Resin Tapping in CHIR PINE

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INTRODUCTION

Chir pine is the principal pine species occurring in India which provides resin on a commercial scale. Its distribution extends from 450m. to 1250m. in the lower Sivaliks and from 1050m. to 2250m. in the Himalayas. The total area under Chir forest is about 6,990,000 ha. distributed in J & K (1,58,800 ha), Himachal (1,15,400 ha), Punjab (12,800 ha) and U.P. (4,12,000 ha). Resin tapping forms an important forest industry in J & K, Himachal and U.P.

The Chir pine resin is of good quality and its products viz rosin, turpentine and pine oil find use in a variety of industries such as soap, paper sizing, camphor and other chemicals. On distillation, it yields on an average about 70% rosin and 17% turpentine. The constituents of turpentine are L-pinene 25%, d-B pinene 9.7%, terpine with carene 36.6%, L-terpene 1.7%, d-longifolene 20.30%. Besides these minute quantities of L-thugene, B-myrcene, L-limonene and terinolene have also been isolated.

Resin tapping is a labour intensive industry and has an important bearing on the economy of the local people. Its derivatives find wide applications in a variety of industries. Therefore a study of the factors influencing yield of resin is of utmost importance. A series of comprehensive studies on resin tapping were started in F.R.I. Dehradun, West Almora Division of Uttar Pradesh and elsewhere covering various aspects of resin tapping. The summary of findings of these experiments is given here.
CHAPTER I

RESIN CANAL SYSTEM IN CHIRPINE AND THE FLOW OF RESIN

In Chirp pine, the resin canal system includes vertical and horizontal resin canals with epithellium. The vertical canals are irregularly distributed and confined for the most part to the middle or outer portions of the ring. The frequency of the vertical canals varies from 21-33 per 100 sq.mm. and size from 204 $\mu$ to 260 $\mu$. The horizontal canals are smaller, solitary and inserted in the fusiform rays. The frequency varies from 44 to 60 per sq.mm. and the size from 45 to 59 $\mu$. The epithellium is 1-2 cells thick. Average diameter of the canal within a growth ring along the different radii as well as in different growth rings at same level shows considerable variation from 180 to 250 microns. However the average diameter of canal of 15-20 growth rings along 2 radii and height varies within narrow limits ranging from 204 to 230 microns. The size of the horizontal canals remains more or less constant throughout the tree.

Experiments done at F.R.I. indicate that frequency and size of canals undergo considerable change but the effect is confined to the wood formed after tapping. The maximum effect is immediately above the blaze and does not extend laterally. The frequency was found to increase up to 25 times while size decreases up to 60% of the normal in different trees. No correlation was found between the size and frequency of the vertical canals both before and after tapping and the variation in resin yield in individual trees.

Resin content of the Wood

The resin content of the wood has been studied by taking wood cores at different heights along the bole. The % of resin content on dry weight basis has been calculated by extracting resin from the core samples. The resin content varied from 4.4 to 5% up to a height of 6 m. and 5.4 to 6.0% above it the maximum being at a height of 9 m.

The Resin Flow Pattern

The observations on the daily yield of resin on a freshening cycle of 7 days with the standard method provide the trend of fall of yield from day to day during the weekly interval after freshening. The yield obtained in the 1st day after initial freshening forms
slightly more than 50% of the total yield obtained during the week. The % of yield on the 2nd day falls sharply and more gradually thereafter. 80-85% of the total resin yield during the week is exuded within the first four days of the week.

ii) To see trend of hourly flow of resin, 10 trees tapped on a standard freshening schedule of 7 days were observed for the hourly yield for two weeks.

The measurements of resin exudation were taken at the interval of one hour starting from 8.00 am in the morning till 6.00 pm. in the evening. It was found that resin exudation rises steadily from 10 am. and reaches maximum between 1-2 pm. and then drops down.
CHAPTER-II
FACTORS AFFECTING RESIN YIELD

Temperature, Rainfall and Humidity

The resin yield from Chirpine varies according to the season. In general, the yield increases during the summer season and falls with the approach of the rainy season. The yield during winter months is much less. Thus temperature and rainfall appear to influence the resin yield of Chirpine. The trend of variation in the resin yield with various climatic factors has been studied in the experimental resin tapping plots of F.R.I. and also cooperative experiments laid out in Punjab and Himachal Pradesh. In all these experiments, the standard Indian resin tapping technique with wood chipped blazes 10 cm. wide freshened 1.25 cm. at each freshening was followed. The freshening interval was 7 days.

The examination of trends in flow of resin with respect to the temperature, rainfall and humidity, only temperature shows markedly similar trend with the resin yield while in case of rainfall and humidity opposite or conflicting trends are seen in many cases. The peak period of resin yield is May to August at Dehradun (670m.) May to July at Chambari (823m.) and May to June or early July at Habrol and Benetin (1067m. and 1372 m. respectively). Thus season of peak resin yield varies considerably according to the elevation. There is time lag between the commencement of the freshening and production of resin yield normal to the locality. It is maximum during the month of May-June when the temperatures are the highest. In similar experiments conducted in U.P., it was noticed that the yield of resin showed a close parallel trend with average maximum temperature and the highest yield was found to coincide with the maximum temperature of over 80° F. with humidity less than 90%. The rise in humidity generally corresponded with the fall in resin yield. Low humidity with high temperature had tendency to increase the yield.

The rise in yield is fairly rapid during the initial tapping period. Maximum yields are obtained during May/June. The fall in latter part of the year is comparatively gradual.

