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RESEARCH ARTICLE

DIPLOKNEMA BUTYRACEA (ROXB.) LAMB.: A VIABLE LIVELIHOOD OPTION FOR HILL COMMUNITIES OF CENTRAL HIMALAYAN REGION

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ABSTRACT

Mankind has been exploiting forest resources for many million years which is adversely affecting the environment and livelihood of people of Himalayan region. It is important to reforest the wastelands and degraded areas as they remaining unutilized or under-utilized. *Diploknema butyracea* is one important multipurpose species which is suitable for reclamation of these wastelands. The main objective of present study was to assess the regeneration status of this multipurpose tree species, estimate fruit and seed yield and identify the high oil yielding sites. Across all the sites the tree density of *D. butyracea* ranged between 2 trees/ha and 33trees/ha. The seedling density ranged between 30 seedlings/ha and 310 seedlings/ha. At several sites absence of saplings shows that conversion of seedlings into sapling is poor. Across all the sites the average seed yield varied between 28.1±0.52kg tree^{-1} and 45±0.94kg tree^{-1} and average kernel yield varied between 17.8±0.59kg tree^{-1} and 33.7±0.70kg tree^{-1}. The oil content percentage (kernel dry weight basis) ranged between 60.6±0.75% and 38.8±1.12%. Production of *D. butyracea* oil can be a viable livelihood option for the local farmers. A hectare of plantation can generate 65,360 rupees to 2,45,400 rupees per year from sale of oil at the rate varying from 80 to 120 rupees kg^{-1}

INTRODUCTION

In India the area of land that belongs to degraded category is considerable and commonly known as wasteland. The total area of such category in India is variously estimated between 70 million ha to more than 170 million ha (Radhakrishna, 2006). It is the need of the hour to develop and reforest these wastelands and degraded areas as they remaining unutilized or under-utilized. The National Wasteland Development Board suggested that for reclamation and afforestation of any type of wasteland, the choice of tree species should be such that the inter culture inputs are least and attention needed is negligible.
Degradation of national forest is a global problem. Mankind has been exploiting forest resources for many million years. Ruthless exploitation of the vegetal cover from the steep slopes of Himalaya has adversely affected environment and living condition of the people in this region. Majority of land holdings (>70%) in the mountainous part of Himalayas are small and scattered (Lead, 2007). The local populations of the entire region depend on the non timber forest products for fulfilling their daily needs.

Diploknema is a small genus (Family- Sapotaceae) of trees distributed from India to Philippines. The species is distributed from Kumaun eastwards to Sikkim and Bhutan (sub Himalayan tracts and outer Himalayan ranges) and it also occurs sporadically in tropical moist deciduous forest. It has been reported from Andaman Islands where it is frequently found in semi-deciduous and evergreen forests (Troup, 1921**)** the trees occur chiefly along the sides of ravines of hills and in shady valleys. It is found in the elevation range between 300 to 1500masl. The species is promoted on the margins of agricultural fields as a fodder tree. Besides the fruit which is a valuable staple food; flowers constitute bee forage during winter months and utilized for the preparation of jaggery and spirituous liquor. Both traditional as well as modern methods are used for production of "Cheura honey" which is beneficial for health. The kernels of cheura yield edible oil, known in the trade as "Phulwara Butter" which has been classed along with commercial Morwa bassia fats (Singh et. al. 2010). The fatty oil extracted from the *D.butyracea* kernels in an important article of commerce. As the species is multipurpose it is heavily exploited and is under anthropogenic pressure. The purpose of the study was to assess the (i) regeneration potential of this important species; (ii) estimate fruit and seed yield tree^{-1}; (iii) and identifying the high seed oil yielding sites that varied in altitude for future multiplication and propagation.

