Article

Effect of morphological parameters with relation to the Oleoresin production: A case study from Narendranagar Forest Division, Uttarakhand, India

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Abstract
Pinus roxburghii is one of the most important tree species used for resin tapping and for commercial purpose in Uttarkhand. The present study aim to investigate the relationship of Oleoresin production with morphological parameters. We have divided the three Oleoresin yield classes, i.e., high resin yielders (HRY's), medium resin yielders (MRY's) and low resin yielders (LRY's). The production potential of Oleoresin showed tends to increase with the various morphological parameters like diameter at breast height, number of bore holes. At the same time, bark thickness, tree needle length along with the thickness and colour of needle also has been tested which showed the positive correlation with the Oleoresin production. Further we have recorded significant differences in the diameter ranges 40-50 (12.99 ltr. = HRY'S, 28.30 ltr. in MRY'S and 7.27 ltr. in LRY'S) and 50-60 (10.82 ltr. = HRY'S, 3.2 ltr. in MRY'S and 6.05 ltr. in LRY'S) with maximum yield of Oleoresin in Chir pine. ANOVA showed that Oleoresin production vary significantly in all the categories of Oleoresin production (P<0.05) with respective to the different diameter ranges along with the bark thickness, needle length and colour.

Keywords Oleoresin; morphological parameters; Narendranagar Forest Division; diameter.

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1 Introduction

Pinus roxburghii is commercially tapped for Oleoresin in Western Himalaya. It is generally found as a sub-tropical species in the Himalayan sub-tropical pine forests (Champian and Seth, 1968). *Pinus roxburghii* is most commonly known as Chir pine and mainly used for resin tapping in Uttarakhand, Himachal Pradesh, Jammu and Kashmir. Resin tapping is one of the important forest based industry which play important role for bearing on the rural economy. Many important products like rosin serve as raw material for paper, soap, paints and variety of other chemical industries (Nimkar and Sharma, 2007). Whole belt of Himalaya has been diversified for medicinal and aromatic wealth which has been although explored but more information need to come yet on the status of medicinal and ethnomedicinal plants (Akash et al., 2020a). Every years diversity, structure, patters of species and regeneration potential changes which has to be explored (Akash et al., 2019, 2020b). *Pinus roxburghii* is the principal pine being commercially tapped for Oleoresin and huge source of revenue for Government in Himalayan states.

Oleoresin is an important non wood forest product (NWFP) which on distillation yield essential oil, which is known as turpentine and non volatile product, called the rosin. The proportion of rosin and turpentine oil in Chir pine is 75% and 22% respectively, with 3% losses. The composition of turpentine can vary considerably according to the species of pine exploited, and this greatly influences its value and end use (Sharma, 2001; Nimkar, 2002). The major Oleoresin producing states are Uttarakhand, Himachal Pradesh and Jammu and Kashmir (Seth and Lohani, 1971) in which Himachal Pradesh singly produces 40% of the total resin in India (Pant, 1978).

There were many methods of Oleoresin tapping in different countries. From time to time, one tapping method succeeds another one. Earlier resin tapping was done with cup and lip method and then it has been replaced by rill and Bore-hole method. In 1995, Hodges was the pioneer scientist who discovered the revolutionary method for resin tapping and named it Bore-hole method. It mainly involves drilling holes into the Pine wood to open the resin ducts and collect Oleoresin in closed containers. This method was greatly supported by the environmentalist as it causes less damage to the pine bark and internal tissues like cambium. On the other hand, no damage occurs to the merchantable part of pine as the holes are near the ground level. This method was greatly supported by scientist for conservation and management of Pine trees in India. The oleoresin extracted by this method is superior and without impurities, so the quality of rosin turpentine and other products manufactured from are better and fetch higher prices (Lekha and Sharma, 2006). In Himalayas, the production of Oleoresin is chiefly affected by the topography, wind, and various environmental factors like temperature, evapo-transpiration, humidity and periodicity. On the other hand, diameter, crown size, tapping methods, crown density, stimulant used and width of blaze etc. (Seth and Rajkhowa, 1961; Verma and Pant, 1978), diameter at breast height and width of crown, diameter, climatic factor (Kaushal and Sharma, 1988 and Lohani, 1985, Simao (1941) also affects the production greatly. So in present study, we have made an attempt to record the production potential of Oleoresin with respect to the morphological characteristics like temperature, humidity, periodicity, diameter, crown size, tapping methods, crown density, twist, stimulant used in bore-hole method and factors which are responsible for oleoresin tapping in *Pinus roxburghii.*

2 Study Area and Methodology

2.1 Study site

The present study was carried out during 2020 with in three different forests Compartment of Narendranagar Range lies at 30° 29' to 30° 3' N latitude and 78° 10' to 78° 53'E longitude from July to September. Narendranagar Forest Division comes between Alaknanda River in the east with the forest ranges of Rudraprayag Forest Division and by Mussoorie-Dehradun Forest division in the West. The present study area is highly occupied with *Pinus roxburghii* (Chir pine) with an area of 22977 ha along with *Quarcus-Rhododendron* community, *Shorea-mallotus* community and mixed dense forest community (Fig. 1; Table 1). Most of the resident of the area were Garhwali and small villages of Muslim. They live in the vicinity of the forest and depend on the forest for sustainability and livelihood.

