STANDARDIZATION OF SUSTAINABLE GUM TAPPING TECHNIQUES IN *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) TO OBTAIN HIGHER GUM PRODUCTION IN TROPICAL DRY DECIDUOUS FORESTS.

M.Sc. (Forestry) Thesis

by

AMIT PRAKASH NAYAK

DEPARTMENT OF FORESTRY
COLLEGE OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (C.G.)

2019

STANDARDIZATION OF SUSTAINABLE GUM TAPPING TECHNIQUES IN *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) TO OBTAIN HIGHER GUM PRODUCTION IN TROPICAL DRY DECIDUOUS FORESTS.

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

by

AMIT PRAKASH NAYAK

IN PARTIAL FULFILMENT OF THEREQUIREMENTS FOR THE DEGREE OF

Master of Science

In

Forestry

College ID No. 120117250 **U.E. ID No. 20171827448**

July, 2019

CERTIFICATE - I

This is to certify that the thesis entitled **"Standardization of Sustainable Gum Tapping Techniques In *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) *to* Obtain Higher Gum Production in Tropical Dry Deciduous Forests."** submitted in particular Fulfillment of the requirements for the degree of **" Master of Science in Forestry"** of the Indira Gandhi Krishi Vishwavidyalaya ,Raipur is a record of bonafide research work carried out by **Amit Prakash Nayak** under my guidance and supervision .The subject of the thesis has been approved by the Students Advisory Committee and Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published part has been fully acknowledged .All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Date: 22/07/2019

Chairman 22/07/19

(Dr. R.K Prajapti)

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	:	**Dr. R.K Prajapati**	22/07/19
Member	:	**Dr. Lalji Singh**	
Member	:	**Dr. M. L Lakhera**	22/07/2019
Member	:	**Dr. Pratibha Katiyar**	P. Katiyar
Member	:	**Dr. S.S Tuteja**	

CERTIFICATE – II

This is to certify that the thesis entitled **"Standardization of Sustainable Gum Tapping Techniques in *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** submitted by **Amit Prakash Nayak** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirement for the degree of **Master of science** in the **Department of Forestry** has been approved by the external examiner and Student's Advisory committee after oral examination.

30/07/19

Signature External Examiner

(Name Dr. S. S. Dhuria)

Date: 30/07/2019

Major Advisor .....

Head of the Department .....

Faculty of Dean .....

Approved/Not approved

Director of Instructions .....

ACKNOWLEDGEMENT

It is by the blessings of the almighty, that I have able to complete my present studies succeAssfully and the piece of work for which I am eternally indebted.

It gives me immense pleasure to express my profound sense of gratitude and respect to my Major Advisor and Chairman of the Advisory Committee Dr. R.K. PRAJAPATI SIR Professor in Department of FORESTRY, IGKV, Raipur, for his sensible and freehearted guidance, discreet approach, illative and appraise critique and perpetual encouragement during the entire course of investigation.

I am highly indebted to the member of advisory committee Dr. Lalji Singh, Professor and Head, Department of Forestry, IGKV, Raipur, for his untiring help, valuable suggestions and timely moral support, which enabled me to accomplish this task. I am greatly indebted to other members of my advisory committee Dr. Pratibha Katiyar, , Department of Plant Physiology, Agricultural Bio-Chemistry, Medicinal and Aromatic Plants ,College of Agriculture IGKV, Raipur for their continuous advice, guidance and encouragement throughout Dr. M.L Lakhera professor ,Dept. Of Agricultural statistics and Dr. S.S.Tuteja ,Centre of Excellence NTFP for their continuous advice, guidance and encouragement throughout the course of investigations.

I am highly obliged to teaching staffs of Department of Forestry,, Shri Pratap Toppo, Assistant Professor, Smt Sarita Bodalkar,Scientist, Dr. V. L. Kog, Assistant Professor and Smt Shilpa Chandrawanshi, Sr. Tech. Astt. for their suggestions and kind cooperation

With deep and heartfelt respect, I extend my appreciation to Dr. S. K. Patil, Hon'ble Vice Chancellor, Dr. M.P Thakur Director Instructions, Dr. (Major) G.K. Srivastava, Dean Student Welfare and Dr. S. S. Rao, Dean, College of Agriculture, IGKV, Raipur for providing necessary facilities, technical and administrative supports for conductance of my research work.

I like to express my sincere thanks to Shri Vishwesh Roy (D.F.O) Balodabazar Forest Division ,Shri Udaya singh Thakur .S.D.O (Kasdol),Lakhanala Sinha (R.F.O) ,Basant Khandekar(Forester), Sadhulal sahu, Ajit Kumar Dhruw (Forest Guard) ,Mohan Sahu for their kind support and help at various stages of the study.

My cordial thanks goes to my senior and juniors,Sirdhat Pandey sir, Jai Mangal Tirkey sir Rupesh Netam sir, Pramod Sethy, Abhishek Raj sir, Nalish Anchal Sir, Manutai Thakrey mam ,Indrani Rana mam , Swapnil,S, and Rajkumar. Friendship is a golden chain made stronger with each minute. Each link is forged of memories that make you still dearer. The thoughtful things you say and do become the links of gold that I will treasure through the years and in my heart will hold sweet memories of ,Barsha ,Avinash, Sudha , Jiwan, Gorakh, Gaurab, Raj kumar ,Palmula , Denii, Joy laxmi for being with me and making my stay in this campus memorable

Diction is not enough to express the heartfelt gratitude to my beloved father Mr.Pradeep Kumar Nayak, mother Smt. Anita Nayak whose filial affection encouragement, obstinate, sacrifice, sincere prayers and love have always been to most vital source of inspiration and raising me to the present position.

Needless to say Errors and Omissions are mine

Department of Forestry
College of Agriculture, ***(Amit Prakash Nayak)***
I.G.K.V., Raipur (C.G.)

Date: _____

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF SYMBOLS

>	Gretaer than
<	Less than
S	Square shape
R	Replication
V	V shape
H	Hole shape
%	Percentage
cm	Centimeter
g	Gram
^{0} C	Degree Celsius
Fig.	Figure
conc	Concertation
viz.	Namely
i.e.	That is
ml	Millilitre
a.i	Active ingredient
Wt.	Weight
±	Plus or minus

LIST OF ABBREVIATIONS

Abbrevation	Description
pH	Physical hydrolysis
RH	Relative Humidity
SS	Sum of Square
NTFP	Non-Timber Forest Product
NWFP	Non Wood Forest produce
D.F.	Degree of Freedom
D.B.H	Diameter at breast height
EMS	Error mean of square
g/tree	Gram/tree
SEm±	Standard error due to mean
CD	Critical difference
RBD	Randomized block design
IGKV	Indira Gandhi Krishi Vishwavidyalaya
et al.	And others
ANOVA	Analysis of Variance
Temp.	Temperature
MSS	Mean Sum of Square

THESIS ABSTRACT

a)	Title of the Thesis:	:Standardization of Sustainable Gum Tapping Techniques in *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests
b)	Full name of the student	: Amit Prakash Nayak
c)	Major subject	: Forestry
d)	Name and address of the Major Advisor	: Dr. Rajendra Kumar Prajapati Professor, Department of Forestry, College of Agriculture IGKV, Raipur(C.G)
e)	Degree to be Awarded	: M.Sc. Forestry

Amit Prakash Nayak
Signature of the Student

22/07/2019
Signature of Major Advisor

Date: 22/07/2019

Signature of Head of the Department

The present studied entitled "**Standardization of Sustainable Gum Tapping Techniques in *Boswellia serrata* Roxb. and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** was carried out at Deopur forest Range, Balodabazar Forest Division (Chhattisgarh) during winter and summer season and the laboratory work was Carried out in Department of Forestry, College of Agriculture, IGKV, Raipur (Chhattisgarh) during the year 2018-2019. It is one of the most important Non-Timber Forest Produce (NTFP), provide viable income source of forest dwellers. Oleo gum resin From *Boswellia serrata* and gum of *Lannea coromandelica* has high medicinal value both these tree species are not tapped in this state of Chhattisgarh. Since

Forest Produce (NTFP), provide viable income source of forest dwellers. Oleo gum resin From *Boswellia serrata* and gum of *Lannea coromandelica* has high medicinal value both these tree species are not tapped in this state of Chhattisgarh. Since these tree species found abundantly in patches in various forest stands of the state. Hence, there is a need to develop a sustainable method of tapping for these gum yielding trees to increase the yield sustainable and safe method of tapping as well better management of Forest stands. Therefore, the study was carried out to evaluate various mechanical methods, Mechanical +Chemical methods of tapping for their quantification of yield and safety of the tree health.