MATERIAL AND METHODS

The study area lies between 610 and 1600m on the southern extremity of lesser Himalayan zone in Kumaun, between 29˚24'N latitude and 79˚28'E longitude . As the distribution of this species is restricted in the Kumaun region only a thorough survey of the Kumaun region was carried out and total 28

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potential sites were identified (Table 1). Mean maximum temperature in the study area varies between 36°C and 41.6°C (Singh *et al*. 2010) and mean annual rainfall generally ranges from 800 to 1900 mm per annum. The data on tree resource availability was collected by placing 10, 31.5 X 31.5m quadrats along the base, middle and top of the slope at each site (Singh *et al*., 2011). However, seedlings were estimated by laying ten, 5 × 5m quadrats. The vegetational data were analyzed for density and total basal area following Curtis, 1959. On each potential site five superior individuals were marked. The superior trees were selected on the basis of healthy tree, free from buttresses, well developed crown and had good number of flowers and fruits. The tree height was measured with Ravi multimeter and girth and crown cover (length × width) of each selected tree was measured with meter tape following Tewari *et al*. 2011.

Fruit/seed yield estimation

The fruit/seed yield estimation was made by counting the number of branches, twigs /sub branches, number of branches per twigs and number of fruit per bunch (Barik *et al.*, 1996).

$$\text{Fruit or seed weight (kg per tree)} = \frac{\text{No. fruits on tree or seed} \times \text{Average weight of 1 fruit or seed (g)}}{1000\ (g)}$$

Oil yield estimation

For oil estimation ripe fruits were collected from each selected tree in May end- June first week. The collected fruits were brought to the laboratory within 24 hours and de-pulped. The extracted seeds were thoroughly washed under running water and spread for sun drying for 48 hours. The shells of seeds were removed for kernel extraction. The oil was extracted by using Soxhlet apparatus. 250 gm of grounded seed kernels (3 replicate tree^{-1}) were taken and placed in the soxhlet apparatus and the oil extracted using petroleum ether as solvent. The assembly was made to run for 8 hours. Anhydrous Sodium Sulphate was added to remove any trace of moisture from the extracted solution at the completion of extraction process the oil was recovered from the mixture by distillation and stored in a labeled sample bottle. This process was repeated for each sample (Joshi *et al*, 2013).

Table 1 Fruit, Seed, Kernel and Oil yield kg/tree areas different study site.