Table 1 Meteorological data of the study area.

Months	**Temperature (C^o)**		**Rainfall (mm)**		**Humidity (%)**	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
July	37	17	322. 5	309.2	86	77
August	36	16	321. 1	287.1	85	72
September	29	15	167.6	101. 3	82	73

Source: Indian Meteorological Department.

Fig. 1 Bore-hole method for Oleoresin tapping in Narendranagar Forest Division, Uttarakhand.

2.2 Data collection

In present study, the morphological parameters were tested with relation to the Oleoresin production potential in Narendranagar Forest Division. 75 trees were randomly selected from all three compartments in each 25 trees was further divided into three different classes Viz. HRY'S, MRY'S and LRY's for Oleoresin tapping. Further, *Pinus* forest was divided into different diameter ranges 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80 cm. We have recorded the diameter of the tree, bark thickness, Needle thickness, needle length, needle colour and correlated all these morphological parameters with respect to the Oleoresin production potential. Hand driven drill bits of 1.00 inch, 1.25 inch were made for drilling bore-hole. The chemical stimulant was sprayed and small pipes were fixed tightly in the holes which are attached with the plastic bags on which the oleoresin collected. Various statistical Parameters like Analysis of variance (ANOVA) and Pearson correlation was done for statistical analysis by using the SPSS Version 20 (Statistical Package for Social Science) for morphological parameters recorded with respect to Oleoresin production. Pearson analysis was also done to see which parameters are closely associated with other.

2.3 Analysis data

In morphological characteristics, the following parameters were recorded to obtain the data.

2.3.1 Tree diameter and bark thickness

In Chir pine, DBH (1.37 m from the ground level) was measured for each tree with the help of tree caliper. It was measured at two points which were at right angle to each other and mean value of these two observations was recorded as diameter at breast height in centimeters. On the other hand, the bark thickness of the tree was measured in centimeters at breast height with the help of Swedish Bark Gauge. It was measured at four locations perpendicular to each other at breast height and the average of these was recorded as bark thickness.

2.3.2 Tree needle length, thickness and colour

Mature needles were collected from bottom, middle and top branches of the each tree. Thirty needles were taken from each section of the crown. The average length of these needles was measured with the help of simple scale and expressed in centimeters. On the other hand, mature needles which were used for determining length were also used for measurement of thickness with the help of Digital Vernier Caliper. The average diameter of thirty needles was computed in millimeters. For the colour of tree needles was compared with the colour chart of the Royal Horticultural Society, Kew, London. On the basis of colour differentiation they were categorized into three categories: Dark Green (DG, 136A), Green (G 137B), and Yellowish Green (YG, 145A)

3 Results

3.1 Oleoresin production potential in study area

A total of 75 trees of *Pinus* were selected for Oleoresin tapping in Narendranagar range with the help of Bore-hole method. The entire trees were divided into three different category viz. Low resin yielders (LRY's), Medium resin yielders (MRY's) and High resin yielders (HRY's). The overall production of Oleoresin was 54.21 ltr. in HRY's, 42.08 in MRY's and 26.97 ltr. in LRY's (Fig. 2). ANOVA showed the yield of Oleoresin production vary significantly in LRY'S, MRY'S and HRY's ($P>0.05$). Further ANOVA also revealed that Oleoresin production vary significantly in all the categories of Oleoresin production ($P<0.05$) with respective to the different diameter ranges Viz. 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80 cm involved in the study.

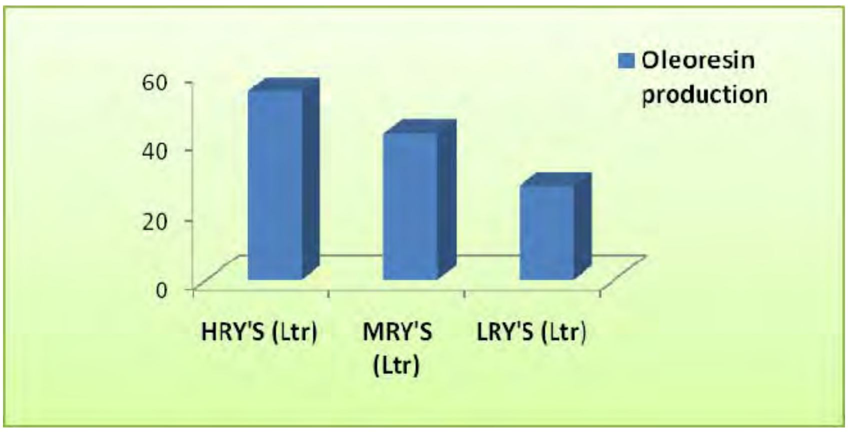

Fig. 2 Overall Oleoresin production in the study area.