The effect of climatic factor on resin yield was also analysed by regression technique to assess the factors having significant correlation with resin yield. The analysis indicates that among the various climatic factors temperature alone accounts for nearly 70% of variation in the resin yield. Soil temperature at 30cm, depth and the humidity are the other factors having significant effect on resin yield.

Evapo—Transpiration

A correlation of evapo-transpiration and resin yield was attempted and it was found that (i) factors like light intensity, cloudy days, suspended particles in the air and the soil moisture do influence the resin yield but as they are confined to shorter part of the resin tapping season their overall effect is negligible.

ii) There is definite relation between the resin yield and the evapo—transpiration. This can be expressed as

\[ \frac{Y}{ET} = K \]

the value of K varies with locality, seed origin and diameter class. (iii) Months having minimum evapo-transpiration of 110mm, yield major portion of resin of the year.
Viscosity and Resin Yield

The values of viscosity when plotted against the average value of ratio Y/ET showed that the resin yield in a tree is inversely proportional to viscosity. The average viscosity values were found to have an ascending trend starting from the highest resin yield class and trees and various provenances could be characterised for their resin yielding capacities by the viscosity values of resin. The average viscosity value of provenances, west of Chakrata were lower than those of east of Chakrata, East Almora being an exception. This indicated possible presence of two broad strains in the Chir pine.

Periodicity in Yield

The formation of resin being a physiological process, an attempt was made to test the periodicity in resin yield. The probability of a cycle of 2 to 6 years varied from 0.50 to 0.60 and a maximum probability of 0.6 was indicated for a cycle of 5 years. From the analysis, a periodicity of 2-6 years appears to be inherent.

Tree Characters Influencing Yield

The correlation of resin yield with tree characters such as seed origin, diameter, size and twist etc. were studied in a number of experiments. Trees of 9 seed origins viz Chakrata, Kangra, Lansdowne, Hazara, East Almora, Darjeeling, Rawalpindi, Nainital and Dehradun were studied. The Rawalpindi and Chakrata origins were found to be the best and the Darjeeling the worst. The variation in yield between the highest and the lowest was almost twice. Thus seeds origin appears to exercise very significant effect on resin yield and by proper selection of seed origin, the yield can be substantially enhanced.

Individual Variation in Yield

Individual trees of the same seed origin also show wide difference in yield. In F.R.I. Chir plantations, trees of the same age and growing apparently under similar conditions show wide variation in resin yield.
The variation between the lowest and highest being as much as 6 times. The trees can be classified as poor resin yielder and high resin yielder on the basis of their resin exudation, though there was hardly any difference in their morphological characters. It is suggestive of strong genetic influence on resin producing capacity of trees.

Diameter and Resin Production

In U.P. experiments, the relation between diameter and resin yield has been worked out from the yield data of 471 trees varying from 30 cm. to 60 cm. diameter tapped by standard method. A marked correlation of yield with diameter was found, the region of maximum yield being 37.5-47.5 cm. diameter size.

Crown size and Resin Production

The yield of resin was studied vis-a-vis the crown size of each stem recorded in three qualitative classes (a) Above average (b) average (c) below average on the basis of average crown size for the particular diameter class. Generally reduction in yield was noticed with the reduction of crown size but there were exceptions to this, most probably due to small number of observations available in each case.

Crown Density and Resin Production

Individual tree resin yield data were studied for the three crown classes viz above average, average and below average but the differences between the three crown density classes were not found significant.
Crown Height and Resin Yield

Variation in the resin yield with crown height was studied from the yield figures of 254 trees tapped by the standard method in Kaligad block (U.P.) during 1963. The trend of yield in various girth classes showed a general increase in yield with respect to increase in crown ratio though in some classes the trend was not regular. This could be ascribed to the smaller number of observations in these classes and the inherent variation in resin yield between trees becomes pronounced when number of observations are limited.

Twist and Resin Production

Studies at F.R.I. Dehradun on the correlation of resin yield with twist of the trees indicate a tendency for the yield to rise as the degree of twist increases. However statistical analysis showed that the differences either on the basis of individual origins or all the origins taken together were not significant at 5% level of probability.

Minimum size of Trees which can be Tapped for Resin

To find out the effect of tapping trees below 90 cm. girth, both on mortality due to tapping and the yield, experiments, were conducted in the demonstration area of F.R.I. in 1965. 180 trees were selected such that each of the 3 diameter classes below 30 cm. i.e. 15-20 cm., 20-25 cm. and 25-30 cm. were equally represented. Light tapping was carried out for three years with the standard method of tapping i.e. weekly freshening with the 12.5 mm. rise and the depth of channel not exceeding 12.5 mm. Weekly yields from trees were recorded correct to a gram. Mortality of trees in various diameter class was also recorded for the tapped trees as and when it occurred.

The yield figures of the different diameter classes show a regular fall in yield with decrease in the diameter class. A fall of about 10% in yield was noticed with a decrease of 3 cm. dia. It was also noted that while the yield in lowest diameter class show a gradual falling off from year to year, no such fall appears in the higher diameter classes where on the other hand, yield show an increasing trend. This indicates that tapping of trees 15-20 diameter class affects the sustained production of resin adversely. As regards mortality it was 14.5% in the lowest diameter class in the first year which increased to 33-35% in the third year of the tapping. During 3 year period of tapping, it was about a third of mortality in the lowest diameter class while there was no mortality in 25-30 cm. diameter class.

