness of 0.334 mm in sub-zone V and 0.477 mm in sub-zone IV. Very thick (0.525 mm) leaves were observed in control in sub-zone IV. There was no significant impact of climates of sub-zones in leaf thickness. Better performance of control burning might be due to struggling of the Tendu plants for its survival and moisture stress into the soil, which might have resulted in multiple coppice shoots with thin leaves. Coppice and coppice-cum-split also exhibited medium thickness whereas, pruning and control found thicker than all treatments with respect to their degree of injury, the similar findings reported by Saha and Howe (2003) [9].

Table 3: Thickness of leaf

Treatments	Thickness of Leaf (mm)			
	Sub-zone IV	Sub-zone V	Sub-zone VI	Pooled
Coppice	0.477	0.472	0.466	0.472
Coppice-cum-split	0.471	0.468	0.459	0.466
Control Burning	0.361	0.346	0.334	0.347
Pruned	0.519	0.511	0.508	0.513
Control	0.525	0.520	0.518	0.521
S.Ed±	*0.020*	*0.016*	*0.017*	S.Ed ± C.D. 5%
C.D. 5%	*0.043*	*0.036*	*0.037*	
C.V.%	*5.881*	*5.026*	*5.210*	
Treatments				0.0094 0.0188
Environments				0.0072 0.0146
Treatment x Environments				0.0162 0.0326
C.V.%				4.86



On the basis of 14 years' secondary data, the average collection of *Tendu* leaf in Jharkhand was 4,74,900 standard bags per year which was only 59.67% of the notified yield of 7,95,875 standard bags. The average production was highest in sub-zone V, accounting for 2,76,657 (76.24%) standard bags followed by 60,067 (58.66%) standard bags in sub-zone VI and the lowest was 1,38,176 (41.80%) standard bags in sub-zone IV.

Impact on quantity and quality production

Coppice treatment exhibited its superiority in terms of maximum numbers (5) of coppice shoots per plant, 44 numbers of leaves per plant and leaf area (231.08 cm^2). Coppice and Coppice-cum-split were statistically at par to each other in terms of leaf area and thickness. Overall, all treatments were significantly different than control. On the basis of primary data, the maximum number of leaves can be obtained through coppicing. By which on an average 435800 leaves per ha. i.e., 8.72 standard bags per ha. can be achieved. As far productivity of sub-zones are concerned, sub-zone V was the most productive sub-zone which can produce 452500 leaves (9.05 standard bags) per ha., keeping with second position, sub-zone IV can produce 430000 leaves (8.60 standard bags) per ha. whereas, sub-zone VI can produce 425000 leaves (8.50 standard bags) per ha. If all factors remains positive.

As far the quality is concerned Control burning proved its superiority by minimum thickness (0.347 mm), leaf area (227.16 cm^2), number of coppice shoots (4 shoots) per plant, without prominent of midrib/mid vein, greenish white in colour, more uniform and texture as good body, soft and free from hairs. Likewise, second quality achieved jointly by Coppice and Coppice-cum-split which had medium but good leaf area, good quality thickness, very less prominent midrib/ mid vein, greenish to greenish yellow/grey colour, similar texture as Control burning but, comparatively less and more uniform in shape and size. Both the treatments were statistically at par with respect to leaf area and thickness.

Conclusion

Various silvicultural operations in *Diospyros melanoxylon* Roxb. such as coppicing, control burning pruning etc. were studied in three Agro-climatic sub-zones of Jharkhand and have been proved to be quite effective for not only increasing the quantity of the leaf but also improving its quality and, therefore, could be profitably used. Among silvicultural treatments; coppicing without splitting injury showed significant effect on quantity, quality and uniformity aspects. As far quality and uniformity are concerned, control burning performed the best but, may not be recommended due to environmental concern until any specific condition and strict supervision. Control performed very poor. Productivity and quality can be enhanced with better management and augmentation through artificial regeneration of the species in all agro-climatic sub-zones of Jharkhand.

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