3. 2 Biosynthesis of Oleoresin with respect to tree diameter

Tree diameter is one of the most important parameter involved in the resin tapping. Different diameter has showed different yield in earlier studies. Diameter is directly related to the oleoresin production in Chir pine. In present study, the analysis of the data reflected significant differences among different diameter classes of Oleoresin yield. Oleoresin production varied significantly among the entire diameter ranges viz. 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80 cm in all the selected trees (Fig. 3). We have also found significant differences in the diameter ranges 40-50 (12.99 ltr. = HRY'S, 28.30 ltr. in MRY'S and 7.27 ltr. in LRY'S) and 50-60 (10.82 ltr. = HRY'S, 3.2 ltr. in MRY'S and 6.05 in LRY'S) with maximum yield of Oleoresin in Chir pine (Tables 2-4).

Table 2 Oleoresin production potential in HRY tees.

Tree Diameter (cm)	**Tree Number**	**Height (cm)**	**No. of Bore-hole**	**Crown (cm)**	**Tree Age (cm)**	**Total Yield**
30-40	T- 01	22	4	450	35	3.13
40-50	T- 02	23	4	600	40	4.02
50-60	T- 03	28	4	450	53	2.43
40-50	T- 04	23	4	500	38	3.41
60-70	T- 05	30	5	602	60	2.57
30-40	T- 06	18	2	706	30	2.76
50-60	T- 07	18	5	500	50	2.32
50-60	T- 08	22	7	458	55	4.43
40-50	T- 09	20	4	500	40	1.51
60-70	T- 10	26	4	605	55	1.45
30-40	T- 11	18	3	410	35	1.06
50-60	T- 53	32	4	490	50	1.64
40-50	T- 60	41	4	570	49	2.59
70-80	T- 16	25	6	500	75	1.39
40-50	T- 19	32	5	850	45	1.46
60-70	T- 20	20	5	500	60	1.55
40-60	T- 26	29	4	680	42	1.84
60-70	T- 27	30	5	680	65	2.14
60-70	T- 28	28	4	710	62	1.73
20-30	T- 59	17	3	390	31	1.75
40-50	T- 60	41	4	570	49	2.09
50-60	T- 64	40	4	700	50	1.67
30-40	T- 67	28	4	306	32	1.99
30-40	T- 77	28	5	900	38	1.61
50-60	T- 92	37	5	805	50	1.67
	Total					**54.21**

Data of best 25 trees of Chir pine in Narendranagar range (P>0.05).

Table 3 Oleoresin production potential in MRY tees.

Tree Diameter (cm)	**Tree Number**	**Height (cm)**	**No. of Bore-hole**	**Crown (cm)**	**Tree Age (cm)**	**Total Yield**
40-50	T- 28	18	3	200	45	1.8
60-70	T- 38	20	5	500	70	1.2
40-50	T- 41	20	5	300	45	1.6
40-50	T- 55	17	4	200	40	1.6
40-50	T- 77	19	4	500	45	1.2
40-50	T- 79	20	6	300	40	1.4
30-40	T- 131	17	4	600	40	1.12
40-50	T- 139	17	5	600	45	2.15
40-50	T- 147	19	6	1000	50	2.3
40-50	T- 200	20	6	700	45	1.4
40-50	T- 245	20	6	1200	45	1.25
60-70	T- 253	20	6	1000	60	1.25
40-50	T- 261	18	6	700	45	1.75
40-50	T- 272	19	6	1000	45	1.35
40-50	T- 273	20	5	1000	45	1.45
30-40	T- 280	15	4	700	40	1.25
50-70	T- 286	20	7	1500	50	1.85
40-50	T- 288	16	6	1500	45	1.65
50-60	T- 296	20	7	1500	50	1.75
40-50	T- 381	20	6	1000	40	1.75
40-50	T- 383	20	6	1000	45	5.65
50-60	T- 406	19	5	1500	50	1.35
30-40	T- 577	20	4	600	40	1.25
40-50	T- 601	19	4	800	45	1.35
50-60	T- 627	20	8	1000	60	1.41
	Total					**42.08**

Data of best 25 trees of Chir pine in Narendranagar range (P>0.05).