The investigation was conducted in Factorial RBD replicated in three in mechanical methods and nine replication in Mechanical + Chemical method of tapping in each tree in both season winter and summer. The available trees *viz.*, *Boswellia serrata* (Roxb), *Lannea coromandelica* (Merr.) were selected on the basis of their girth ranges from 80-150 cm and tapping incision made at breast height treated with mechanical tapping and Mechanical+ Chemical tapping in incision like Square shape cut ,V shape cut, Hole shape cut. In Mechanical Method three types of incision made for tapping one was Square Shape, second one was V shape cut and third one was Hole shape cut. Whereas in Mechanical+Chemical methods of tapping, various concentrations of gum enhancer Ethephon having 39% active ingredient was used in nine treatments i.e T4($S_2$10%), T5 ($V_2$10%), T6 ($H_2$10%), T7 ($S_3$20%),T8($V_3$20%) and T9 ($H_3$20%), T10(S_4 30%), T11 (V_4 30%),T12 ($H_4$30%) were used in *Boswellia serrata* and in *Lannea coromandelica*. Then gum enhancers were injected in various cuts made at DBH (Diameter at breast height) by battery operated drill machine and wooden Chisel the quantity of gum enhancer injected 4 ml in each tree and treatment. The parameters of rate of gum yield (g/tree) were recorded since month of October to May. Among the mechanical method of tapping, Square shape cut was found significantly superior in both the tree species and maximum gum production was obtained by this cut

. As per Season wise gum production from *Boswellia serrata* by using $V_3$20% Chemical conc. was much effective for highest gum production in the winter season the yield was 26.18 g/tree. However, in summer season $H_4$30% Conc. was much effective for highest gum production and the yield was 52.94 g/tree. Similarly in *Lannea coromandelica* as per season wise gum production by using $V_4$30% Chemical conc. was much effective in production of gum in winter season and the yield was 51.13g/tree. However, in summer season similar treatment $V_4$30% Conc. was found effective and the gum yield was 140.59 g/tree recorded.

It can be concluded that in both the method of tapping studied the Mechanical +Chemical method of tapping was found superior in both the tree species. The Ethephon gum enhancer found significantly superior over mechanical method. It was observed that ethephon 30% conc. in case of *Lannea coromandelica* and ethephon 20% and 30% in *Boswellia serrata* was found significantly superior in both the season.

थीसिस सारांश

1.	थीसिस का शिर्षक	: *Boswellia serrata* (Roxb.) *और Lannea coromandelica* (Merr.) *में टिकाऊ गोंद दोहन तकनीकों का मानकीकरण। उष्ण कटिबंधीय शुष्क पर्णपाती जंगल में अधिकतम गोंद उत्पादन प्राप्त करने हेतु प्रयोग*
2.	छात्र का पुरा नाम	अमित प्रकाश नायक
3.	प्रमुख विषय	वानिकी
4.	मेजर एडवाइजर का नाम और पता	डॉ. आर. के. प्रजापति, प्रोफेसर, वानिकी विभाग, कृ. म. वि., इं.गां.कृ.वि.वि. रायपुर
5.	डिग्री से सम्मानित किया जाएगाः	एम. एस. सी. वानिकी

Amit Prakash Nayak
छात्र का हस्ताक्षर

22/07/2019
मेजर एडवाइजर का हस्ताक्षर

विभाग प्रमुख के हस्ताक्षर

तारीख 22/07/2019

सारांश

वर्तमान अध्ययन ***'Boswellia serrata* (Roxb.) और *Lannea coromandelica* (Merr.) में टिकाऊ गोंद दोहन तकनीकों का मानकीकरण। उष्ण कटिबंधीय शुष्क पर्णपाती जंगल में अधिकतम गोंद उत्पादन प्राप्त करने हेतु प्रयोग'** सर्दियों और गर्मियों के मौसम के दौरान देवपुर वन रेंज बलौदाबाजार वन मंडल छ.ग. में किया गया था और प्रयोगशाला का काम वानिकी विभाग कृषि कालेज इ. गां. वि. वि. रायपुर छ.ग. वर्ष 2018–19 के दौरान । यह सबसे महत्वपूर्ण गैर

इमारती लकडी वन उपज (अकाष्ठीय वनोपज) में से एक है जो वनवासियों के जीविकापार्जन का मुख्य स्त्रोत है।

प्राकृतिक गोंद हमे वृक्षो से प्रापत होता आया है। वृक्षों से गोंद निकालने के लिये आदिकाल से मनुष्य द्वारा वृक्ष के तने पर घाव बनाते है। जिससे गोंद बूंद बूंद इकट्ठा होता है। इस तरह से गोंद एकत्रीत किया जाता रहा है। वृक्षों मे किसी स्थान पर यदि फफूंद का संक्रमण होता है अथवा छिलने कटने से जो घाव वृक्ष की छाल टहनियों पर प्राकृतिक रूप से बनते है उन कटे फटे स्थानों से गोंद धीरे धीरे रिसता हैं। समय के साथ जो व्यक्ति गोंद एकत्र करने का कार्य करते है । लालच मे ज्यादा से ज्यादा गोंद प्राप्त करने के लिये एक ही वृक्ष पर बहुत सारे घाव बनाते है जो कि काफी गहरे होते है जिसके कारण वृक्षों मे संक्रमण कीटों का प्रकोप होता है। आग जल्दी पकडने से वृक्ष एक या दो वर्षो मे मर जाते है।

उपरोक्त समस्या के निराकरण एवं गोंद की अधिक माता वृक्ष को बिना हानी पॅहुचायें के लिये प्रयोग किया गया । यह प्रयोग देवपुर वन जो बलौदाबाजार जिले मे आता है प्राकृतिक जंगल के खण्ड 281 में वर्ष 2018 के शीत ऋतु एवं वर्ष 2019 के ग्रीष्म ऋतु मे किया गया । यह प्रयोग सलाई वृक्ष जिसका वानस्पतिक नाम बोसवेलिया सर्राटा है एवं झींगन वृक्ष जिसका नाम लेनिया कोरोमेन्डेलिका है का चयन किया गया। शीत ऋतु में माह अक्टूबर से दिसम्बर 2018 एवं ग्रीष्म ऋतु मार्च से मई 2019 मे प्रयोग किया गया । इस अनुसंधान के लिये उपरोक्त दोनों वृक्षों मे यान्त्रिक विधि अर्थात बढई के औजारों के उपयोग से स्केवर शेप कट, वी शेप कट एवं होल शेप कट जो की ड्रिल मशीन से बनाये गये एवं प्रत्येक 15 दिनों के अंतराल से इन बनाये गये घाव से जो भी गोंद निकला उसकी मात्रा के रिकार्ड किया गया । उपरोक्त प्रयोग मे यान्त्रिक कट के साथ + रासायनिक कट मे रसायन इथेफोन 10 प्रतिशत, 20 प्रतिशत, 30 प्रतिशत 4 मि.ली. रसायन इंजेक्शन की सहायता से वृक्ष के तने मे इंजेक्ट किया गया एवं इसका प्रभाव विभिन्न टाईप के कट पर गोंद निकालने की मात्रा का 15 दिनों के अंतराल पर डाटा इकट्ठा किया गया।

(बोसवेलिया सेराटा) और (लानिया कोरोमेंडेलिका) वृक्षों का उच्च औषधीय महत्व है। इन दोनों पेडों की प्रजातियों को छत्तीसगढ राज्य में गोंद नही निकाला जाता है। चूँकि ये पेड प्रजातियां राज्य के विभिन्न वन खण्डों मे बहुतायत से पाई जाती है। इसलिए दन गोंद उत्पादक पेडों के लिए दोहन की एक स्थायी विधि विकसित करने की आवश्यकता थी ताकि उपज की टिकाउ और सुरक्षित तरीके के साथ–साथ वन खण्डों का बेहतर प्रबंधन हो सकें। इसलिए विभिन्न यांत्रिक तरीकों का मूल्यांकन करने के लिए अध्ययन किया गया था। वृक्षों के स्वस्थ्य पैदावार और सुरक्षा के लिए उनकी मात्रा का निर्धारण करने के लिए यांत्रिक + रासायनिक

तरीकों का अध्ययन किया गया था। फैक्टरियल RBD में यांत्रिक तरीकों मे तीन और यांत्रिक + नौ रासायनिक उपचार कि गई थी । प्रत्येक मौसम में प्रत्येक पेड में दोहन की रासायनिक विधि बोसवेलिया सेराटा और लानिया कोरोमेंडेलिका 80–150 सेमी. वृक्ष की परिधि के आधार पर चुने गए थे । और छाती की उँचाई पर चीरो को चीर कर बनाया गया था। मैकेनिकल विधि मे पेड को टेप करने के लिए बनाए गए तीन तरह के चीरे स्कायर शेप, दूसरे मे वी शेप कट और तीसरे मे होल शेप कट किया गया था। जबकि दोहन की यांत्रिक + रासायनिक तरीकों मे गोंद बढाने वाले इथोफोन के 39 प्रतिशत सकिय घटक के विभिन्न सांद्रण का उपयोग नौ उपचारों यानी T4 ($S_2$10%), T5 ($V_2$10%), T6 ($H_2$10%), T7 ($S_3$20%), T8 ($V_3$20%), T9 ($H_3$20%), T10 ($S_4$30%), T11 ($V_4$30%) और T12 ($H_4$30%) का उपयोग बोसवेलिया सेराटा और लानिया कोरोमेंडेलिका में किया गया था। फिर गोंद निकालने वाले विभिन्न कट्स में इंजेक्शन लगाया गए थे। डीबीएच पर बैटरी चलित ड्रिल मशीन और लकडी की छेनी द्वारा गोंद बढाने की मात्रा प्रत्येक पेड और उपचार में 4 मिलि. इंजेक्ट की गई थी। अक्टूबर से मई के महीनें में गोंद क उपज की दर ग्राम/पेड दर्ज गई थी।

