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Production and Cost of Chir-Pine Resin Tapping by Bore-Hole Method in Narendranagar Forest Division

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ABSTRACT

Oleoresin is a non-timber forest product of Pine around the world. Oleoresin is an abundant source of terpenes which generally has two major fractions namely turpentine and rosin. Turpentine is a volatile fraction whereas rosin is a solid fraction. Terpenes have great potential and conventional uses. The present study was conducted to investigate the production and cost of chir-pine resin tapping by the Bore-Hole method in the Narandrangar forest division. The borehole method involves the drilling of holes in the stem of Pinus, spraying the chemical stimulants like sulphuric acid, nitric acid, and ethephon, and installation of an apparatus on which oleoresin is collected. We have selected the three compartments of Narendrangar forest division viz. Udkhanda Compartment No. 13, Fakot Compartment No. 2, and Advani Compartment No. 1 with a total of 240, 137, and 683 trees of Pinus with varied diameter ranges of 70-80 cm, 60-70 cm, 50-60 cm, 40-50 cm, 30-40 cm, and 20-30 cm, in July, August, and September. The total oleoresin production was 162.60 ltr in Udkhanda, 56.48 ltr in Fakot, and 241.95 ltr in Advani. It was observed that 50-60 cm and 40-50 cm contributed the maximum yield with 15.55 ltr and 14.52 ltr of oleoresin in all three months whereas in Fakhot and Advani, 40-50 cm and 50-60 cm diameters contributed the maximum oleoresin production with 8.96 ltr, 7.57 ltr, 33.52 ltr, and 8.56 ltr yield. Further, our results also showed that the production of oleoresin varied significantly in the bore-hole method with 8.36 ltr per tree as compared to the rill method with 2.36 ltr in three months. The purity of yield also enhanced the rate of oleoresin which can be concluded that the bore-hole method can be implemented in all other forest divisions of Uttarakhand for sustainability and livelihood.

Keywords: *Bore-hole, Oleoresin, Pinus, Narendranagar, Diameter ranges*

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INTRODUCTION

Pinus roxburghii is an important plant species from India that covers an area of 8900 km^2 (Sharma, 2002; Lange *et al.,* 2022). It is grown in Jammu and Kashmir, Himachal, Uttarakhand, and West Bengal. It is generally found at an altitude of 450-2300 above mean sea level in Uttarakhand. In Uttarakhand, It covers an area of 412,000 ha whereas in Himachal Pradesh 1,36000 ha (Anonymous, 1990).

The borehole method involves drilling holes in the stem of *Pinus,* spraying chemical stimulants like sulphuric acid and Ethephon, and installing an apparatus on which oleoresin is collected. After drilling the hole with a hand driver borer, polythene bags are attached for the collection of Oleoresin. There is no damage on the merchantable part of *Pinus* as the holes are near ground level resulting in less damage to the bark and cambium. The derivatives of Oleoresin are widely used in food industries, pharmaceuticals, cosmetics, and various industries that manufacture different products like varnishes, paint, aroma and flavor, food additives, cleaners, insecticides, and disinfectants (Swift, 2004; Liu *et al.,* 2022). Oleoresin from Pine has been a widely used natural product by humans since ancient times. In ancient times, it was used in lighting, sealing, and in preserving wooden ships. Oleoresin obtained through the Borehole method is generally free from wastes and unnecessary particles. The rosin looks white whereas dark yellow in the traditional rill method. It was also observed that a higher content of turpentine (32.3%) along with low ash content was observed in the borehole method. This method is new and highly standardized which involves the maximum number of resin ducts to open so large production, and improved quality can be obtained. It was observed from various studies that, tree crown, time of tapping, diameter growth rate, various environmental factors, stimulants, depth of boreholes, and diameter in pine affect the cost and oleoresin production (Verma & Pant, 1978; Hodges, 1996).