Table 4 Oleoresin production potential in LRY tees.

Tree Diameter (cm)	**Tree Number**	**Height (cm)**	**No. of Bore-hole**	**Crown (cm)**	**Tree Age (cm)**	**Total yield**
50-60	T- 1	45	6	500	56	2.2
60-70	T- 2	40	6	800	50	1.79
60-70	T- 3	40	5	1000	55	1.65
40-50	T- 4	45	4	900	30	0.69
60-70	T- 6	50	6	900	52	0.55
40-50	T- 7	35	5	950	30	0.44
50-60	T- 10	45	5	700	40	0.54
40-50	T- 12	35	5	800	30	2.54
30-40	T- 15	35	4	500	25	0.44
40-50	T- 16	40	4	500	25	1.62
40-50	T- 17	40	5	400	25	0.53
40-50	T- 18	35	5	650	20	0.74
60-70	T- 19	40	5	500	50	0.32
30-40	T- 20	20	3	400	30	0.78
40-50	T- 21	30	5	500	35	0.71
30-40	T- 22	30	5	400	40	0.42
30-40	T- 23	35	3	550	25	0.94
50-60	T- 25	30	5	400	40	1.02
30-40	T- 29	40	4	750	30	1.3
50-60	T- 30	45	6	1200	50	1.06
50-60	T- 37	50	5	1050	40	1.16
60-70	T- 43	45	5	350	55	1.32
50-60	T- 53	45	5	1000	50	1.13
30-40	T- 54	35	3	500	30	1.04
30-40	T- 56	45	3	600	30	2.04
	Total					**26.97**

Data of best 25 trees of Chir pine in Narendranagar range (P>0.05).

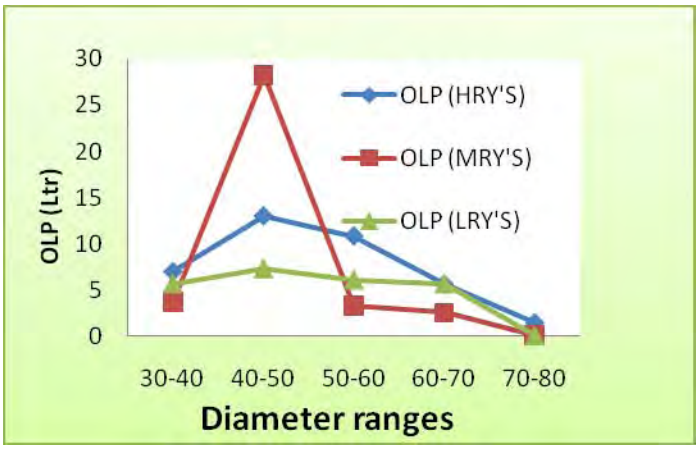

Fig. 3 Diameter ranges contributed Oleoresin production (OLP = Oleoresin production).

3.3 Biosynthesis of Oleoresin with respect to needle thickness (mm)

Sometime the morphological parameters are also helpful in determining the selection of tree for Oleoresin tapping. Variation in needle thickness also play important role and has been recorded with the direct effect on yield. Since environmental factors are helpful in determining the tree selection for resin tapping so the thickness parameter can also be observed. In present study, we have recorded the varied thickness of needle and divided the trees into LRY, MRY and HRY on the basis of Oleoresin production. The thickness of the needle in various classes of Oleoresin was presented in Table 5. It was observed from the present study that the average thickness of needle was recorded for HRY's, MRY's and LRY's trees with 14.717 mm, 15.615 mm and 16.123 mm respectively. For LRY trees, maximum thickness of needle was recorded for tree T- 22 (0.694 mm), for MRY tree: T- 10 and T- 131 (0.693 mm) whereas for HRY, T- 5 (0.706 mm) has been recorded with maximum thickness of needle. ANOVA showed the Oleoresin production vary significantly in LRY'S (Sig.= 0.620, P>0.05), MRY'S (Sig.=0.69, P>0.05), and HRY's (Sig.=0.092, P>0.05) with respect to the bark thickness (Fig. 4).