दोहन की यांत्रिक विधि को बीच चौकोर आकर में दोनों पेडो की प्रजातियों मे गोंद का अधिक उत्पादन पाया गया और इस कट से अधिकतम गोंद प्राप्त हुआ। सलिहॉ वृक्ष में मौसम के अनुसार ($V_3$20%), रासायनिक और यांत्रिक विधि बहुत प्रभावी थी पैदावार 26.18 ग्राम/पेड थी । हालांकि, गर्मियों के मौसम ($H_4$30%) सें उच्चतम गोंद उत्पादन के लिए बहुत प्रभावी पाया गया पैदावार 52.92 ग्राम/पेड था। इसी तरह लानिया कोरोमेंडेलिका में मौसम के अनुसार गोंद उत्पादन ($V_4$30%) रासायनिक उपयोग करके। सर्दियों के मौसम में गोंद के उत्पादन मे बहुत प्रभावी था। पैदावार 51.13 ग्राम/पेड था। हालांकि गर्मियों के मौसम मे इसी तरह का उपचार ($V_4$30%) कट मे प्रभावी पाया गया था 140.59 ग्राम/पेड गोंद उपज दर्ज की गई।

उपरोक्त प्रयोग में यह पाया गया की सलिहा वृक्ष में V_3 Shape cut + 20% ईथेफोन का प्रयोग से अधिकतम गोंद दोनों ऋतुओं शीत 26.18 ग्राम/पेड एवं ग्रीष्म में 37.42 ग्राम/पेड एंव कुल मिलाकर यह मात्रा 63.6 ग्राम/पेड प्राप्त हुई। इसके अलावा दूसरा वृक्ष झींगन मे गोंद निकालने के लिए उपयुक्त विधि V_4 Shape cut + 30% ईथोफोन देने पर शीत ऋतु में 51.13 ग्राम/पेड और ग्रीष्म ऋतु मे 140.59 ग्राम/पेड प्राप्त हुआ कुल गोदं का उत्पादन दोनों ऋतुओं का मिलाकर 199.72 ग्राम/पेड प्राप्त हुआ अतः हमारे इस प्रयोग का निष्कर्ष है कि सलिहा वृक्ष में V_3 Shape cut के साथ 20 प्रतिशत ईथोफोन 4 मिली. प्रतिवृक्ष देने पर रिजल्ट अच्छा मिलता है औंर झीगंन वृक्ष में V_4 Shape cut के साथ 30% ईथोफोन 4 मिली. प्रतिवृक्ष देने पर रिजल्ट अच्छा मिलता है। जबकि यांत्रिक विधि जिसमें विभिन्न कट के घाव बनाकर बहुत कम गोंद की प्राप्ति होती है।

CHAPTER 1

INTRODUCTION

Forests are the natures most attractive and versatile renewable resources providing simultaneously a wide range of social, economic, cultural, environmental services and benefits. Forests provide a wealth of profitable products, which have significantly improve the quality of life for human societies worldwide. India has a vast flora and immense plant wealth of economic importance forest tree species. Gums and Resins occupy an important role among non-wood forest produce (NWFP) and are known to mankind since ancient time. Gums are important natural biopolymers demand from biological system under stress condition *i.e.* injury/disease to bark etc. Gums used as a principal element in pharmaceutical industries, food, and play a key role in source of income for tribal residing in side and fringes of forest areas .They hold a significant place in tribal economy and rural development. In many taxa, gum or gum-resin is normally accumulated in the internal secretory structures and it oozes in response to mechanical injury or natural cracks. The gum exudates from trees and shrubs in striated nodules or amorphous lumps, tear-like structure. It dries in contact with air and sunlight and forms hard, glass like lumps. Gum production increases at high temperature and limited moisture (Sao,2012). In others the secretory structures are formed in response to injury and the substance exudes through the injured portions immediately or after some time. The exuded gum or gum-resin gets hardened, and then collected and sold with or without being sorted into grades in the local markets by the tribes for their livelihood. Gum industry is a forest based, it provide employment opportunities to many tribal people for the collection of gum or gum-resin from different forest areas of the country. The demand for various Indian gums in the international market, particularly in the developed and technologically advanced countries has been increasing very fast and therefore, it has become quite a problem to cope up with the demand (Farooqi, 1976). India is affluent in plant biodiversity having more than 15,000 species of plant including about 120 gum

yielding plants. Several gum supplying factories under the Department of Small Scale Industries or State Forest Development Corporations have been established in several States of India. According to a recent study India exports gums and resins worth Rs. 5 billion annually (Anonymous, 2006). The demand is increasing day by day in the global market because of a shift in demand from synthetic to natural products looking to health security the awareness is created by health department and world level agencies like WHO etc.

Chhattisgarh state is gifted with the most virginal and abundant set of natural resources in the country and known for its vast diversity of Non Timber Forest Products. Gums are primarily categorized as grade-I, grade II, grade III on the basic of colour, quality, and value in the market, Karaya gum (*Sterculia urens*) is categorized under grade-I gum and Babool gum (*Acacia indica*) and Khair (*Acacia catechu*) and of Dhawda (*Anogeissus latifolia) are categorized is under* Grade-II in Chhattisgarh. The gum producing forest divisions in the Chhattisgarh state are Surguja, Raigarh, Dharamjaigarh, Manendragarh, Rajnandgaon, Mahasamund, Dhamtari, Korea, Sukma, Bijapur, Dantewada and West Bhanupratapur Bilaspur (Mungeli, Dindori, Ratanpur, Takhatpur, Lormi), Raipur, East Surguja (Balarampur), Marvahi (Kota). The collection charges to the collectors at collection centre's are paid by the purchaser at the rate fixed by Chhattisgarh State Minor Forest Produce (Trading and Development) Co-operative Federation Limited, run by the Chhattisgarh government.

What is Gums?:-

The gums are plant exudations, partly as a natural phenomenon and partly as a result of injury to the bark or stem. These injury may caused by fungal attack or bacterial attack cut or incision made. Gums are primarily formed by the disintegration of internal plant tissue through a process known as gummosis. The process breaks down complex carbohydrates known as cellulose and Hemicelluloses which are located in the cell walls of plants. Mostly gums are ooze out by the stem, only a few gums are obtained from leaves, roots and other parts of the plant. Gums are comprised of, hydrogen, oxygen carbon and are found in a

large number of families. Notable among them are Leguminosae and Sterculiaceae ,Combretaceae, Meliaceae, Rosaceae, Rutaceae , Burseraceae and Anacardiaceae found in India and Asia.

CLASSIFICATION OF GUM

A. True gums: These are directly exuded from the plant or plant parts.

a. Real gums: These gum are exuded from tree or plant parts and completely soluble in water e.g: Gum Kino –*Pterocarpus marsupium* , Jhingan gum-*Lannea coromandelica*

b. Vegetable mucilage: These are not completely soluble in water but swells when comes in contact with water e.g: Tragacanth gum-*Astragullus gummifer* etc.

B. Gum-resins: - These are a mixture of both gums and resins and possess the properties of both the groups. They contain traces of essential oils and not completely soluble in water. These are usually derived from the plant growing in dry and arid regions. Some of the commonly used gum-resins are Myrrh/ Guggal -*Commiphora mukul*, Salai gum -*Boswellia serrata* etc

A. TRUE GUMS	**a) REALGUMS** 1. Gum Kino (*Pterocarpus marsupium*) 2. Jhingan gum (*Lannea coromandelica*) **b) VEGETABLE MUCILAGE** 1. Tragacanth gum (*Astragullus gummifer*)
B. GUM RESINS	1. Myrrh/ Guggal -*Commiphora mukul*, 2. Salai gum -*Boswellia serrata* *3.* Gamboge- *Garcinia morella* 4. Assafoetida - *Ferula asafetida.* *5.* Galbanum - *Ferula galbanifllua* 6. Olibanum - *Boswellia carterii.*

Botanical description of *Boswellia serrata* (Indian frankincense or Olibanum)

Salai gum is obtained from the tree *Bowsellia serrata* which is also known as Salai guggal, gum olibanum or frankincense tree. It is one of the most important forest products of our country. The genus Boswellia belongs to the family of Bruseraceae and extent widely in the dry regions of tropical Africa, Arabia and India. The leaves of this tree is imparipinnate, alternate 30-45cm long ,crowded at the ends of branches, leaflets 17-31, opposite, variable in shape and size. Flowers are small, white in short racemes, crowded at the ends of branches .Fruits are trigonous,12mm long, drupe, containing three 1-seeded pyrenes, weinged along the margins. Seed are compressed, hard and winged.