Bore-hole vs Rill method

In recent times, new complementary products have been obtained from the plants by various scientific technologies through proper microbiological and pharmacological based study (Akash *et al.*, 2020a). Plants provide various nutraceuticals, food supplements, nutraceuticals, and different pharmaceuticals that have huge efficacy in disease treatment (Akash *et al.,* 2020b). It is imperative for the new generation to scientifically explore floral diversity, design constructive strategies for sustainable utilization of forest-based products, and conservation of forest flora (Mir *et al.*, 2017). On the other hand, using the plants in an unsustainable manner led to the natural extinction of the species in different areas of the globe (Sharma *et al.*, 2021). Oleoresin is the oldest NWFP used by

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human beings on a large scale for lighting (Snow, 1949), and in religious ceremonies by the people of Greece (Langenheim, 2003). The major causes of the decline of *Pinus* sp. were unscientific methods of tapping and frequent fire in the chir-pine forests which has caused heavy mortality of the trees. So it becomes imperative to search for an alternative. The high international demand for oleoresin has transformed the pine resin industry into a profitable business (Bohlmann & Keelong, 2008; da Silva Rodrigues *et al.*, 2011; Rakhshan *et al.,* 2021). Unlike other crops, the pine forest does not require any care, investment, or maintenance and it can be grown in high draught or low fertile soil. French cup and lip method was famous for resin tapping in old times which deteriorated wood due to the deep cut on the tree which led to the breaking of trees. So, the Rill method came to a height to overcome this problem use but failed because a new rill was made after four days or at a weekly interval. Further excessive amounts of chemicals used in this method deteriorate resin quality and tree structure.

The borehole technique for resin tapping has been described by Hodges. In this method, firstly drilling of holes into wood takes place to open the resin ducts and oleoresin collected in a container. This method causes very little damage to the bark and cambium tissues. As soon as boreholes are covered by new cambium and bark growth. There is no damage on the bark of *Pinus* as the holes are near ground level resulting in less damage to the bark and cambium. Oleoresin obtained through the Borehole method is generally free from waster and unnecessary particles. The rosin looks white whereas dark yellow in the traditional rill method. This method has proved effective in the management and conservation of pine resources in India. Further, oleoresin obtained from this method is free from impurities resulting in the quality of turpentine, rosin, and other products manufactured from it being better and fetching higher market. In 1975-76, the production of oleoresin increased rapidly but it considerably decreased during 1990-91 up to 25,000 tons. The production was 5,000-30,000 tones during 1994-95 (Coppen & Hone, 1995). Studies also showed that the production increases greatly in the bore-hole method than in the rill method.

The present study was conducted to investigate the production and cost of chir-pine resin tapping by the Bore-Hole method in the Narandrangar forest division.

MATERIALS AND METHODS

The present study was conducted in 2020 within the Narendranagar Range of Narendranagar forest division, under Bhagirathi circle lies at 30°29' to 30°3' N latitude and 78°10' to 78°53' E longitude **(Figure 1)**. This forest division is located between the Alaknanda River in the east with the forest ranges of Rudraprayag Forest Division and by Mussoorie- Dehradun Forest Division in the West. Along with the Chir-pine, the area is occupied by *Shorea- mallotus, Quarcus- Rhododendron* community in which Chir-Pine has contributed 22977 ha. We have divided the forest of Chir-pine into diameter ranges of 70-80 cm, 60-70 cm, 50-60 cm, 40-50 cm, 30-40 cm, and 20-30 cm in three months of July, August, and September for assessment of cost and production of Oleoresin. Hand-driven drill bits of 1.00 inch, and 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 to the plastic bags on which the oleoresin collected. For quantitive assessment, we have applied Pearson correlation and ANOVA by SPSS Version 20.

Figure 1. Oleoresin tapping by Bore-hole method in Narendranagar forest division, Uttarakhand

RESULTS AND DISCUSSION

Total Oleoresin production in three months

About 240 trees of Chir-pine in Udkhanda Compartment No. 13, 137 in Fakot Compartment No. 2, and 683 in Advani Compartment No.1 were involved in Oleoresin tapping in