During 1966-1970 experiments were laid out at Kaligad and Sauni Block in W. Almora Division to
find out the minimum tappable diameter class, channel width and depth.
Diameter class - 15-20 cm., 20-25 cm. and 25-30 cm.
Channel with 5 cm., 7.5 cm. and 10 cm.
Channel depth 1.875 cm. (3/4) and 3.75 (1.5)

Diameter class 25-30 cm. and width 7.5 cm. and 10 cm. were found to be the best for resin yield. The difference in 7.5 cm. and 10 cm. was not significant. Similarly difference in channel depth 1.875 cm. and 3.75 cm. was not found significant.

Yield in Relation to the Number of Blazes

For studying the variation of yield by increasing the number of blazes both along the stem vertically and horizontally, 28 trees of comparable diameter were taken in F.R.I. and divided into 7 groups. In each tree of a group of 4 trees, one two, three and four blazes of standard size were made along the periphery. In the remaining 3 groups one had two blazes vertically along the bole, the other three and the third, 4 blazes vertically along the bole. The resin yield was recorded for 5 years i.e. 1962 to 1965.
It was found that when the number of blazes along the periphery is increased, the yield increases up to 3 blazes and drops down when the number of blazes is increased to 4. With an average girth of about 100 cm. of the experimental trees, exceeding the area by more than one third of the circumference, affects the yield sharply. As regards vertical blazes, the yield for 2 and 4 blazes show proportionate increase in yield while the yield under 3 blazes is almost the same and slightly lower than 2 blazes.

Resin Yield and the Surface Area Tapped

The correlation of area tapped to resin yield was studied in U.P. during 1963 and 1964. In one set, 18 trees were selected and three channels of 5cm, 10cm. and 15cm. width were made. Channels were separated by 10cm. wide bark at the same height on the stem and on the same aspect but the orientation of channel with respect to each other was randomised to even out difference due to aspect. In another set, channel width was kept at 1/10th, 1.5/10th and 2/10th of the girth and two variations of height of refreshenings i.e. 1cm. and 2cm. were adopted. In each treatment there were 40 trees and total 240 trees in this set.

In the 1st set, highly significant correlation between area tapped and resin yield was found. The safe limit of rate of increase of yield by an increase of 5 cm. width in channel was 614 gm per tree. In the second set, with 1 cm. height of freshening, increase in yield due to increase in width was linear.
but with 2 cm. freshening, yield increases proportionally up to 1.5/10th of width and for higher width, the same ratio is not maintained.

Influence of Method of Fixing Lips on Resin Yield

An experiment was laid out at F.R.I. during 1958 and 1959 to study the performance of nailed lips vis-a-vis wood inserted lips. The difference in resin yield from two types of lips was found significant at 1 percent level. The nailed lips gave 11% extra resin during first year of tapping and about 18% during 2nd year of tapping as compared to wood inserted lips. It was also found that the face of tree on which blaze is made makes no difference on resin yield.

Periodicity, Height and Depth of Freshening

As series of experiments have been carried out to study the effect of periodicity, length and depth of freshening in U.P., H.P., Punjab and F.R.I. with various combinations of freshening period, depth of blazes and heights of freshening. Effect of depth of freshening was not found significant. 0.75 cm. (0.3") height of freshening gave the best results as compared to 0.375 cm. (0.15") and 1.125 cm. (0.45") heights of freshening. For the same height of freshening, a shorter freshening cycle gave higher yield. Inter-relationship of periodicity height and depth of freshening was also studied. Four tapping intervals viz 1, 2, 3, and 4 days, two depths 2 cm. and 3 cm. and two heights of freshening i.e. 3 mm. and 6 mm. were kept. It was found that the effect of freshening period varied significantly according to the freshening height being 3 mm. or 6 mm. or depth was 2 cm. or 3 cm. For the same freshening period, the effect of change in freshening height was same irrespective of the depth. In case of 2 and 3 days freshening cycle the mean yield did not differ significantly whether the depth of tapping was 2 or 3 cm. but in case of daily freshening depth of tapping had very significant effect on resin yield. Similarly the greater height of tapping always increases yield significantly. The response of different freshening intervals varied from month to month. The effect of tapping with a higher frequency is more pronounced during summer and decreases during the colder months. A higher frequency of tapping during two summer months, May - June, is much more effective in obtaining higher yield than higher frequency of freshening during cold months.

Pattern of Yield under Variable Frequencies of Freshening

In case of 6, 4 and 2 days freshening cycle, the yield was found to be in proportion of 1:1.25 : 1.95 while for 3, 2 and 1 days freshening cycle, the proportion was 1:1.29 : 2.16 for 3 mm. height of freshening and 1:1.42 : 2.16 for 6 mm. height of freshening. The yield flow during the succeeding days after a freshening varied and in the 1st day flow is about 50% of the total flow of the resin during the week, 66% in two days, 88.5% in four days and 97.6% in six days. The flow of resin from a blaze almost ceases once a fresh chipping is done above the blaze. and the entire resin yield begins to flow from the newest blaze.
CHAPTER-III
EFFECT OF CHEMICAL STIMULENTS ON RESIN YIELD

Increase in yield by improved method of tapping is of considerable importance for resin production from Chir pine forests. Chemical stimulents have shown increased gum production in several species of pine and sulphuric acid is used as resin stimulant in some countries. A series of experiments were conducted in F.R.I. U.P. and Himachal Pradesh on the use of chemicals for enhancing the resin yield.