Geographical distribution and Ecology:

Worldwide there are about 18 species of Boswellia which are either shrubs or trees with outer bark often flaking. Out of these, only two species i.e. *B. serrata* and *B. ovalifoliolata* are distributed in India (Arabia, 2005). Two new species (*B. bullata* and *B. dioscoridis*) were recently identified in Yemen as reported by (Thulin 2001). Out of these, only two species i.e. *B. serrata* and *B. ovalifoliolata* are distributed in India (Arabia, 2005). In India it has a well marked distribution in central India between 16^0 to 31^0 N Latitude and 73^0 to 86^0 E Longitudes .It is a moderate to large branching tree, found in dry deciduous forests, being common in dry hills throughout India. The tree occurs mainly in Madhya Pradesh, Andhra Pradesh, Odisha, Rajasthan and Gujarat and to a lesser extent in Maharashtra, Uttar Pradesh and in other dry and tropical regions of the country but it is almost absent in the moist regions of North-east India and western Ghat regions. It is a characteristic species of dry teak forest, Southern dry mixed deciduous forests, dry peninsular Sal forest, northern dry mixed deciduous forest, and the edaphic climax type of the dry deciduous forests (Champion and Seth,

1968). It is present either singly or in pure belts or patches. Naturally the tree is found on the slopes and ridges of hills, as well as on flat terrain.

The tree is resistant to frost and serves as a nurse tree for other species grown in forest. It is a strong light demander and does not tolerate to shade. It is extremely resistant to drought and resists fire better than any other species in its zone of occurrence. It typically grows well on neutral soils above schist, quartzite, and limestone and sandstone gneiss. It produces root suckers, coppices and pollards well. The species has the ability to resist in the poorest and the shallowest soils where most of its associates remain stunted. The tree can be found up to 1150 m in elevation. The gum obtained from this tree commonly known as Salai guggal, gum olibanum or frankincense having constituents: gum: 20-36%, acid resin: 56-65% and volatile oils: 4-8%. Besides, the acid resin of *Boswellia serrata* usually contains 43% boswellic acids. Additionally the gum has been reported to contain arabinose, galactose, xylose, galacturonic acid and digitoxose (Holmes, 1999).

The extract obtained from this plant known as Shalaki extract. These extracts made into a very fine powder and transformed into a liquid like substances. Its gum is used for multiple health and medicinal benefits as per Ayurvedic system of medicine This extracts is also known for its and anti-inflammatory properties and its ability to manage inflammatory disorders, reduce arthritis pain and also speed up healing from infections. These extract from this tree has proved to be beneficial in the prevention of loss of cartilage and also found as an effective painkiller. Extract are also used in many industries such as beverage, cosmetics, spa treatment food and aromatherapy.

Global Boswellia Extract Market:

Although there is a very limited market for Boswellia extract in the western world currently, traces have been seen its uses in India and Asia for decades. Indonesia, India and China are among the world's biggest producers of gums and resins. Some of the key Players include Alchem International, Alps Pure, Ambe

NS Agro Product Private Limited, Herbal Creations, Jayshree Nath Herbals S.A. Arjuna Natural, Venkatesh Natural Extract Pvt Ltd, Marven Bio Chem, Manus Aktteva BioPharma LLP, and Sydler India.

Botanical description of *Lannea coromandelica* (Indian ash tree)

Gum Jhingan is an exudates of gum obtained from the tree of *Lannea coromandelica*. It belongs to family Anacardiaceae. It is also known as Jhingini in Sanskrit and wodier or Indian ash tree in English and is located in Tropical Asia (Kaur *et al*., 2013). It's a moderate to large sized deciduous tree with specific crown generally attaining a height of 20 m or more a girth 2.5-3.0 with a tall, clean, cylindrical bole up to 12m. In dry localities of its distribution in the Cental India, It remains straggling, rarely exceeding 2.0 m girth. *L. coromandelica* have grey bark which is thick scaly, flaking off in irregular plates under bark smooth, shallow pitted from fallen scales. Leaves about 35 cm long with 3-5 pairs of opposite leaflets and a solitary terminal one .Leaflets are 7-15 cm long velvety when young, tips pointy. Flowers are tiny, unisexual male and female on separate trees. The fruits are 10-12 mm long, olive shaped with a thin over scanty flesh and a single hard stone, red when ripe. .The fruiting season is found between May to July.

Geographical distribution and Ecology:

The genus *Lannea* constitutes about 40 species of trees, shrubs, and under shrubs. They are widely distributed in Africa, but only one species, *Lannea coromandelica* is located in tropical Asia. The *Lannea coromandelica* tree is distributed throughout the hotter parts of India from N-W to eastern states of West Bengal and Assam ascending to an elevation of 1200 m in hills; southwards it extends through Odisha, Madhya Pradesh, Andhra Pradesh, Maharastra,

Karnataka, Tamilnadu, Karnataka and Kerala. Elsewhere it is found in moist and mixed dry deciduous forests of India (Champion and Seth, 1968). It is a strong light demander tree species. It is resistant to fire and drought. However, it is frost tender, severe frost kills the seedlings planted in the open, but the fresh shoots, may be produced in the next growing season. It coppice well, the coppicing power varies; generally two shoots per stool are produced. It pollards well and produces root suckers.

The gum of this tree is known as Jhingan gum, which exudes from wounds and cracks in the bark of *Lannea coromandelica* tree. The colour of gum is yellowish white when it is fresh, and then turns brown, and ultimately black on drying. *Lannea coromandelica* is an important medicinal tree. It is found in degraded places and forests all over India. The leaves are used in the treatment of coma caused by narcotics, dyspepsia, general debility, gout, dysentery, sore eyes, leprosy, sprains, ulcers, inflammations, impotency and wounds healing etc.

Production and consumption of Gums:

Commercially important gums in the country came in huge quantity from the forests of central india consisting of various states like Madhya Pradesh, Chhattisgarh, Odisha, Jharkhand ,part of Andhra Pradesh and Bihar while state like Gujarat and Rajasthan contribute a small portion of it. The rest of the states in India produces a very small quantity of gum annually. More than 90% of gums produced in India come from just four states that are Andhra Pradesh, Odisha, Madhya Pradesh and Chhattisgarh. Most important Indian gums like gum Karaya, Dhawara and Salai gum are exported to America and Europe, where they are processed and value added. The local use of these gums and resins is very less i.e less than 5%. Usually most of the gums obtained from trees are used by pharmaceutical industries. In northern India, the *Acacia nilotica* Babool gum is used in food items. They are commonly used in the preparation of "laddu" to improve the vigor and vitality. Gums like *Canarium strictum* (Black dammar) and *Sterculia urens* (Katira gum) have been given vulnerable status by IUCN. Gum Karaya contributes 2% of the revenue from the medicinal plant exports from India.

The unsustainable, harsh methods of gum extraction and over exploitation leading to the death of the trees that are tapped for gum production. On account of injurious and harmful tapping practices leads to reduce the populations of gum producing trees in the natural forest stands. This causes loss of wild germplasm from natural forest stands.

Therefore, the present study was conducted at Deopur forest area of Balodabazar district of Chhattisgarh to standardize the safe potential tapping techniques for sustainable gum production technique entitled **"Standardization of Sustainable Gum Tapping Techniques In *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** with the following objectives:

1. To observe the effect of different type of mechanical cut like Square shape cut ,V shape cut, Hole shape cut on tree of 80 to 150 cm Girth class as a mechanical tapping methods for sustainable higher gum production.
2. To see the Effect of Ethephon chemical application of different concentrations on trees as enhancers and their doses standardization for optimum production of gum.
3. To study the process of gummosis in different season in trees available in the study site.
4. To determine the yield and quality of gum with mechanical methods and chemical methods.

CHAPTER -II
REVIEW OF LITERATURE

Gum is a commercially important NTFP obtained from trees and important source of income for forest dwellers, especially various tribal groups who resides inside, outside and fringes of forest area. Gum yielding trees are commercially very important and used widely in industrial sector as well as in food, pharmaceutical and medicinal purposes. Gum collection from the forest and sold to market to get money is very common practice among the forest communities particularly tribal's in India during the summer season. Around 285 million rural people in India depends on forests for their source of income and livelihood support by selling minor forest produce which tribal collect from the forests.

Gum also produced by some herbaceous perennials, trees and shrubs plant which are generally produced either naturally or in response to injury. The present practice of gum extraction from the tree is unscientific resulted loss/death of tree because of deep and so many injuries made in same tree to extract more amount of gum is a serious challenge to find out the solution. Keeping these things in view and to develop a sustainable method of gum tapping the present experiment entitled as **"Standardization of Sustainable Gum Tapping Techniques In *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** has been reviewed under the following heads.

2.1 Tapping techniques in different shapes and gum production in tree.
2.2 Gummosis process of gum yielding tree species.
2.3 Quality parameter of tapped gum.

2.1 Tapping techniques in different shapes and gum production in tree.

Sinha and Pathak (2016) carried out field experiment on various tapping methods with few modifications for sustainable and high yield of oleo-gum resin in 14 years old *Boswellia serrata* plantation raised by a pharmaceutical company of Gujarat. The results of tapping observed that tapping with a slant cut yielded more oleo-gum resin than the straight cut. The trees were tapped by making ten types of incisions in the bark to find out sustainable gum yield. Out of ten mechanical methods, only two methods, the first, V shape cut method with a hole on the lower side & treated with Ethephon and the second, hole method treated with ethephon & patched up with clay were suggested to adopt for sustainable and high yield of oleo-gum-resin.