Narendranagar range. The total production was 162.60 ltr in Udkhanda, 56.48 ltr in Fakot, and 241.95 ltr in Advani **(Table 1)**. The production of Oleoresin varied significantly in all the studied diameter ranges of 70-80 cm, 60-70 cm, 50-60 cm, 40-50 cm, 30-40 cm, and 20-30 cm, in July, August, and September for selected trees. We have also recorded the data of the best 32 trees to determine the yield of oleoresin in the three compartments of the study area. In Uthkhanda compartment No. 13, the maximum yield was recorded in August with 43.06 ltr followed by 13.80 ltr in July and 5.49 ltr. in September whereas in Fakot compartment No. 2, severe variation was recorded in the yield with 24.59 ltr. in August and 3.95 ltr in September **(Tables 2-4)**. In Advani compartment No. 1, the maximum yield was obtained in August with a total production of 41.15 ltr and 9.00 ltr in September. Advani compartment No. 1 and Fakot compartment No. 2 were two areas where no oleoresin was recorded in July. Since the borehole method was first started in the Narendranagar range in July, so less production or nil yields were recorded in the study area. Results obtained from our study can be comparable with the study of Rai and Lekha (2013) in the Chir-pine forest of Himachal Pradesh. Similar studies were also carried out by Murtem (1998), Singhal (1996), and Kaushal and Sharma (1988) from different Chir-pine forests of India with positive results in terms of oleoresin yield. ANOVA from our result revealed that oleoresin production varies significantly in three compartments viz. Udkhanda, Fakot and Advani ($P > 0.05$) **(Table 5)**. Pearson correlation test revealed that oleoresin production of Udkhanda was positively correlated with Fakhot ($r = 0.99$), and Advani ($r = 0.99$) and negatively correlated with the three months ($r = -0.82$) whereas oleoresin production in Fakhot was positively correlated with Udkhanda ($r = 0.99$), Advani ($r = 0.99$) and negatively correlated with the three all months ($r = -0.77$). In the case of Advani, oleoresin production is positively correlated withUdkhanda ($r = 0.99$), Fakhot ($r = 0.99$), Advani ($r = 0.97$), and negatively correlated with the three months ($r = -0.85$). The oleoresin production in all three months (July, August, and September) was negatively correlated with Udkhanda ($r = -0.82$), Fakhot ($r = -0.77$), and Advani ($r = -0.85$) **(Table 6)**.

Table 1. Total Oleoresin production in the study area

Months	Advani (Ltr)	Fakot (Ltr)	Udkhanda (Ltr)
July	0.00	0.00	13.80
August	216.05	45.22	117.23
September	25.90	11.26	31.57

* Data from best trees of Chir-pine Viz. 240, 137, and 683 in the study area

Table 2. Oleoresin production in Udkhanda, compartment No. 13

Tree diameter (Cm)	Tree Number	Yield (Ltr) July	Yield (Ltr) August	Yield (Ltr) September
30-40	01	1.60	1.18	0.35
40-50	02	1.40	2.46	0.16
50-60	03	1.00	1.29	0.14
40-50	04	1.60	1.75	0.06
60-70	05	0.60	1.85	0.12
30-40	06	1.50	1.05	0.21
50-60	07	1.70	0.40	0.22
50-60	08	0.90	3.10	0.43
40-50	09	0.80	0.57	0.14
60-70	10	0.60	0.80	0.05
30-40	11	0.80	0.21	0.05
50-60	53	0.80	0.58	0.26
40-50	60	0.50	1.92	0.17
70-80	16	-	1.32	0.07
40-50	19	-	1.39	0.07
60-70	20	-	1.49	0.06
60-70	24	-	1.00	0.16
50-60	25	-	1.25	0.14
40-60	26	-	1.76	0.08
60-70	27	-	1.59	0.55
60-70	28	-	1.62	0.11
30-40	49	-	1.15	0.12
50-60	54	-	1.32	0.19
40-50	58	-	1.01	0.14
20-30	59	-	1.56	0.19
40-50	60	-	1.92	0.17
50-60	64	-	1.59	0.08
30-40	67		1.89	0.10
30-40	76	-	1.19	0.23
30-40	77	-	1.53	0.08
50-60	92	-	1.32	0.35
70-80	93	-	1.36	0.24
	Total	**13.80**	**43.06**	**5.49**

* Showing data of the best 32 trees of Chir- pine in the study area

Table 3. Oleoresin production in Fakot compartment No. 2

Tree diameter (Cm)	Tree Number	Yield (Ltr) July	Yield (Ltr) August	Yield (Ltr) September
50-60	01	-	1.35	0.85
60-70	02	-	1.17	0.62
60-70	03	-	1.00	0.65
40-50	04	-	0.68	0.01
50-60	05	-	0.10	0.030
60-70	06	-	0.20	0.35
40-50	07	-	0.40	0.04
50-60	08	-	0.30	0.03
40-50	09	-	0.10	0.03
50-60	10	-	0.50	0.04
40-50	11	-	0.20	0.05
40-50	12	-	2.50	0.04
30-40	13	-	0.10	0.03
40-50	14	-	0.20	0.03