Acid Stimulents:
(i) In a pilot trial at F.R.I., two treatments viz (i) the standard 7 day freshening cycle with wood chipped blazes and (ii) freshening every seven days with 1.25 cm. of bark alone and application of 50% sulphuric acid were started in September 1956 with 102 trees having diameter of 30 to 45 cm. A high increase in resin yield for the first two weeks by spraying acid was followed by a decreased yield to less than that of standard blazes from about 6th weeks so that the cumulative yield by the end of the year was nearly the same.

(ii) In the following year an experiment was laid out with six treatments arising out of factorial combinations of two freshening periods (8 and 16 days) and three strengths of sulphuric acid (20, 35 and 50%). Freshening in all treatments was by bark chipping alone. The experiment was conducted in 102 trees and started in the first week of February and continued upto November. The acid treatments neither produced increased yield as compared to standard method nor there was much difference between 8 days and 16 days freshening period.

(iii) In the third experiment laid out in May 1957 and continued upto November 58, different strengths of acid sprays on bark chipped blazes were compared to wood chipped blazes in different seed origin crops. The number of trees per treatment varied from 5 to 12 trees. In case of bark chipped blazes freshening height was 12 mm. and in case of wood chipped blazes rise per freshening was 6 mm. for 4 days freshening cycle, 12 mm. for 8 days freshening cycle so that both the blazes used the same surface area per season. The results show that the most pronounced effect in the yield is due to the freshening period, both in the controls and the acid treated blazes, the yield generally decreasing with the increase in freshening period. The four day control was significantly better than all the treatments except in case of Lansdowne origin in 1958. No acid treatment was significantly better than 8 day control. In several cases, the effect of acid treatment was to depress the resin yield.

The freshening cycle had much more effect on resin yield. Using the same surface area of the trunk, halving the rise per freshening and doubling the number of freshening per season, yielded a much higher amount of resin per year.

(iv) During 1958, in addition to Sulphuric acid, Hydrochloric acid, and Sodium hydroxide were also tried in the trees of Chakrata origin. There were 16 trees per treatment and the treatment included 12%, 20% 25% 35% and 40% strength of the chemicals. Interval of tapping was 8 days and blazes were bark chipped. In this experiment use of 20% HCl showed significantly higher yield and Sodium hydroxide solution significantly inferior yield than all other treatments. Acid spraying did not improve yield from bark chipped blazes to justify the use of bark chipped blazes at all.

(v) In 1959 another experiment was started to see the effect of different strengths of Sulphuric and Hydrochloric acids in both bark chipped and wood chipped blazes with an unsprayed control. In all cases, the freshening period was 7 days and the depth of blazes 12 mm. Tapping was done from May to October. The yield showed a positive response to the application of Hydrochloric acid to wood chipped blazes while bark chipping with acid application was found to give low yield.

(vi) Another set of experiments were carried out in 1965 and 1966, resin solvents and acid singly and in mixtures were tried in case of 35 years old Chir pine plantation of Nainital seed origin in the Demonstration Area of F.R.I. The Nainital provenance was selected because this provenance proved to be a low resin yielder. 45 trees were divided in three groups (A,B,C) on the basis of their resin yielding capacity and diameters. Each tree was given three blazes at equal distance around the tree periphery. The following treatments were given to the trees in each group.
Group A: All blazes were refreshed on every Tuesday and blazes number 2 and 3 were washed with alcohol and terpenine respectively on every Thursday and Saturday.

Group B: All the blazes were freshened on every Wednesday and in case of blazes number 2 and 3 freshenings were followed by spraying 20% Nitric acid and 20% Sulphuric acid respectively.

Group C: All blazes were refreshed on every Friday and in case of blazes number 2 and 3 freshenings were followed by spraying of (i) mixture of Sulphuric acid + Hydrochloric acid and (ii) Hydrochloric acid, each 20%.

It was observed that Nitric acid, Sulphuric acid and mixture of Sulphuric acid and Hydrochloric acid gave outstandingly high yield. In comparison to control blazes, Sulphuric acid increased resin yield by 20%, mixture of Sulphuric and Hydrochloric acid by 35% and Nitric acid 41%. There was no significant increase in other treatments, although these gave slightly higher yields than the control blazes.

(vii) During 1966, another experiment was laid out in which 20% mixture of Nitric acid plus Sulphuric acid + Hydrochloric acid as well as 20% of HCl, HNO3 and H2SO4 were tried. 43 trees were divided in 3 groups and each tree had 3 blazes with following treatments.

Group A: 1st blaze control
           (15 trees) 2nd blaze 20% HCl + HNO3
                     3rd blaze 20% HNO3 + H2SO4
Group B: 1st blaze - control
           (14 trees) 2nd blaze 20% HNO3
                      3rd blaze 20% H2SO4
Group C: 1st blaze control
           (14 trees) 2nd blaze 20% H2SO4 + HCl
                      3rd blaze 20% HCl.

Freshening was done once a week and excepting control ones, freshenings were followed by spraying of acid solutions as indicated above. Excepting Hydrochloric acid, all mixture and individual acid gave significantly higher resin yield in early months. For
the whole tapping season, mixture of Nitric and Sulphuric acid proved to be the best one followed by the mixture of Nitric acid + Hydrochloric acid and Sulphuric acid + Hydrochloric acid as compared to spraying of individual acids. The effect of HCl was the poorest among all the treatments.

(viii) During 1967 another experiment was laid out to find out the correct strength of a mixture of Sulphuric and Nitric acid on wood chipped blazes with or without Kaolin paste. 144 tree having diameters of 30-35 cms. were selected from 37 year old Chir pine crop of Chakarata seed origin. The following 12 treatments were included in this experiment.