Rijkers *et al.* (2006) reported that in *Boswellia papyrifera* that frequent gum extraction affects the flower, fruit and viable seed production. He conducted his experiment in horn of Africa, The forest stand studied; non-tapped trees produced three times more as compared to tapped trees healthy and filled seeds as compared to tapped trees. In non-tapped trees germination success was very high (> 80%) and lowest in tapped trees (<16%). The results shows that tapped trees the rate of sexual production decreased with increasing tapping regime. Overall result shows, that bigger size trees produce high seed yeild than small trees, and seed weight from non-tapped trees were heavier compared with tapped trees.

Nair *et al.* (1995) analyzed that ethephon application in *Bombax ceiba* causes schizolysigenous formation of gum duct in the axial parenchyma of sapwood of the tree .This chemical associated with the creation of cavities in tree and the vessels of secondary xylem are clogged with gummy substances.

Bhatt *et.al.* (1989) reported in *Commiphora wightii* that temperature is playing significant effect on yield of gum therefore, summer season tapping had significant effect on gum production rate ; usually in summer April and May months are peak months when temperature was maximum because of this gum production rate is higher.

Harsh *et.al* (2013) developed a technique for gum extraction from *Acacia senegal* he used 4 ml ethephon (2-chloroethylphosphonic acid) /tree containing 195 mg active ingredient per milliliter all these experiment were done during the hot dry season (March to June) at AFRI,Jodhpur. In his final result he found that by using Ethephon year by year there is successive reduction in gum yields as well as seed yields, while alternate-year application ensured a stable production of gum.

Nair (2000) conducted survey on commercial tapping methods of gum and resin in *Boswellia serrata* by blazing, peeling or making deep incision on the tree bole. In his observation the gum and resin by blazing technique so many blazes were made on same tree that excessive injury and deep cut caused death of the trees. He reported that the unsustainable harvesting unscientific methods will be banned because of death of trees.

Bhatt (1987) reported in *Mangifera indica* that the improved method of gum tapping in by using ethephon chemical in tree trunk with the help of a syringe and increment borer. The results recorded the process of gummosis is enhanced by using ethephon chemical as a catalyst to ooze out more amount of gum, he noticed that when plants were treated with 1600 mg of this chemical during April-May there is 466 fold increases in gum yield was recorded.

Gaafar (2005) showed in his experiment that production of gum was positively correlated to soil water having a depth of at 75-150 cm. He conducted his experiment in *Acacia senegal* bush-fallow system at Sudan and studied the

effect of tree density on two crops i.e *Sorghum bicolor* and *Hibiscus sabdariffa* with regard to their physiological interactions, yields and soil water depletion. *Hibiscus sabdariffa* appears to be more suitable for intercropping with *A. senegal* than sorghum .

Arya and Chaudhary (2002) reported that at the same age of 52 months irrigated trees of *L. coromandelica* with more girth at breast height (GBH) yielded nearly five times more gum (88 g) than control (18 g). Therefore, GBH along with age might be right criteria for selecting a tree for gum extraction from all gum yielding trees. There is need to work out on different girth class of trees and find out the maximum gum yielding girth class so that the gum will be extracted from those girth class trees.

Sharma *et al*.(2012) reported in his study for two years to standardize the tapping methods, tapping with different seasons, chemical concentration on trees having dbh more than 40cm from natural stands the gum yield is more. To obtaining maximum gum from these tree species, different tapping techniques have been applied to enhance the gum production in *Lannea coromandelica*. In bore hole tapping method, a hole of 5 cm is made on tree stem yielded higher gum yield when injected with ethephon concentration of 300 mg/ml and 400mg/ml in *Lannea coromandelica*. The Maximum gum production was obtained in borehole mechanical tapping method and minimum was procured from V-shaped tapping method. Ethephon has proven better extraction chemical over the sulphuric acid because acid is deadly for death of trees . Ethephon concentration of 300mg/ml showed the highest gum production of 144.2 grams/tree. However, lower concentration of sulphuric acid did not show significant results Ethephon induces gummosis without affecting the health of tree.

Ballal *et al.* (2005) conducted a experiment on Gum arabic yield, from *Acacia senegal*,Western Sudan. The effects of the date and tapping intensity, rainfall and temperatures at tapping and gum collection on gum arabic yield were examined for eight consecutive year starting from 1992-2000 in a 12-year-old

plantation. The results showed that yield was found to be positively correlated with tapping intensity, rainfall and the minimum and maximum temperatures .

Harmand *et al.* (2012) observed that the gum tapping time is best in starting of the dry season, when the relative humidity is reduced. Depending on the location along the climatic gradient he conducted gum tapping by chemical method in January to June 2014. The ethephon chemical having 39% conc. was used in various dilution in *Acacia nilotica* tree.

Misra and Singh (1985) conducted an experiment in *Lannea coromandelica* at Kukrail natural Forest of UP. He made Blazes of 5X10 cm on 50 trees and treated with NaOH (N/5, N/10, N/15, N/20), H2SO4 (N/10), and mud paste, or untreated. Maximum gum production was observed in the N/20 NaOH treatment; as compared with other treatments (except mud paste and N/5 NaOH) also stimulated production compared with control treatment in the experiment.

Nair (2000) reported that the causes of gum and resin formation and synthesis process are still not fully understood. This may be Poor soil condition of that area; drought and other unfriendly environmental conditions increase their production. Presence of the resins and natural gums either in the (cavities or ducts) of the plant parts or as exudates produced due to injury. Gums and resins are unable to re-enter the metabolism process of the plant in which they are produced and therefore, they are also called as by-products of the said trees.

Ali *et al.* (2009) have observed that the tree stem diameter play an important rolet on the frankinscense yield in *Boswellia papyrifera.* The aim was to determine the effect of position of tapping, intensity of tapping (number of tapping incisions) and diameter (DBH) of the trees on resin yield, The design are based on two factor RBD. The resin of each tree was collected after four weeks and dried in the shade for 2 weeks and then weight was measured. The result showed that diameter (dbh) of the tree had a very significant ($P < 0.01$) on frankincense yield; the yield was increased with increase in the level of tapping.

The yield from the lowest diameter i.e 50 cm was 40% lower than the yield obtained from the highest diameter i.e 150cm.

Mishra and Behera (2012) conducted a field experiment at Sambalpur district of Odisha , they analyzed comparative study of gum producing capacity of two tree species available in natural forest and find out a relationship between the girth size and gum producing capacity of these two tree species. The results showed that *Sterculia urens* is a better gum producer as compared to *Boswellia serrata*. Both of these plants were found to attain gum producing ability when reaching a girth at breast height of 41.9cm. (*Sterculia urens*) and 38.1 cm *(Boswellia serrata*).The gum producing capacity get stabilized after attaining a girth of 119cm in case of *Sterculia urens* and 86 cm in *Boswellia serrata* after that increase of DBH and age of the trees the gum yield in decreasing order

Dione and Vessal (1998) observed that the pre tapping rainfall in *Acacia senegal* affects the onset of tapping. On the other hand, low temperature at tapping seems to seal the gum canals available in the wood it resulted the close the exudation points. The impact of rainfall , temperature difference and the time of tapping affect the yield of gum significantly. In general, peak gum production period is stimulated by the commencement of drought conditions as the rainy season ended and air temperature rises.

Singh and Shukla (1975) standardize the technique of tapping in *Butea monosperma* trees belongs to diameter classes and tapped under the two different methods and yield data were recorded. During Statistical analysis the data discover that there is no significant difference in yield of gum whether the trees are tapped by local method or notching method.

2.2 Gumosis Processes of gum yielding tree species

Fahn and Evert (1974) reported that gum ducts initiate and develop schizogenously in the inner ground tissue of rachis and petiole in *Buchanania lanzan* and *Lannea coromandelica and* pith in the stem of *Anacardium*

occidentale, *Ailanthus excelsa*, and secondary xylem rays in stem of *Lannea coromandelica* tree.

Dell and Comb (1978) reported that the gum is soluble in cold or hot water, but insoluble in organic solvents. On the other hand, resin is insoluble in water but soluble in organic solvents. This is the observation made by him

Morrison and Polito (1985) studied that gum ducts found in both woody tissues and fruits in all cultivated *Prunus* species. Gum ducts are formed naturally in healthy fruit trees. However, gum production enhanced after the use of ethylene releasing compounds, infection in tree trunk, insect attack, mechanical damage, and environmental stress.

Sniewski *et al.* (2006) observed that gums are ooze out by infection, attack of insects, mechanical incision or injury, by chemical, water stress and other climatic condition including stress in plant species. All these factors are believed to act *via* ethylene produced in plant tissues. Ethylene is the main factor responsible for the gummosis process takes place in gum yielding tree species. Ethylene releasing compounds such as ethephon substantially stimulate gum formation in many trees yielding gum and resin.