S. No.	Site	Altitude	Height (m)	Circumference (cm)	Average Fruit Yield kg/tree	Average Seed Yield kg/tree	Average Oil Content % tree^{-1}
1.	Hupli	1150	19.0 ± 2.32	216.0 ± 1.35	250 ± 5.24	45.0 ± 0.94	60.6 ± 0.75
2.	Bagartoli	1262	16.5 ± 2.24	198.5 ± 1.22	220 ± 2.91	39.6 ± 0.52	57.8 ± 0.75
3.	Matola	1257	23.4 ± 1.98	280.0 ± 3.06	200 ± 3.53	36.0 ± 0.63	58.0 ± 0.89
4.	Rameshwar	836	18.5 ± 3.02	182.0 ± 2.45	180 ± 4.84	32.4 ± 0.87	42.7 ± 0.74
5.	Dhingal	1300	20.4 ± 1.87	195.6 ± 1.56	190 ± 1.22	34.2 ± 0.22	51.3 ± 1.12
6.	Chamoli	1000	20.0 ± 2.65	190.1 ± 3.11	190 ± 3.39	34.2 ± 0.61	47.7 ± 1.73
7.	Syat	990	18.5 ± 3.11	158.0 ± 2.45	180 ± 4.84	32.4 ± 0.87	48.5 ± 0.71
8.	Dhuhani	1011	24.0 ± 2.55	176.5 ± 2.88	190 ± 3.39	34.2 ± 0.61	49.7 ± 0.67
9.	Madanpur	1200	18.4 ± 2.19	195.0 ± 1.67	195 ± 2.91	35.1 ± 0.52	53.9 ± 1.10
10.	Banspatan	900	18.9 ± 1.87	239.1 ± 0.98	245 ± 4.84	44.1 ± 0.87	45.8 ± 2.02
11.	Tarigaon	1240	20.8 ± 2.56	203.5 ± 1.43	240 ± 4.06	43.2 ± 0.73	59.8 ± 1.25
12.	Bakarihat	900	19.7 ± 2.19	210.8 ± 2.19	210 ± 2.54	37.8 ± 0.45	49.1 ± 1.47
13.	Dungatoli	1050	22.7 ± 1.35	198.5 ± 1.87	215 ± 3.39	38.7 ± 0.61	48.8 ± 0.29
14.	Gaunali	800	20.2 ± 2.56	215.8 ± 1.99	185 ± 2.54	33.3 ± 0.45	41.2 ± 1.76
15.	Thali	900	19.8 ± 1.87	260.3 ± 1.96	220 ± 4.30	39.6 ± 0.77	45.8 ± 1.07
16.	Gourihaat	1270	23.8 ± 2.42	242.1 ± 2.15	230 ±4.30	41.4 ± 0.77	58.3 ± 0.72
17.	Napad	1050	20.6 ± 2.19	247.2 ± 1.89	200 ± 3.53	36.0 ± 0.63	49.6 ± 0.62
18.	Cheurani	800	22.8 ± 1.35	293.0 ± 3.06	220 ± 3.67	39.6 ± 0.66	41.8 ±0.42
19.	Kanari Cheena	1560	15.2 ± 2.02	138.4 ± 2.14	210 ± 3.28	35.0 ± 0.20	45.3 ± 0.55
20.	Mangalta	1050	14.8 ± 1.87	135.3 ± 2.52	150 ± 2.25	31.5 ± 0.51	48.2 ± 0.48
21.	Bhaisiachana	800	16.9 ± 1.23	185.2 ± 1.89	160 ± 2.23	33.8 ± 0.36	42.1 ± 0.71
22.	Jhoaradibora	1200	18.2 ± 2.51	165.2 ± 3.04	170 ± 3.81	30.4 ± 0.26	54.3 ± 0.53
23.	Ganai	1450	17.4 ± 1.21	185.6 ± 2.59	195 ± 1.25	31.4 ± 0.20	49.1 ± 0.93
24.	Masmoli	850	18.3 ± 1.12	170.9 ± 3.31	150 ± 1.35	30.2 ± 0.55	43.2 ± 1.01
25.	Malaseema	800	17.4 ± 2.42	205.8 ± 3.14	170 ± 2.00	35.8 ± 0.81	44.3 ± 0.98
26.	Bhakhunda	1020	14.8 ± 2.11	190.4 ± 4.46	195 ± 2.30	29.1 ± 0.23	50.6 ± 0.55
27.	Murti	1450	16.5 ± 1.31	145.5 ± 1.44	180 ± 2.01	33.4 ± 0.50	52.9 ± 0.55
28.	Katura	1550	12.4 ± 3.00	130.2 ± 1.99	140 ± 1.81	28.1 ± 0.52	38.8 ± 1.12
Source of variation					Average Fruit Yield kg/tree	Average Seed Yield kg/tree	Average Oil Content percentage/tree
Site F value					**	**	*
CD at 5%					38.56	6.15	9.54
Mean					195.71	35.55	49.25
SD					2.85	4.48	5.98
SE					5.38	0.84	1.13

± = Standard Error, ** = Significant at 5%, * = Significant at 1%,

RESULT

Phytosociological Analysis: All the selected 28 sites were located between 610 and 1600m elevation. Across all the sites the tree density of cheura ranged between 2 trees/ha at Murti site and 33trees/ha at Hupli site. The maximum total basal area of trees was at Churani site 10.23m^2 ha^{-1} and minimum at Katura site (0.21m^2 ha^{-1}). At several sites absence of saplings was conspicuous and the maximum sapling density was 33 saplings ha^{-1}. The seedling density was highest at Hupli site being 310 seedlings ha^{-1} and minimum at Ganai site being 30 seedlings ha^{-1}.

Tree Characteristics*:* Across all the sites the mean tree height of selected trees ranged between 16.5±2.24m and 24.0±2.55m. The tree circumference varied between 158.0±2.45cm and 29.3 ±3.06cm. The crown cover varied between 180.0±2.56m^2 and 344.0 ±1.98m^2. The average number of flower per bunch ranged between 45.0±2.31 and 68±3.05 (Table 1). The tree height was maximum at Dhuhani site and minimum at Katura site whereas circumference was maximum at Cheurani and minimum at Katura site. Crown cover and number of flower per bunch was maximum at Hupli site and minimum at Katura site.