(a) Mixture of Sulphuric acid + Nitric acid applied once a week.
(b) Mixture of acids in Kaolin paste form applied once a week.
(c) Mixture of acids in Kaolin paste form applied once in two weeks.
(d) Mixture of acids in Kaolin form applied once in 3 weeks.
(e) Concentrations (i) 15% (ii) 20% (iii) 25%.

Randomised block design with 12 replications was used for these experiments, each tree forming a replication and 12 treatments combinations were given to the trees at random. Each tree had two blazes, out of which one was control and the other, one of the treatments. This experiment was continued for
MONTHLY YIELD WITH APPLICATION OF 20% SULPHURIC AND NITRIC ACID MIXTURE
1968

FREQUENCY ONCE IN A WEEK

FREQUENCY ONCE IN 2 WEEKS

FREQUENCY ONCE IN 3 WEEKS

MARCH APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

MONTH

ACID MIXTURE APPLICATION AT 3 WEEKS FRESHENING % YIELD IN THE FIRST WEEK WITH DIFFERENT STRENGTH OF ACID 1969

% yield

20% 40% 60%

40 50 60 70 80 90 100

15/5 5/6 26/6 17/7 1/8 23/8 13/9 4/10 25/10 15/11 5/12

Date & month
two years (1967 and 1968) then it was modified to have freshening once in two weeks and once in 3 weeks. The strength of acid mixture was raised to 20%, 40% and 60% in place of 15%, 20% and 25% in the earlier experiment and results were observed for two years (1969 and 1970).

Resin yield under different treatments for the year 1967 and 1968 indicated that the acid treatment on weekly freshening cycle both in the spray and paste form, gave much higher yield than control, increases varying from 42 to 63% of the yield under control. There was no significant difference between the various strengths of acid mixture and the paste and spray treatments. Spray or Kaolin paste application gave equally good results and increase in resin yield being on an average 50% higher than the yield obtained by conventional method (without the use of acid mixture). The yield figures for one week freshening cycle for 1969 and 1970 also showed similar results. Thus the results of 4 year tapping indicate that application of mixture of Sulphuric and Nitric acids of 15 to 25% strength either in spray or paste form on weekly freshening, increases yield by 50% as compared to the conventional methods.

The effect of two and three week freshening frequency with low strength acid application as compared to one week freshening frequency; is decrease in the resin yield. There was however, no significant difference in yield due to variation in the strength of acid mixtures.

Increase in the acid strength resulted in the fall of yield as compared to weekly control. In terms of absolute yield, an application of 15 to 25% mixture of Sulphuric and Nitric acids on weekly freshening gave highest yield (about one and half times of the normal yield).

(ix) In 1969 another experiment was laid out on the use of higher strength of Sulphuric and Nitric acid and two percent solution of 2,4-D to find out the effect of prolongation of resin flow by the use of higher strengths of resin. 150 Chir pine trees of Lansdowne seed origin having 30 to 42 cm. diameters were selected. There were 10 treatments and 15 replications, each tree forming one replication as given below:-

T₁-40% Sulphuric acid in Kaolin paste applied once in two weeks, height of freshening 2.5 cm.
1969

- 40% H₂SO₄, 13 WEEKS f.c., RISE, 3.7 cm.
- CONTROL – WEEKLY TAPPING BY STANDARD METHOD – RISE 1.25 cm
- 40% H₂SO₄, 2 WEEKS f.c. RISE, 2.5 cm.
- 40% H₂SO₄, 2 WEEKS f.c. RISE, 3.7 cm.
- 40% H₂SO₄, 3 WEEKS f.c. RISE, 2.5 cm.
- 60% H₂SO₄, 2 WEEKS f.c. RISE, 2.5 cm.
- 60% H₂SO₄, 3 WEEKS f.c. RISE, 3.7 cm.
- 60% H₂SO₄, 2 WEEKS f.c. RISE, 3.7 cm.
- 2% 2, 4-D APPLIED ONCE A WEEK, RISE, 1.25 cm.

Yield in gm (TOTAL)

12 Days periods commencing from 1st May
Periods
T₂ - As above with a height of freshening 3.7 cm.
T₃ - 60% Sulphuric acid in Kaolin paste applied once in two weeks height of freshening 2.5 cm.
T₄ - As above with a height of freshening 3.7 cm.
T₅ - 40% Sulphuric acid in Kaolin paste applied once in 3 weeks. height of freshening 2.5 cm.
T₆ - As above with a height of freshening 3.7 cm.
T₇ - 60% Sulphuryric acid applied once in 3 weeks with a height of freshening 2.5 cm.
T₈ - As above with a height of freshening 3.7 cm.
T₉ - 2% 2,4-D as a water solution applied once a week with a height of freshening 1.25 cm.
T₁₀ - Control weekly tapping by standard method height of freshening 1.25 cm.

Statistical analysis showed that 10 treatments differ significantly at 1% level and T₉ i.e. application of 2% 2,4-D on weekly freshening cycle gave the highest yield, 80% higher as compared to the yield by conventional weekly tapping. Sulphuric acid of 40% strength applied on a cycle of 2 weeks with a height of freshening 3.7 cm. gave yield comparable to the conventional method.

Similar experiments carried out in Kaligad block of West Almora Division of UP., indicated higher yield with acid stimulants as compared to yield by conventional method. A lower strength of acid tends to give higher yield than the higher strengths. Frequency and height of freshening had bearing on the strengths of acid used.