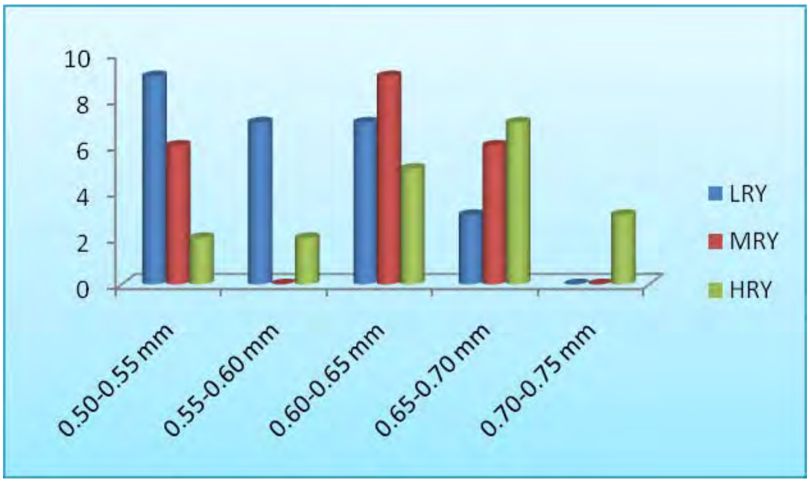

Fig. 4 No of trees in different thickness ranges of needle in LRY, MRY and HRY.

Table 5 Needle thickness (mm) of low, medium and high Oleoresin yielders.

Sr. No.	Tree No. of LRY	LRY	Tree No. of MRY	MRY	Tree No. of HRY	HRY
1	T- 1	0.656	T- 28	0.531	T- 1	0.712
2	T- 2	0.567	T- 38	0.556	T- 2	0.742
3	T- 3	0.598	T- 41	0.653	T- 3	0.675
4	T- 4	0.511	T- 55	0.643	T- 4	0.697
5	T- 6	0.523	T- 77	0.624	T- 5	0.706
6	T- 7	0.637	T- 79	0.685	T- 6	0.634
7	T- 10	0.611	T- 131	0.693	T- 7	0.651
8	T- 12	0.543	T- 139	0.534	T- 8	0.587
9	T- 15	0.502	T- 147	0.635	T- 9	0.557
10	T- 16	0.587	T- 200	0.656	T- 10	0.642
11	T- 17	0.567	T- 245	0.645	T- 11	0.674
12	T- 18	0.555	T- 253	0.693	T- 53	0.634
13	T- 19	0.547	T- 261	0.531	T- 60	0.625
14	T- 20	0.513	T- 272	0.645	T- 16	0.631
15	T- 21	0.608	T- 273	0.641	T- 19	0.559
16	T- 22	0.694	T- 280	0.658	T- 20	0.684
17	T- 23	0.687	T- 286	0.556	T- 26	0.692
18	T- 25	0.612	T- 288	0.674	T- 27	0.636
19	T- 29	0.579	T- 296	0.675	T- 28	0.713
20	T- 30	0.534	T- 381	0.636	T- 59	0.621
21	T- 37	0.691	T- 383	0.678	T- 60	0.704
22	T- 43	0.557	T- 406	0.623	T- 64	0.586
23	T- 53	0.643	T- 577	0.643	T- 67	0.611
24	T- 54	0.563	T- 601	0.564	T- 77	0.573
25	T- 56	0.632	T- 627	0.543	T- 92	0.577

P>0.05, LRY'S(Sig.=0.620,), MRY'S (Sig.=0.69), and HRY's (Sig.= 0.092).

3. 4 Biosynthesis of Oleoresin with respect to needle length (cm)

In earlier studies, while selecting the tree for tapping, needle length was also considered. Needle and cone characteristics might be a useful indicator of resin yield in various breeding program. We have recorded that different needle length at the time of data collection and divided the Oleoresin classes into HRY, MRY, LRY. The length of the needle in various classes of Oleoresin was presented in Table. It was observed from the present study that the average length of needle was recorded for HRY's, MRY's and LRY's trees with 545.62 cm, 576.79 cm and 600.93 cm respectively. For LRY trees, maximum length of needle was recorded for tree T- 18 (22.89 cm), for MRY tree: T- 253 (24.06 cm) whereas for HRY, T- 2 (25.24 cm) has been recorded with maximum length of needle (Table 6; Fig. 5). ANOVA showed the Oleoresin production vary significantly in LRY'S (Sig.= 0.436, P>0.05), MRY'S (Sig.=0.748, P>0.05), and HRY's (Sig.=0.460, P>0.05) with respect to the needle length.

Table 6 Needle length (cm) of low, medium and high oleoresin yielders.