30-40	15	-	0.40	0.04
40-50	16	-	1.40	0.22
40-50	17	-	0.50	0.03
40-50	18	-	0.70	0.04
60-70	19	-	0.30	0.02
30-40	20	-	0.60	0.18
40-50	21	-	0.65	0.06
30-40	22	-	0.40	0.02
30-40	23	-	0.90	0.04
50-60	25	-	1.00	0.02
30-40	29	-	1.20	0.10
50-60	30	-	1.02	0.04
50-60	37	-	1.12	0.04
60-70	43	-	1.30	0.02
50-60	53	-	1.00	0.13
30-40	54	-	1.00	0.04
30-40	56	-	2.00	0.04
30-40	74	-	0.30	0.07
	Total		**24.59**	**3.95**

* Showing data of the best 32 trees of Chir- pine in the study area

Table 4. Oleoresin production in Advani compartment No. 1

Tree diameter (Cm)	Tree Number	Yield (Ltr) July	Yield (Ltr) August	Yield (Ltr) September
50-60	04	-	1.00	0.10
40-50	28	-	1.60	0.20
60-70	38	-	1.00	0.20
40-50	41	-	1.40	0.20
50-60	47	-	1.00	0.10
40-50	55	-	1.40	0.20
40-50	77	-	1.00	0.20
40-50	79	-	1.20	0.20
30-40	131	-	1.10	0.02
40-50	139	-	2.00	0.15
40-50	147	-	2.20	0.10
60-70	169	-	1.10	0.10
40-50	177	-	1.10	0.10
40-50	200	-	1.30	0.10
40-50	245	-	1.10	0.15
60-70	253	-	1.10	0.15
40-50	261	-	1.70	0.05
40-50	272	-	1.20	0.15
40-50	273	-	1.30	0.15
30-40	280	-	1.10	0.15
50-70	286	-	1.70	0.15
40-50	288	-	1.50	0.15
50-60	296	-	1.60	0.15
40-50	381	-	1.60	0.15
40-50	383	-	0.65	5.00
40-50	390	-	1.00	0.02
50-60	406	-	1.20	0.15
40-50	418	-	1.10	0.10
40-50	493	-	1.10	0.15
30-40	577	-	1.20	0.05
40-50	601	-	1.20	0.15
50-60	627	-	1.40	0.01
	Total		**41.15**	**9.00**

* Showing data of the best 32 trees of Chir- pine in the study area

Table 5. Analysis of variance (ANOVA) between different sites of oleoresin production

		Sum of Squares	df	Mean Square	F	Sig.
Udkhanda	Between Groups	22.003	1	22.003	3.288	**0.144
	Within Groups	26.766	4	6.691		
	Total	48.769	5			
Fakot	Between Groups	9.275	1	9.275	1.263	**0.324
	Within Groups	29.373	4	7.343		
	Total	38.648	5			
Advani	Between Groups	9.830	1	9.830	1.389	**0.304
	Within Groups	28.311	4	7.078		
	Total	38.142	5			

*= Significant, ** = Non significant, **
[Significant (P<0.05), NS = Non significant (P>0.05)]

Table 6. Pearson correlation two-tailed test between different sites of oleoresin production

Correlations					
		Udkhanda	**Fakhot**	**Advani**	**Months**
Udkhanda	PC	0.96	0.99	0.99	-0.82
Fakhot	PC	0.99	0.67	0.99	-0.77
Advani	PC	0.99	0.99	0.97	-0.85
Months	PC	-0.82	-0.77	-0.85	0.66

* Correlation is significant at the 0.05 level (2-tailed).
PC = Pearson Correlation

Effect of diameter on Oleoresin production

The production of Oleoresin is highly influenced by the chemical stimulants used, bore-hole diameter, and depth (Kumar & Sharma, 2005; Lekha & Sharma, 2005). The oleoresin production is highly affected by treatments for borehole diameter, depth, and chemical stimulants (Kumar & Sharma, 2005; Lekha & Sharma, 2005). The diameter in all the parameters plays a significant role in oleoresin production **(Table 7)**. There is a significant difference has been observed in oleoresin production in different diameter ranges in the present study area. In all three compartments, Udkhanda has contributed 178.55 ltr of oleoresin followed by Advani (50.18

ltr) and Fakot with 28.54 ltr. A diameter range of 60-70 cm has contributed to the maximum oleoresin production with 125.44 ltr in Udkhanda, 7.88 ltr in Fakot, and 34.35 ltr in Advani by a diameter range of 40-50 cm. We have also recorded the seasonal variation in oleoresin production potential in different studied diameter ranges. In Udkhanda, 50-60 cm, and 40-50 cm contributed the maximum yield with 15.55 ltr and 14.52 ltr oleoresin in all three months whereas in Fakhot and Advani, 40-50 cm and 50-60 cm diameter contributed the maximum oleoresin production with 8.96,7.57 ltr and 33.52, 8.56 ltr yield. This could be due to the high number of resin ducts in the trees of these diameter ranges. Our results can be comparable with the study of Chaudhari *et al*. (1992), and Kaushal and Sharma (1988), who have reported the best yield of oleoresinin in these diameter ranges of *Pinus roxburghii*. ANOVA revealed that oleoresin production varied significantly in all three months ($P < 0.05$) respective to the different diameter ranges involved in the study.