Purkayastha (1959) recorded that in *Anogeisus latifolia* the gum formation ducts in present in the xylem or wood in response to injury/ incision which exude gum profusely and called these ducts as 'traumatic' ducts or gum ducts. When the young stem is cut transversely gum exudation can be seen with naked eye on the cut surface. However, after sometime gum is also seen exuding in the xylem region near the cambium.

Dadswell and Hillis (1962) reported that due to damage of cambium by different mechanical disturbances like abrasion, insect, fire etc gum canals as well as resin pockets developed in the hard woods of the trees.

Esau (1965) reported that the production of gums in plants is not well understood, these substances often gathered in response to stress, injury, or bacterial, fungal or insect attack on the plant and usually associated with xylem cells and special structures called gum duct. During gummosis process, cellulose become decomposed due to disintegration of internal tissue results in the reduction of starch in cells and in many cases appears to involve breakdown of cell walls.

Hall and smith (1995) reported that the ethephon used as gum enhancer usually metabolizes into ethelene gas inside plant tissue and biosynthesized in, especially drought plants in response to environmental stress it is just like the catalyst which activate the gummosis processes in a faster rate resulted more amount of gum yield compared with normal injury/ incision made on the gum yielding trees which are economically important.

Wilde and Edgerton (1975) reported that the ethephon release may be a cause's loss of middle lamellar cohesiveness and the breakdown of the primary cell walls in phloem tissue in and around gum pockets. These are the physiological observations made by the author of this paper.

Joel and Fahn (1980) reported that initiation and development of ducts are lysigenous in the secondary phloem of stem in *Anacardium occidentale*, *Buchanania lanzan* and *Lannea coromandelica*. Also in cortex region of stem and primary phloem of pseudocarp and endocarpic region of nut in *Anacardium occidentale* tree.

Shah *et al.* (1980) conducted experiment and observed that enzymes activites peroxides, acid phosphatase, succinate dehydrogenase, ATPase, amylase and lipase were present in the epithelial cells of gum and resin canals available in Guggal *(Commiphora mukul)* and Salai *(Boswellia serrata)*. He recorded high level of amylase as well as lipase in the epithelial cells because of breakdown and conversion of starch and lipid into gum and resin as a byproduct of trees.

2.3 Quality Parameter of tapped Gum.

Reddy *et .al.* (2015) In his work studied the microscopic as well as phyto-chemical analysis of leaf powder of *Boswellia serrata* observed all the distinctive minute features of the plant and physico-chemical contents like ash values, loss on drying, extractive values, fluorescent character are under limits. The Preliminary phyto-chemical screening, TLC and Total Phenolic content revealed the presence of Poly phenols in the methanolic extract of the leaf the value of Gallic Acid Equivalents and Tannic Acid Equivalents were 7.43 and 11.864 found respectively.

Niphadkar *et al.* (2017) work on extraction of maximum amount of AKBA Chemical from *Boswellia serrata* by using Three Phase Partitioning (TPP) technique. The present work establishes the application of ultrasound for intensification of extraction of acetyl 11-keto-*β*-boswellic acid (AKBA), it used as a anti-inflammatory agent from *Boswellia serrata* tree. Ultrasound-assisted extraction (UAE) yield is also compared by using Soxhelt and batch extraction techniques.

Muhammad *et al. (2017*) studied the Biological activity of *Boswellia serrata* oleo gum resin by using supercritical carbon dioxide and traditional method. In his final result of this study he also suggested that chemical composition, essential oil yield, antioxidant and antimicrobial activity and other values of *Boswellia serrata*. The essential oils extracted by hydro distillation and steam distillation and supercritical fluid carbon dioxide methods vary from each other and the optimum essential oil yield was obtained by using hydro distillation method of distillation of essential oil available in gum.

Ramachandran *et al.* (1968) Observed different chemical Properties of Jhingan gum. The gum obtained from the tree species of *Lannea coromandelica* has been found to be a neutral polysaccharide composed of D-

galactose and L-arabinose in the ratio of 4:1. During hydrolysis of the methylated polysaccharide gave result of presence of 2, 3, 4, 6-tetra-*O*-methyl-D-galactose (1 mole) and 2, 3, 5-tri-*O*-methyl-L-arabinose (2 moles).

Tahara *et.al.* (2002) In a survey showed zoosporicidal activity of of the *Aphanomyces cochlioides* and *Lannea coromandelica* and found that secondary metabolites regulating motility and viability of zoospores.. Commercial polyflavonoid tannins, Quebracho and Mimosa, also showed identical zoosporicidal activity. Both the tree species were visualized through electron microscopic observation as well as cell membrane fragmentation method.This may be useful in the medical treatments.

Kaur *et al.* (2012) studied the phytochemical analysis of extracts *in Lannea coromandelica.* The results obtained positive for flavonoids, tannins, terpenoids etc and thr physicochemical parameters such as total ash content, acid insoluble ash value and water soluble ash value were determined which was 10.08% w/w, 0.77% w/w, 1.80% w/w respectively.

Gerbeth *et al.* (2012) studied and reported that regarding *Boswellia serrata* gum resin extracts and found the medicinal uses widely utilized for the treatment of various inflammatory diseases. However, very low concentrations in the plasma and brain were observed for the boswellic acids (1-6, the active constituents of *B. serrata*). The gum will be used for the treatment of inflammatory diseases

Sharma A.K (2018) describes the fabrication of silver nano-composites based on semi interpenetrating network as well as interpenetrating network (IPN) matrices of *Boswellia serrata* determine their antibacterial activity. By using microwave radiation the semi IPN and IPN matrices were prepared. Polyacrylic acid and polyacrylamide chains are used to graft copolymerize the polysaccharide fraction of gum Salai.

.

Mengistu *et al.* (2013) examined two tapping treatments, one without tapping (control) and the other with tapping by making 12 incisions on *Boswellia papyrifera* single tree at Ethiopia . Trees are tapped during the leafless dry season, reducing their carbon storage pools. To study the impact of tapping on TNC concentrations in stem-wood this experiment was conducted on bark and root tissues of the *Boswellia papyrifera* tree .In his final result he found the highest TNC concentrations occurred in the stem-wood.

Davison (1980) reported that the natural gums (gums obtained from plants) are hydrophilic in nature and have high molecular weights and are water soluble or absorb water and swell up in cold water to give a viscous solution or jelly. Generally they composed of monosaccharide units joined by glucocidic bonds. They are generally insoluble in oils or organic solvents such as hydrocarbons, ether or alcohols.

Vadivel *et al.* (2012) studied and reported the preparation of different extracts by using successive solvent extraction technique on *Boswellia serrata* tree. Fluorescence analysis of different extracts and powder were observed under UV light and normal ordinary light, which signifies there characteristics. Different physicochemical parameters such as ash content, extractive value were also determined.

Lohithasu *et al.* (2017) analyzed the microbial growth and results came from the experiment that Lannea did does not support microbial growth and it was free from all pathogen organisms. He also determines Moisture content and he found the moisture content to be 8.52 ± 0.59 %. The pH of the 1% w/v GG (Lannea gum) powder mucilage was found to be 6.1 to 6.5. Micromeritic studies of the Gumpena gum powder showed good flow and compressibility characteristics.

Reddy *et al.* (2011) observed the proximate analysis of different gums studied shows that they have low total ash content, high methanolic extractive values, and have low moisture content. He selected tree *Cochlospermum gossypium* belongs to family *Bixaceae,* and gum ghatti obtained from *Anogessius latifolia (Roxb)* belongs to family *Combretaceae* were standardized. The nature of

gums was confirmed by phytochemical screening and with Thin Layer chromatography (TLC), and High Performance Thin Layer chromatography (HPTLC) which indicated distinct finger prints with methanol extract.

Pendyala *et al.* (2010) analized various physicochemical properties of *Leucaena leucocephala* bark gum and analyzed its swelling capacity and viscosities pH, at different temperatures using standard methods. It swells to about 5 times its original weight in water. The gum exhibited pseudo plastic flow pattern at concentrations of 2 and 5 %w/v, while at 10 %w/v concentration the flow behavior was thixotropic.

Gundidza *et al.* (2011) worked on the topic of the rheological, moisture and ash content of a gum resin obtained from *Commiphora africana*, he used a rotational viscometer for rheological studies. The *C. africana tree* shows low shear stress even at high concentration of the gum resins. The change in shear stress with temperatures produced almost a linear graph with a gradient of 0.06. The moisture content obtained was 10.6 ±0.04%. The ash content was 3.64±0.01 %.

Ocheje *et al.* (2013) investigated the physicochemical properties, cationic composition and rheological behavior of exudates from *Ficus glumosa* (mountain fig). At the end of his experiment reported the viscosity of the gum increases with increasing pH level and concentration but decreases with increase in temperature of the site.

CHAPTER - III

MATERIALS AND METHODS

The present investigation entitled **"Standardization of Sustainable Gum Tapping Techniques In *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** was carried out at Deopur Forest Range, compartment no 281,district Balodabazar (Chhattisgarh) during the 2018 and 2019 The details of study site, climate, soils and the methodologies during the course of investigation are briefly described.