Other Chemical Stimulants

Chemical stimulants like 2,4-D, 2,4,5-T etc. are known to effect yield in various pine species. To test their effect on Chir pine, experiments were started at Kaligad block of West Almora and have continued since then. In 1970 and 1971 chemicals like 2,4-D, 2,4,5-T and mixture of Sulphuric and Nitric acids were tried to compare their effect on yield both under standard practice and acid application. During 1971 strength of 10% 2,4-D and 2,4,5-T were also tried. The freshening cycle of one week was kept in all the treatments. During 1970 spray of 5% and 2% of 2,4,5-T gave the highest yield, increase being 11.5% and 10% respectively followed by 5% and 2% of 2,4,5-T gave the highest yield, increase being 11.5% and 10.1% respectively followed by 5% and 2% spray of 2,4-D (aminesalt) which gave 9.6% and 9.5% more yield. In 1971 5% 2,4-D sodiun salt spray (increase 21.4%) and 10% 2,4-D sodiun salt spray (increase 20%) gave the best results.

(ii) During 1972 an experiment on different strengths of 2,4-D spray on wood chipped channels was laid out in Kaligad. 10 trees each of 40-50 and 50-60 cm. diameter classes i.e. total 20 trees were allotted to each treatment. The strengths of 2,4-D were 2%, 5%, 10% and 20%. In each tree two channels were made. One served as control (tapped by standard method) and the other was treated with a spray of 2,4-D. The freshening period was kept by 7 days. There was no significant different in the yield of various treatments. This experiment was repeated in 1973 and 74 but no consistancy in increase in yield was noticed.

(iii) In 1974 another trial was carried out on the application of 2,4-D, 2,4,5-T and Grammaxone (paraquet) as stimulants. The strength of solution in each case was 2%. In this trial 2% grammaxone and 2% 2,4,5-T gave higher yields.

(iv) In 1975 an experiment was laid out to study the comparative efficiency of 2,4-D, 2,4,5-T Grammaxone, MCPA and a mixture of Sulphuric and Nitric acids. A total of 384 trees were selected in Kaligad block and 48 trees were allotted to each treatment. The blaze width in each treatment was 10 cm. depth 1.27 to 1.9 cm. Freshening was done every week so that increase in freshening was about 4.7 cm. This experiment was continued till 1976 November. The maximum increase in yield was in case of mixture of 2% Grammaxone and 2% 2,4-D.
CHAPTER IV
TAPPING ITS EFFECTS ON TREES

Seed Production

In order to study the effect of tapping on production of seed crop in Chir pine, studies were taken up during 1971 seeding season in the Demonstration area of F.R.I. and Chir pine crops of 9 different seed origins viz. Rawalpindi, Hazara, Kangra, Chakrata, Lansdowne, West Almora, Nainital, Dehradun and Darjeeling. 35 Trees of each origin were under continued tapping by conventional method (10 cm. wide biaze and .1.2 mm. rise in freshening once a week) for 15 years from 1956 to 1970. Observations were recorded for (i) Cone production (ii) Seed production in each tree was recorded during Jan.–Feb. 1971. The seed crop was estimated by finding the average weight of seeds per cone by random sampling. For assessment of differences in weight 10 samples of 50 seeds each, were selected at random for each origin and average seed weight was estimated for all the origins. Trees of comparable girth and of same age left untapped in the same compartment, were selected at random and similar observations were made. For comparison of germination percentage between seeds of different origins and between tapped and untapped trees, 4 samples of 50 seeds both from tapped and untapped trees of each origin, were tested for germination percentage. Correlation between seed production and twist of trees was also attempted for the data available from these studies. The analysis of these observations gave the following results.

(i) For Rawalpindi and Chakrata origins, there was no significant difference between the seed weight of tapped and untapped trees. For Darjeeling and West Almora origins seed weight of untapped trees was higher than that of tapped trees. For the remaining 5 origins seed weight from tapped trees was significantly higher than that of untapped trees.

(ii) There was significant difference in seed weight of different origin at 5% level.

(iii) The percentage of cone producing trees and average cone production per tree was higher in tapped trees than in untapped trees.

(iv) Difference in germination in tapped and untapped trees was not significant except in case of trees of Rawalpindi seed origin where germination of seed from tapped trees was lower than that of seeds from untapped trees. The difference was significant at 1% level.

Rate of Occlusion

In 1919, the rate of occlusion in Chir pine trees was studied in West Almora Division of U.P. and it was found that the average rate of occlusion was about 0.06" per annum and depends primarily on the vigour of the trees and secondarily on the supply of water and food material reaching the edges of the wound.

Effect of Tapping on Diameter of Height Increment and Trees

In the erstwhile Punjab, a study was conducted in Rawalpindi East forest. Division on diameter increment of tapped versus untapped trees. The average increment for the period 1923 to 1930 was computed for 165 untapped and 145 tapped trees by 15 cm. girth classes which shows that tapped trees put on less increment than the untapped trees. In another experiment in U.P., tapping was found to cause a diameter increment at the region tapped but a decrease above the region tapped.

To test the effect of tapping on both height and diameter increment with a variable frequency, a long term experiment was laid out in 1961 at F.R.I. in 31-35 years old Chir pine plantation of Chakrata seed origin. The tapping intensity variables were selected as 2.4 and 6 days and control (no tapping). The rise per freshening was so adjusted that the total length freshened per year under each treatment was the same. The following tapping treatments were adopted.

\[ T_1 = \text{Freshening cycle two days, rise per freshening 4 mm.} \]

\[ T_2 = \text{Freshening cycle 4 days, rise per freshening 8 mm.} \]

\[ T_3 = \text{Freshening cycle 6 days, rise per freshening 12 mm.} \]
$T_4$—No tapping.