Table 7. Diameter ranges contributed best to oleoresin production

Tree diameter (Cm)	Yield (Ltr) Udkhanda	Yield (Ltr) Fakot	Yield (Ltr) Advani 1
20-30	1.75	-	-
30-40	13.24	7.46	3.62
40-50	18.07	7.88	34.35
50-60	17.06	7.57	8.56
60-70	125.44	5.63	3.65
70-80	2.99	-	-
Total	**178.55**	**28.54**	**50.18**

Oleoresin production in Bore-hole and Rill method

Bore-hole techniques have huge advantages in terms of the Superiority of oleoresin as it is collected in a closed-packed container. In this, method, rosin and turpentine obtained are much better than the rill method and hence can be sold at great prices (Lekha & Sharma, 2005). We have made a comparison of Oleoresin production between these two methods in three compartments of Narendranagar forest division in three months which resulted in Advani, with the highest production of 3.03 ltr/per tree followed by 3.01 ltr/per tree in Udkhanda, and 2.32 ltr/per tree of oleoresin in Fakot. The production data of our result also show a positive and significant relation with the study of Rawat (2000) in *Pinus roxburhii,* McReynolds and Kossuth (1984) in *Pinus elliottii,* and Hodges and Johnson (1997) in *Pinus elliottii.*

Effect of chemical stimulant on oleoresin yield

In *Pinus, the* resin is produced and a complex network of radial and axial resin ducts is responsible for its storage and through which it flows (Vázquez-González *et al*., 2020). In the present study, chemical stimulants like sulphuric acid and nitric acid were sprayed simultaneously to increase oleoresin production. 213 ml sulphuric acid + 787 ml water and 370 ml Nitric acid + 630 ml water were prepared in a different container which was further used for the borehole. Although we didn't change the concentration of the chemical but recorded data with the same concentration of both the stimulants. It was also evident from the studies of Sharma and Lekha (2013), that adding sulphuric acid as a chemical stimulant has significantly increased the production of oleoresin. Increasing the concentration of sulphuric acid, the oleoresin yield is also increased. This might be because sulphuric acid increases the production by prolonging flow to reduce the turgescence of various epithelial cells due to tapping injury, preventing crystallization of resin ducts and formation of tylosiods (Kossuth, 1984; Haidar *et al.,* 2023). The increasing yield of oleoresin by using sulphuric acid has also been reported by Lohani (1984), Ribas *et al*. (1986), and McReynolds and Kossuth (1985). An alternative of Nitric acid and ethephon was also added as a chemical stimulant by Sharma and Lekha (2013) in which significant oleoresin yield was recorded in Himachal Pradesh with the highest 1780 g/hole/tree at the 10% ethephon + 20% H_2SO4 concentration. The study of McReynolds and Kossuth (1985) also recorded high oleoresin production in *Pinus Elliott* with 50% H_2SO4 + 10% ethephon while Vankaiah (1991), 5% ethephon + 20% H_2SO4 mixture in *Pinus roxburghii.* Further, it was also evident from various studies that resin yield varied across the season (Lombardero *et al*., 2000; Hood & Sala, 2015; Neis *et al*., 2018; Zas *et al*., 2020) which needs to be checked more.

CONCLUSION

Pinus roxburghii (Chir-pine) is an important source of oleoresin in Uttarakhand. It was concluded from our results that oleoresin production depends on the techniques used in tapping. The Bore-hole method can play a huge role in terms of high production, purity, and cost of resin. Further study also suggests that different concentrations of chemical stimulants can be used when the environmental conditions are unfavorable. Our study also showed that the production potential of oleoresin associated with the diameter of trees like 40-50 cm and 50-60 cm has made a significant contribution to yield. So as per the trail, we can select only those trees with diameter ranges of 40-60 cm which have great potential for oleoresin production. This will also ensure that no harm should be done to other Chir-Pine trees. The results also indicated that higher yield and good cost of resin tapping can be achieved by using the bore-hole as an alternate method along with managing the subset of *Pinus* trees based on different diameter classes.

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