3.1 Experimental site:-

The study was conducted in natural forest stands of *Boswellia serrata* and *Lannea coromandelica* at Compartment no 281 of Deopur Forest Range Deopur, Balodabazar Forest Division (Chhattisgarh) during the year 2018 and 2019.

3..1.1 Geographical location:-

The experimental site Deopur is situated at 21^0 23' N Latitude and 82^0 33' E Longitude with an altitude of 319 M meters above the mean sea level.

3.1.2 Climate:-

The climatic condition of experimental site is Sub-Humid Dry Tropical. The area receives an average annual rainfall around 100-120 cm. About 90% of the rainfall takes place during the South West Monsoon i.e between June to September. Only 8% of the annual rainfall takes place during the winter season from October to February and only 2% of the annual rainfall takes place during summer season .May is the hottest month during which temperature rises upto 42 ^{0}C and December is the coolest month during which the temperature decreases to 16.5 ^{0}C. During the driest period i.e summer season is lowest about 35% and is highest during the South West Monsoon.The Maximum 18.2 mm and minimum 10.5 mm Evapo-transpiration is observed during the month of May, while wind velocity is high from May to August.

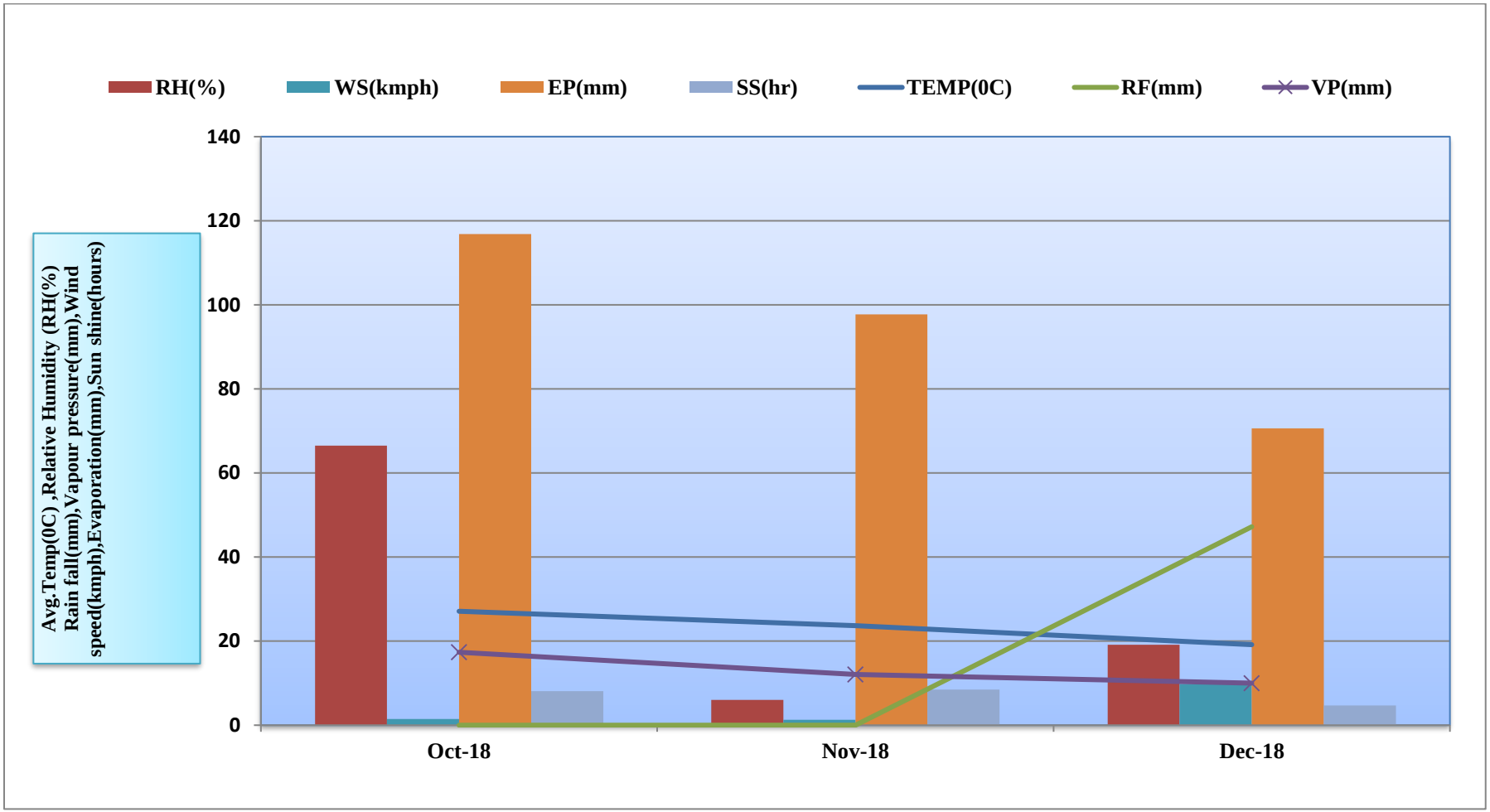


Fig 3.1- Monthly meteorological data from October to December 2018.

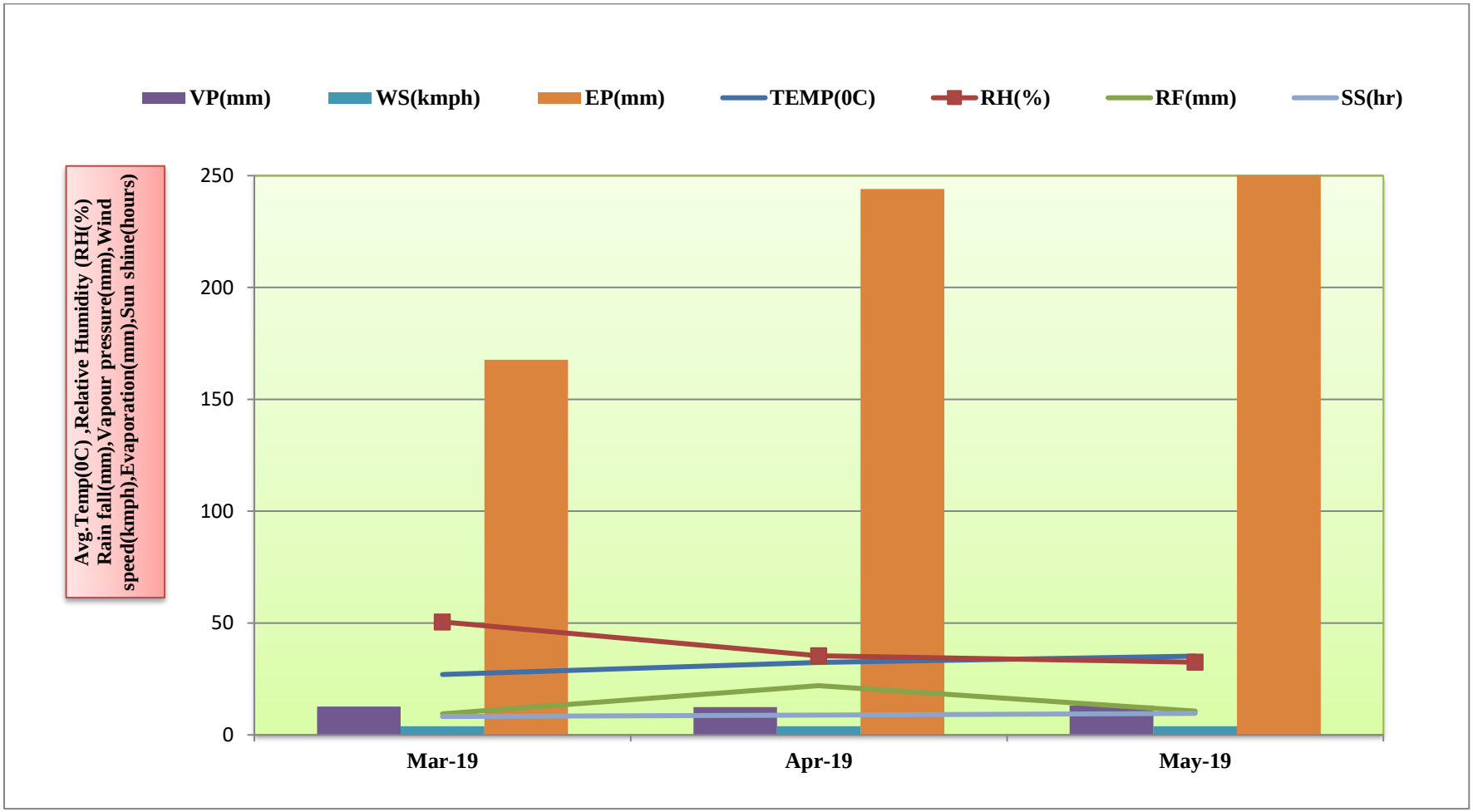


Fig 3.2 - Monthly meteorological data from March to May 2019.

3.1.3 Soils:-

The soils of this experimental area ranges from heavy clays to shallow loamy ,reddish ,brown upland graved.The soil comes under arang series which further subdivided in to Kanhar-Dosra and Dosra and soil shows slight acidic or neutral in reaction (Working Plan Report).