Fruit and Seed Yield*:* Across all the sites the average fruit yield varied between 140±1.81kg $tree^{-1}$ and 250±5.24kg $tree^{-1}$. The average seed yield varied between 28.1±0.52kg $tree^{-1}$ and 45±0.94kg $tree^{-1}$ and average kernel yield varied between 17.8±0.59kg $tree^{-1}$ and 33.7±0.70kg $tree^{-1}$. ANOVA showed that the average fruit yield kg/tree and average seed yield kg $tree^{-1}$ varied significantly across the sites ($p<0.05$) (Table 1).

Oil Yield: The oil yield was maximum at Hupli site and minimum at Katura site. The oil content percentage (kernel dry weight basis) ranged between 60.6±0.75% and 38.8±1.12%. There are five sites namely Hupli, Bagartoli, Matola, Tarigaon and Gourihaat where the oil content percentage range between 55 and 60% Besides these five sites, in five sites the oil content percentage was 50 to 55%, in eleven sites between 45 to 50%, in six sites between 40 and 45% and only one sites has oil content less than 40%. ANOVA showed that the average oil content percentage varied significantly across the sites ($p<0.01$).

DISCUSSION

In the agricultural economy of India, oilseeds are important next not only to food grains in terms of area, production and value (Hegde, 2012). Apart from annual oilseeds a wide range of other minor oil bearing plants of horticulture and forest origin have to play an important role for meeting the oil demand of the country. During 2010-2011, the country imported about 9.2Mt of vegetable oils costing around Rs 38,000crores, whereas export earning were less than Rs 21,000 crores. In our country per capita consumption of vegetable oils has increased from around 3kg/year in 1950 to 14.2kg/year during 2010-2011 (Hegde, 2012). In view of the increasing demand of edible oil, government of India is promoting non-conventional source of edible oil which would give high per unit area production (Motilal, 1996). *D. butryracea* can be a viable option for meeting the vegetable oil demand of the hill region. As per our study the average oil content percentage of cheura ranged between 38.8 to 60.6% which is higher than the other oil yielding tree species. In other oil yielding tree species *Jatropha curcas* contain 25%, *Pongamia pinnata* contain 35% and *Prunus armenica* contain 43% oil percentage which is lower than *D. butyracea* **(**NOVOD Board report, 2008-09**).** National wasteland Development Board found *D. butyracea* to be useful for block planting and also to be grown in the ravines in hills (NOVOD, 2002).

Production of *D. butyracea* oil can be a viable livelihood option for the local farmers as the oil is generally sold between 80 -120 rupees/lit (Through personal communications). The market price of *D. butyracea* seeds varies from 15 – 20 rupees/kg. As per our estimates one hectare of area can easily support 100 trees of *D. butyracea* at 10 x 10 m spacing. As per our study from 1 ha plantation the average seed yield can range from 2810kg ha^{-1} to 4500kg ha^{-1} and the kernel yield 2107kg ha^{-1} to 3375kg ha^{-1} (75% of seed weight). One hectare plantation can generate 65,360rupees to 245400 rupees per year from sale of oil at the rate varying from 80 to 120 rupees kg^{-1}.

As peer the NOVOD Board Report 2008-09 the average income from oil and other by – products is estimated about Rs. 70,000 to Rs. 1, 20,000 per ha/year which can be helpful for the economic uplifting of the village community. The seed form about 18%, of the fruits and the kernel of the seeds forms about 75% of its weight, is rich in fat but also contains saponin. Uttarakhand's agricultural economy and food security depend vitally on the small holder farmers.

Farmers can opt for the oilseed as cash crops and they can get good monetary return from the crop production, which make enable them to achieve the sustainable livelihood security. However, it is important to mention that the species stand produce seeds only after 10 – 12 years and keep doing so till 60 – 70 years. From the present study it was apparent that there is a huge gap between realized and potential oil production in Uttarakhand, which is indicative of tremendous potential of the species to boost the economy of the rural population.

The gap between per hectare potential and realized production suggests that most of the produce remain untapped. Despite the realized usefulness of the species there is consistent decline in interest of inhabitants for oil production (personal observation).

The cumbersome procedure of traditional oil extraction appears to be the main cause but in the areas where oil expellers are functional the local population has shown a great interest in oil extraction. There is tremendous scope of planting the degraded area with species like cheura in a participatory manner and linking them to livelihood options of poor people of Himalaya who depends critically on their forest for their living.

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