Sr. No.	Tree No. of LRY	LRY	Tree No. of MRY	MRY	Tree No. of HRY	HRY
1	T- 1	21.13	T- 28	21.34	T- 1	24.64
2	T- 2	22.12	T- 38	21.65	T- 2	25.24
3	T- 3	22.27	T- 41	23.44	T- 3	24.65
4	T- 4	20.25	T- 55	23.34	T- 4	24.34
5	T- 6	20.4	T- 77	23.26	T- 5	24.56
6	T- 7	22.10	T- 79	23.78	T- 6	23.55
7	T- 10	21.98	T- 131	23.84	T- 7	23.76
8	T- 12	20.88	T- 139	21.87	T- 8	24.12
9	T- 15	20.17	T- 147	23.12	T- 9	23.54
10	T- 16	22.08	T- 200	23.54	T- 10	23.62
11	T- 17	21.98	T- 245	24.05	T- 11	24.27
12	T- 18	22.89	T- 253	24.06	T- 53	23.57
13	T- 19	22.71	T- 261	22.18	T- 60	24.23
14	T- 20	20.34	T- 272	23.43	T- 16	23.47
15	T- 21	21.80	T- 273	23.34	T- 19	23.23
16	T- 22	22.34	T- 280	23.48	T- 20	24.34
17	T- 23	23.05	T- 286	23.07	T- 26	24.38
18	T- 25	22.75	T- 288	24.00	T- 27	24.12
19	T- 29	21.89	T- 296	23.48	T- 28	24.68
20	T- 30	20.45	T- 381	23.37	T- 59	23.54
21	T- 37	22.78	T- 383	23.34	T- 60	23.45
22	T- 43	22.90	T- 406	23.14	T- 64	24.32
23	T- 53	22.41	T- 577	23.46	T- 67	24.11
24	T- 54	21.82	T- 601	21.45	T- 77	23.34
25	T- 56	22.13	T- 627	21.76	T- 92	23.86

P>0.05.

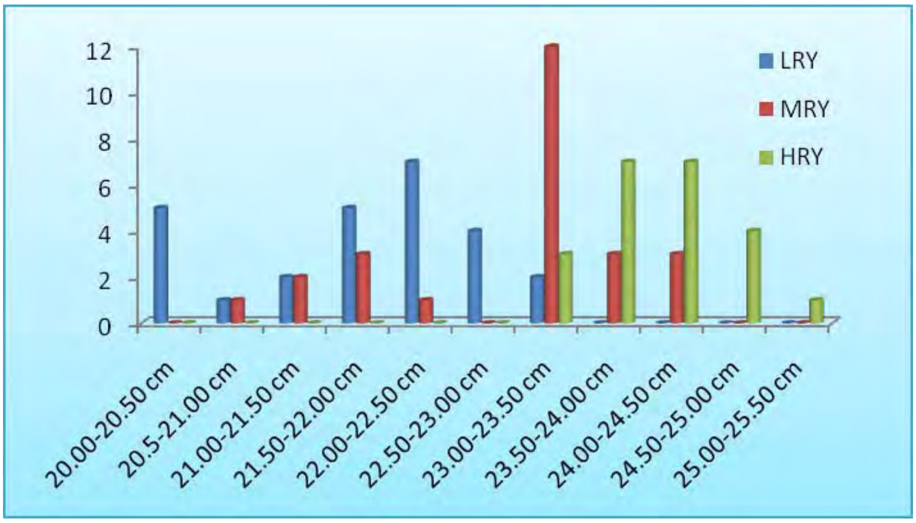

Fig. 5 No. of trees in different ranges of needle length in LRY, MRY and HRY.

3. 5 Biosynthesis of Oleoresin with respect to with needle colour

In present study, we have also recorded the colour of the needle. The trees having green (137 B) needle colour, the observed value was found to be more than expected value in high Oleoresin yielding trees and less in medium and low yielding classes. The trees with yellowish-green (145 A) needles had lesser number than expected in high and medium resin yielding classes, but in low resin yielding classes the observed value was found to be more than expected value. The effect of needle colour on oleoresin yielding potential of trees has been observed in the following descending order- Dark green (136 A) > Green (137 B) > Yellowish green (145 A).

3. 6 Biosynthesis of Oleoresin with respect to bark thickness (cm)

In present study, the thickness of bark was also measured and bark measurement for each tree was divided into three different Oleoresin classes Viz. HRY's, MRY's and LRY's. The bark thickness in various classes of Oleoresin was presented in Table. It was observed from the present study that the average thickness of bark was recorded for HRY's, MRY's and LRY's trees with 59.12 cm, 61.42 cm and 66.11 cm respectively. For LRY trees, maximum thickness of bark was recorded for tree T- 54 (3.30 cm), for MRY tree: T- 28 (3.15 cm) whereas for HRY, T- 60 (3.22 cm) has been recorded with maximum thickness of bark (Table 7; Fig. 6). ANOVA showed the Oleoresin production vary significantly in LRY'S (Sig.=0.530, P>0.05), MRY'S (Sig.=0.579, P>0.05), and HRY's (Sig.=0.853, P>0.05) with respect to the bark thickness.

Table 7 Bark thickness (cm) of low, medium and high oleoresin yielders.