The experiment was carried out till 1970 and yearly measurements of diameter at breast height, 0.9 m., 1.8 m. and 2.25 m. height and yield observations at a cycle of 6 days were taken. Results of this experiment indicated that there was hardly any effect on height increment but diameter increment at different heights was invariably found low for two days tapping cycle as compared to 4 and 6 days tapping cycles. However in statistical analysis significant difference was only at 2.25 m. height. This experiment showed that over an eight year period, a loss of about 20% in diameter increment may be expected if tapping is done at a short frequency of 2 days and only about 5% for 4 days frequency as compared to 6 days cycle.
In Chir pine, the resin canal system consists of vertical and horizontal resin canal with epithelium. The vertical canals are irregularly distributed and confined mostly to the middle or outer portions of the ring. The frequency of vertical canals varies from 21-23 per 100 sq. mm. and size from 204 to 260. The horizontal canals are smaller, solitary and inserted infusiform rays. The frequency varies from 44 to 60 per sq. mm. and the size from 45µ to 59µ. The epithelium is 1-2 cell thick.

**Variation in the Frequency of Resin Canals**

The size as well as frequency of resin canals varies little with the resin yielding capacity of the tree. As a result of tapping both the frequency and size of resin canals undergo changes but the effect is confined only to the wood formed after tapping, maximum effect being just above the blaze upto 15 cm. and does not extend laterally.

**Resin Content of the Wood**

Upto a height of 6 m., resin content of the wood has been found to vary from 4.4 to 5% and above this height, it increase slightly to 5.4-6%. On destructive distillation, Chir pine log showed recovery of 2.5 to 3.5% terpentine and 3-10% of pine tar on weight by weight basis of wood. With solvent extraction, the recovery of resin % weight by weight basis was 13-15% for logs cut into chips, 7-10% for roots and 6-7% from stump wood. The recovery of terpentine was 2-2.5% and 1.2% respectively.

When tapped on a weekly freshening cycle, average percentage of resin exuded daily were found to be 50%, 16.5%, 10.5%, 9%, 6.5% 6% and 2% on first day, second day..... to seventh day respectively. It is also dependent on temperature and exudation rises steadily from 10 cm. and reaches its peak between 1-2 pm. thereafter decreases gradually. The percentage of resin flow during 6 pm. to 8 am. forms nearly 40% of the total daily yield.

**Rate of Occlusion**

It primarily depends on the vigour of tree as indicated by the maturity, crown and height development and secondarily on the supply of water — food materials reaching the edges of the wood. The average rate of occlusion excluding bark was found to be 1.5 mm. (0.60") per annum and in a period of 40 years, nearly 60% of the channels may heal up.

**Factors Affecting Yield**

**Climatic Factors**

Studies carried out both at F.R.I. and U.P. showed that out of three climatic factors viz temperature, rainfall and humidity, temperature alone showed marked correlation with the resin yield. The highest yield were recorded when the average maximum temperatures are over 85° and humidity less than 90%. Low humidity and high temperature increase yield appreciably.

(ii) Correlation of resin yield data of demonstration area of F.R.I. Dehra dun with, maximum, minimum and average temperature, rainfall, humidity, evaporation and soil temperatures at 7.5 and 30 cm. were analysed by regression method for 8 year period (1963 to 1970). The maximum correlation was found with temperature (maximum) which accounts for nearly 70% variation in resin yield. Relative humidity and soil temperature at 30 cm. have also some influence on yield. Soil moisture upto a depth of 1.5 m. appearsto have effect during the latter part of the season but not during hot months.

(iii) The peak season of resin yield lasts from May to June or early July. It also varies with elevation, the higher the elevation, the shorter the peak period.

(iv) There is a time lag between the commencement of tapping and production of yields normal to the locality.

(v) The relation between resin yield and evapotranspiration can be expressed as \(YET = K\) where \(K\) is a constant. The value of \(K\) varies with locality, seed origin and tree size. For fairly good yields, the minimum evapo-transpiration required, is 110 mm.

**Viscosity and Resin Yield**

The resin yield was found to be inversely proportional to viscosity and values varied from 175.2 to
Trees and provenances can be characterised for their resin yielding capacities by viscosity values of resin.

Tree Characters

Seed Origin:

(i) Yield is significantly correlated to seed origins. Rawalpindi origin being the best and Darjeeling origin the poorest.

(ii) Variation between individual trees of the same seed origin is also considerable and difference between the highest and lowest yielders could be almost twice.

Diameter and Resin Yield

Among the individual tree characters, diameter and yield are highly correlated. 10% increase in yield occurs with a rise in diameter of 5 cm.

Crown

Crown size and crown ratio (crown height/total height) shows linear relationship with yield.

Twist

Twist was not found to have any significant effect on resin yield. This result is at variance with the 1933 U.P. Experiments where yield from twisted areas was found to be greater than straight grained ones.

Aspect

Blazes on southern aspect give slightly higher yield than that of northern aspect but influence of eastern and western aspects was non-significant.

Nailed Versus Inserted Lips

The method of fixing resin lips influences yield significantly. The difference in yields from the two types of lips was significant at 1% level and the nailed lips gave 11% extra resin during 1st year and about 18% during the second year of tapping.