Sr. No.	Tree No. of LRY	LRY	Tree No. of MRY	MRY	Tree No. of HRY	HRY
1	T- 1	2.00	T- 28	3.15	T- 1	3.10
2	T- 2	2.60	T- 38	2.85	T- 2	3.03
3	T- 3	2.50	T- 41	3.10	T- 3	2.60
4	T- 4	3.40	T- 55	2.50	T- 4	2.50
5	T- 6	3.20	T- 77	2.80	T- 5	2.66
6	T- 7	2.21	T- 79	2.30	T- 6	2.68
7	T- 10	2.90	T- 131	1.75	T- 7	2.50
8	T- 12	2.20	T- 139	3.25	T- 8	1.85
9	T- 15	2.12	T- 147	2.40	T- 9	2.80
10	T- 16	2.80	T- 200	1.85	T- 10	2.25
11	T- 17	2.23	T- 245	2.15	T- 11	2.30
12	T- 18	1.75	T- 253	1.90	T- 53	2.60
13	T- 19	1.90	T- 261	3.35	T- 60	2.80
14	T- 20	2.15	T- 272	2.20	T- 16	2.30
15	T- 21	2.70	T- 273	2.94	T- 19	3.20
16	T- 22	1.70	T- 280	1.80	T- 20	2.50
17	T- 23	1.80	T- 286	2.40	T- 26	2.40
18	T- 25	2.10	T- 288	2.10	T- 27	2.70
19	T- 29	2.50	T- 296	1.75	T- 28	3.04
20	T- 30	2.16	T- 381	2.80	T- 59	2.30
21	T- 37	1.90	T- 383	1.90	T- 60	3.22
22	T- 43	2.10	T- 406	2.25	T- 64	2.40
23	T- 53	2.30	T- 577	2.40	T- 67	2.90
24	T- 54	3.30	T- 601	2.70	T- 77	2.36
25	T- 56	2.60	T- 627	2.83	T- 92	3.12

P>0.05.

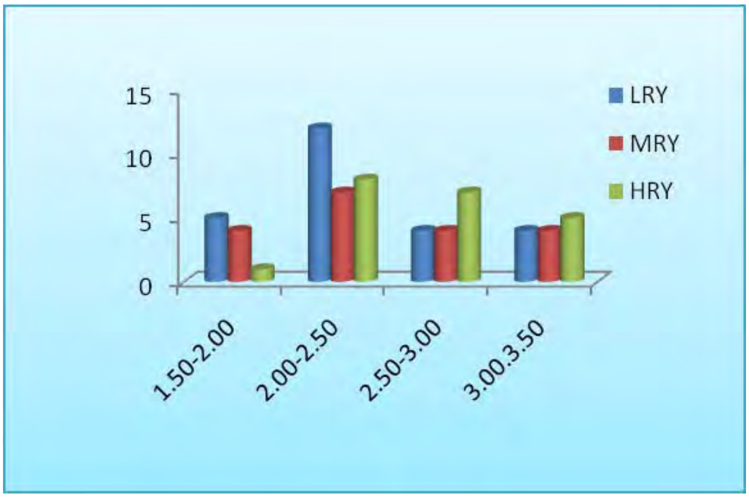

Fig. 6 No. of trees in different ranges of bark thickness in LRY, MRY and HRY.

4 Discussion

Oleoresin obtained from pine is one of the oldest natural products used by human being at large scale as they used it for lighting and to seal as well as to preserve the wooden ships (Snow, 1949) and in religious ceremony by the people of Greek (Langenheim, 2003). The Oleoresin production is highly affected by treatments for bore-hole diameter, depth and chemical stimulants (Lekha and Sharma, 2005; Kumar and Sharma, 2005). In the present study, the relationship of morphological characteristics like as diameter, needle colour, needle thickness, needle length and bark thickness with relation to oleoresin yield has been studied. There was significant differences were observed among various diameter classes for oleoresin yield. We have recorded significant differences in the diameter ranges 40-50 (12.99 ltr.=HRY'S, 28.30 ltr. in MRY'S and 7.27 ltr. in LRY'S) and 50-60 (10.82 ltr.=HRY'S, 3.2 ltr. In MRY'S and 6.05 in LRY'S) with maximum yield of Oleoresin in Chir pine. The increase in resin yield can be attributed to the greater volume of resinous woody tissue, thus having more number of well developed resin canals. Ramified root system in bigger tress helps in absorption of more nutrients from the soil, which may enhance the quantity of Oleoresin in Chir pine. Our results are comparable with the study of Kaushal et al.,(1983), Kaushal and Sharma (1988), Murtem (1998) and Lekha and Sharma (2005) in Chir pine. The yield of Oleoresin decreases as the diameter decreases and increases with diameter upto a certain diameter class In present study, 40-60 cm diameter has been recorded with maximum yield of Oleoresin production. Our results are also similar with the study of Chaudhari et al. (1992), in Chir-pine, in *Pinus pinea* by Magini, 1958, in *P. palustris* by Filho and Garrido (1984).

In present study, the number bore holes also showed huge differences in terms of Oleoresin Production. In first bore-hole, the highest Oleoresin yield is obtained whereas the lowest Oleoresin yield is recorded from third- six number of bore hole. It may due to the long duration period of resin flow for first bore hole and less duration period for third bore hole. Our results are comparable with the study of Hodges and Johnson (1997) in Slash pine, Rawat (2000), and Lekha and Sharma (2005) in Chir pine. There were significant results were recorded in oleoresin production while observing the relationship of needle colors, thickness to the yield of Oleoresin. In Chir pine, two types of branches, long shoots and dwarf shoots or branches of limited growth are found. Dwarf shoots arise in the axils of scale leaves which are green in the beginning and later turn brown. The scale leaves in Chir pine help in the conservation of moisture. Dwarf shoots bear three needles normally remain on the tree for one or half year which are triquetrous, acicular and help in photosynthesis. All needle colour except yellowish-green (145 A) has given higher oleoresin yield. The dark green (136 A) color needles has registered highest oleoresin yield followed by green (137 B) colored needles. The possible reason for high resin yield in dark green colour needles may be the higher rate of photosynthesis, which leads to greater formation of resinous exudates. The present study are similar to the study of Nevzorov (1975), who has revealed that trees of high resin yield have dark green needles. Khosla et al. (1988) has also reported that the dark green and green coloured needles are more productive in respect of timber yield, while yellow-green and yellow types have been recommended for higher pulp and turpentine oil yield. Similarly, Singhal (1997); Murtem (1998) and Lekha (2002) have noticed that all needle colours, except yellow-green colour register high resin yield in association with bole form in Chir pine .Previous name of Chir pine was *Pinus longifolia*, which indicates presence of long needles in Chir pine. The results showed needle length and needle thickness have shown significant variation among various high resin yielders (HRY's), medium resin yielders (MRY’s) and low resin yielders (LRY’s). HRY's have recorded more needle length, needle thickness and bark thickness as compared to MRY’s and LRY’s. Mathauda (1956), while studying the stands of *Pinus roxburghii* on the basis of different characteristics has revealed that the average length of needles for high resin yielding stands is little more than that for the very low yielders. Similarly, Sagwal (1982) has also reported variation in needle length of Chir pine from site to site and tree to tree. Fowler and Morris (1977) have also observed significant variation in the needle length both within species and within an individual.

Bark of *Pinus roxburghii* is dark-grey, deeply fissured, exfoliating in rough longitudinally elongated plates. The cork of bark can be used as a cheap insulating material. Bark thickness of wood has shown significant variation among various selected HRY's, MRY’s and LRY trees. Toda et al. (1994) have reported that variation of bark thickness and fissures varies with tree age. This parameter is dependent upon the age of the tree; hence variability for bark thickness in the selected HRY's, MRY’s and LRY trees is noticed.

Several million people worldwide depend on non wood forest products (NWFP) for their subsistence, food security, health care and cash income. Most of the people residing in the vicinity of forests rely heavily on NWFP’s. Several NWFP provide raw materials for further processing in small-scale enterprises and offer opportunities for employment and income generation. Some NWFP are important raw materials for industry and enter global trade. Gums, resins and latexes are used in various food and pharmaceutical products and several other technical applications. Oleo-resins obtained from pine and other trees are used in wide range of products including medicines, paints, varnishes, paper, adhesives, printing inks, rubber compounds and surface coatings (Anonymous, 1999).

5 Conclusion

Chir pine is an important species of *Pinus* which showed huge quantity of production. The yield of oleoresin varies considerably within the species. The present study showed positive relation with number of factors such as diameter, growth rate, tree crown, inherited capacity of individuals, periodicity, tapping methods, stimulants used and width of the blaze used. It was also observed from study that diameter ranges 40-50 (12.99 ltr.=HRY’S, 28.30 ltr. in MRY’S and 7.27 ltr. in LRY’S) and 50-60 (10.82 ltr.=HRY’S, 3.2 ltr. in MRY’S and 6.05 in LRY’S) with maximum yield of Oleoresin in Chir pine. It was also recorded that quantity also has increases in Bore-hole method as compared to the old cup and lip and Rill method. Presence of vast natural variability is a characteristic feature of forest tree species. Good gains can be achieved in oleoresin yield by selection of high resin yielders with desirable traits. Thus, the present research involving selection of best high oleoresin yielding trees that may help a forester to maximize the net oleoresin productivity of a Chir pine forest.

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