Periodicity of Freshening, Depth and Rise in Freshening in Relation to Resin Yield

(i) Depth has no effect on yield in case of 2 to 6 days of freshening cycle. Only in case of daily freshening, the yield increases with tapping depth.

(ii) There seems to be a tendency of increased yield with the increase in freshening height though statistically significant only when rise in freshening height is twice.

(iii) Frequency of freshening exercises a very significant effect on yield and the yield with one day tapping cycle may be as high as 2.5 to 3 times the yield from 7 days cycle. Even when the height of freshening is so adjusted that the total height freshened in a year is the same under different frequencies of freshening, the yield increases with a shorter frequency of freshening.

(iv) Once a freshening is made in the blaze, the resin flow ceases from the previous freshening and comes out from the newest freshening alone.

(v) While the absolute yield increases with a shorter freshening frequency, the yield per freshening decreases with shorter freshening frequencies.

(vi) The response of different frequency interval varies from month to month. The greatest response of a shorter frequency is during May-June and becomes small from August onwards.

Yield in Relation to Surface Area Tapped

(i) Resin yield is highly correlated to the width of the channels and an increase of about 614 gm. of resin per tree may be expected with the increase in the channel width by 5 cm. However, increasing the width by twice or thrice does not increase the yield by the same proportion.

(ii) The effect of increasing the width is much greater than increasing the height of freshening. When width of channel is increased from 1/10th of the girth to 2/10th of the girth, with a rise of 2 cm. per freshening, the yield rises upto 1.5/10th of girth width but the same rate of increase is not sustained for a higher width.

(iii) In case of blazes placed along periphery, the yield increases upto 3 blazes and drops down when number of blazes is increased to 4, indicating that when total width of blazes increases to more than one third of the circumference of the tree it affects the resin producing capacity of the tree.
(iv) In case of more than one blaze put vertically, increase in yield was linear upto 2 blazes, little when number increased to 3 but again an increase when number was increased, to 4.

(v) There is an inter-effect of channels when these are placed one above the other. The inter-effect is maximum when successive channels are vertically one above the other. When these are displaced and the vertical distance between the successive channels increases, the average yield per channel also increases.

Minimum Size of Trees for Tapping

The result of tapping below 0.9 m. in girth indicate that (i) Yield decreases as the diameter decreases (ii) Mortality in the lowest class (15-20 cm. diameter class) was found to be 33-35% in 3 year period (iii) The average yield from 15-20, 20-25 and 25-30 cm. diameter classes as compared to the average yield for the same locality, was 2%, 29% and 43% respectively.

Chemical Stimulants

(i) Chir pine does not respond well to either acid application on bark chipped blazes or the American method of tapping.

(ii) Application of Sulphuric acid on wood chipped blazes although increase the yield as compared to the yield of bark chipped blazes, it was either equal or lower to the standard method without the application of the acid.

(iii) Application of 15 to 25% mixture of Sulphuric acid and Nitric acid on weekly freshening, gave on an average 50% higher yield than the standard method.

(iv) Both acid spray of application in paste form, were found to be equally effective.

(v) Increasing the frequency of freshening to two and three weeks in case of acid mixture lowers the yield by 32% in two weeks and 55% in three weeks cycle as compared to weekly control (conventional method).

(vi) The use of 2,4-D (Sodium salt) in water solution in 2% strength on weekly freshenings, gave the highest yield, at F.R.I. Dehradun and 2% 25% 2,4-D and 2,4-5-T gave the highest yield in U.P. mixture of grammoxone plus 2,4-D in 2% strength also increased resin yield considerably but a consistancy of increase in yield is not shown by the use of these chemicals.

Effect of Tapping on Trees

(a) On Diameter and Height Increment:

(i) Tapping caused a diameter increment at the region tapped but a decrease above the region tapped.

(ii) There was no difference in diameter increment between tapped and untapped trees in case of 6 days of freshening cycle but difference was significant with 2 days tapping cycle and maximum difference was noticed at a height of 2.25 m.

(iii) These was no difference in height increment between tapped and untapped trees.

(b) Cone and Seed Production, Seed Weight and Germination Percent

(i) Average cone production per tree and average seed production per tree was higher in tapped trees as compared to untapped trees.

(ii) In seed weight, there was no consistant difference between tapped and untapped trees.

(iii) Seeds from high resin yielding trees under tapping gave lower germination percent indicating some correlation between germination percent of seed from tapped and untapped trees.

Conclusion

A number of aspects of tapping and production of oleoresin in Chir pine have been systematically covered in these studies. The experimental results give an insight into the factors correlated with resin yield e.g. tree characters, climatic factors, variation in tapping technique, freshening frequency and application of various chemicals. Results of various experiments on the use of chemicals indicate that bark chipping with the application of chemicals is not a suitable method for Chir pine. For the same reason, the American system of tapping or Herringbone type of tapping can not be adopted in case of Chir pine. The studies show that the tapping has effect on
diameter increment when higher intensity of freshenings are resorted to. By using nailed lips, use of proper strength of acid mixtures on wood chipped blazes and adoption of different frequencies, resin yield can be considerably enhanced. As resin yielding capacity is hereditary character in trees, a practical programme of selection and breeding of high resin yielding strains and establishment of seed orchards and plantations of such strain is called far.

There is need for further studies on anatomical and physiological aspects on the production of resin. Effect of seed origin on the chemical composition of resin and indentification of strains, yielding higher percentage of economically important chemical constituents, improvement in resin tapping tools and work study are other factors, proper knowledge of which, can help in improving the resin yield substantially.
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