3.1.4 Tree species composition in Chhattisgarh

The total geographical area of Chhattisgarh is 137.90 lakh ha (4.15% of the geographical area of the country) .The state of Chhattisgarh being placed in Deccan bio geographical zone. The forests of the state fall under two major forest types, i.e., Tropical Moist Deciduous forest and the Tropical Dry Deciduous forest. The state of Chhattisgarh is gifted with about 22 varied forest sub-types existing in the state.

The Sal (*Shorea robusta*) and Teak (*Tectona grandis*) are the two major dominating tree species in the state. However, other notable over wood species are Bija sal (*Pterocarpus marsupium*), Saja (*Terminalia tomentosa*), Dhawra (*Anogeissus latifolia*), Mahua (*Madhuca indica*), Tendu leaf (*Diospyros melanoxylon*) etc. Amla (*Embilica officinalis*), Karra (*Cleistanthus collinus*) and bamboo (*Dendrocalamus strictus*) constitute a significant chunk of middle canopy of the state forests. From the management point of view, there are four types of forests in the state of Chhattisgarh. These are Teak, Sal, miscellaneous and Bamboo forests. Biogeographically, the state falls in Deccan bio region comprising representative fauna and flora. The recorded forest area in the state is 59,772 sq. km which is 44.21% of its geographical area (FSI,2017report). Reserved, Protected, Un classed Forests constitute 43.13%, 40. 22%, 16.55% of the total forest area respectively.

3.1.5 Vegetation of Deopur Forest Range:-

The Deopur forest range is dominated by tree species like *Terminalia tomentosa, Cleistanthus collinus, Anogeisus latifolia, Diospyros melanoxylon, Madhuca indica, Adina cordifolia, Bombax ceiba, Acacia catechu, Terminalia bellirica, Phyllanthus emblica, Buchanania lanzan, Aegle marmelos, Mitragyna parviflora, Schleichera oleosa, Dalbergia latifolia, Cassia fistula, Careya arborea, Azardirachta indica, Acacia nilotica, Gardenia resinifera, Sterculia urens, Delonix regia.* Associate vegetation consist of *Lagerstroemia lanceolata, Ixora pavetta, Diospyros melanoxylon, Chloroxylon swietenia.*

3.2 Experimental material

The naturally standing trees of Boswellia *serrata and Lannea coromandelica* were selected during winter 2018 and Summer 2019 at Deopur Forest Range, Balodabazar Forest Division in Chhattisgarh.

The brief description of study trees are as follows:

The brief description of study trees are as follows

3.2.1 Gum Salai *(Boswellia serrta)*

Gum Salai is an exudates of gum obtained from the tree of *Bowsellia serrata* which is also known as Salai guggal, gum Olibanum or frankincense is the most important forest product of our country. Salai is a moderate sized to a large sized deciduous tree with a light spreading crown and somewhat drooping branches, attaining a height of 9-15 with a short bole of 3.0 to 4.5 m and a girth of 1.2 to 2.4 m. The bark is dark greenish grey, fairly thick, peeling off in thin papery resinous inside flakes. The genus Boswellia belongs to the Burseraceae family and is widely distributed in the dry regions of tropical India Africa, Arabia. The best quality gum is collected during April, May and June i.e. in summer.

USES

- Salai gum resin is traditionally used as incense because of its very unique fragrance.
- It is widely used in Ayurvedic formulations for treating asthma and arthritis, fibrostitis (muscle pain), inflammatory bowel disease (IBD) and brain tumours.
- Boswellic acids in the resin act as a safe alternative to steroidal drugs like Phenyl butazone and other anti-inflammatory drugs
- Gum has anti inflammatory and anti-cancer effect.
- The resin is widely used as house hold fumigant and fragrance (High quality incence)
- Its timber used in packing case ,toys and paper pulp and toys making
- Burning incense
- Perfume industry (the essential oil of frankincense from *B. papyrifera* consists of mainly n-Octyl acetate (56%), octanol (8%) and limonene (6.5%) .
- It is also used in the fabrication of adhesives, fumigation powders, dye manufacturing and varnishes making.
- It is used as a flavoring in bakeries industry and other food industries that produces milk products and various alcoholic and soft drinks. The distinctive flavor of frankincense also makes it valuable for chewing gum industries.
- Incense is used as an ingredient of lotions, soaps, detergents and creams.
- In addition, it is also used in ointment formulation, for wound plasters, toothpaste and mouthwash.

Fruit bearing in *B. serrata* in summer

Close up view of Leaves of *Boswellia serrata*

Papery bark of *B. serrata* Tree

View of *B. serrata* tree during October month

View of Experimental site during summer season.

Plate- I : A view of *Boswellia serrata* tree in different season at Deopur Forest Range

3.2.2 Gum Jhingan (*Lannea coromandelica*):

Gum Jhingan is an exudate of gum obtained from the tree of *Lannea coromandelica* ***which*** is also known as Indian ash tree, gum olibanum or frankincense is the most important forest product of our country. *L. coromandelica* have grey bark which is thick scaly, flaking off in irregular plates under bark smooth, shallow pitted from fallen scales. Leaves about 35 cm long with 3-5 pairs of opposite leaflets and a solitary terminal one. Leaflets are 7-15 cm long velvety when young, tips pointy. Flowers are tiny, unisexual male and female on separate trees.

USES

- Gum obtained is use as confectionary (Cakes, chocolates) and Powdery bark is used as flavouring.
- Gum is widely used for calico pri nting (floral print), as a size for paper for mixing with lime when white washing, protecting nets.
- Also used in inferior varnishes and ink, paper and cloth sizing
- The plant gum is given in sprains (tearing of ligament), asthma and as a cordial to women during lactation.
- Gum used as medicine to treat asthma and externally as a plaster to alleviate rheumatic pains.
- The bark yield a coarse cordage fibre

3.3 Experimental details:

3.3.1 Mechanical tapping technique

Location of Experiment:	: Compartment no -281,Deopur Range, Balodabazar(Chhattisgarh)
Species	*:Boswellia serrata,Lannea coromandelica*
Design	:Factorial RBD
Number of Replications	:02
Number of Treatment	:3 in each tree in each season in (Total 12 in both winter and summer season)

Bark of *Lannea coromandelica* tree

Flowers in clustur during summer

Fruits of *L. coromandelica* during summer

Leaves *of L. coromandelica during rainy season*

Leafless view of *L. coromandelica* trees during summer season.

Plate-II : View of *Lannea coromandelica* tree in different season at comp. no 281 of Deopur Forest Range

Table 3.1: Details of Mechanical Treatment in Winter Season 2018 and Summer Season 2019.

TREATMENTS	***Boswellia serrata* Trees**	***Lannea coromandelica* Trees**
T1	SQUARE SHAPE	SQUARE SHAPE
T2	V SHAPE	V SHAPE
T3	HOLE SHAPE	HOLE SHAPE

3.3.2 Mecanical +Chemical tapping Technique:-

Location of Experiment: : Compartment no -281,Deopur Range, Balodabazar (Chhattisgarh)

Species *:Boswellia serrata,Lannea coromandelica*

Design :Factorial RBD

Number of Replications :02

Number of Treatment :9 in each tree in each season (Total 36 in both winter and summer season)

3.3.3 Mecanical +Chemical Treatments Details

Table 3.2: Details of Mechanical+Chemical Treatment Winter Season 2018 and Summer Season 2019.

Treatments Mechanical+ Chemical	***Boswellia serrata* Trees**	***Lannea coromandelica* Trees**
T4	Ethephon 10%+Square shape cut	Ethephon 10%+Square shape cut
T5	Ethephon 20%+Square shape cut	Ethephon 10%+Square shape cut
T6	Ethephon 30%+Square shape cut	Ethephon 10%+Square shape cut
T7	Ethephon 10%+V shape cut	Ethephon 10%+V shape cut
T8	Ethephon 20%+V shape cut	Ethephon 20%+V shape cut
T9	Ethephon 30%+V shape cut	Ethephon 30%+V shape cut
T10	Ethephon 10%+Hole shape cut	Ethephon 10%+Hole shape cut
T11	Ethephon 20%+Hole shape cut	Ethephon 20%+Hole shape cut
T12	Ethephon 30%+Hole shape cut	Ethephon 30%+Hole shape cut

3.4 Gum tapping methods:-

The detailed methods of the experiment are described below:

3.4.1 Mechanical tapping method:-

Three mechanical cut as Square shape, V shape and Hole shape incision were made on each tree species *Boswellia serrata and Lannea coromandelica* in Winter 2018 and Summer 2019 season details of these incision is given below.

1. The Square shape cut of width 8 cm and length of 8 cm were made with carpenter wood Chisel having depth of 1-2 cm on trees of 80-150 cm girth class at DBH .

2. The V shape cut of length 9 cm and width 3 cm having depth of 1cm depth was made on trees of 80-150 cm girth and confined nearer to breast height with the help of chisel.

3. The Hole shape cut made with driller machine 2.5 * 2.5 cm. deep. These all were made at DBH of the tre.

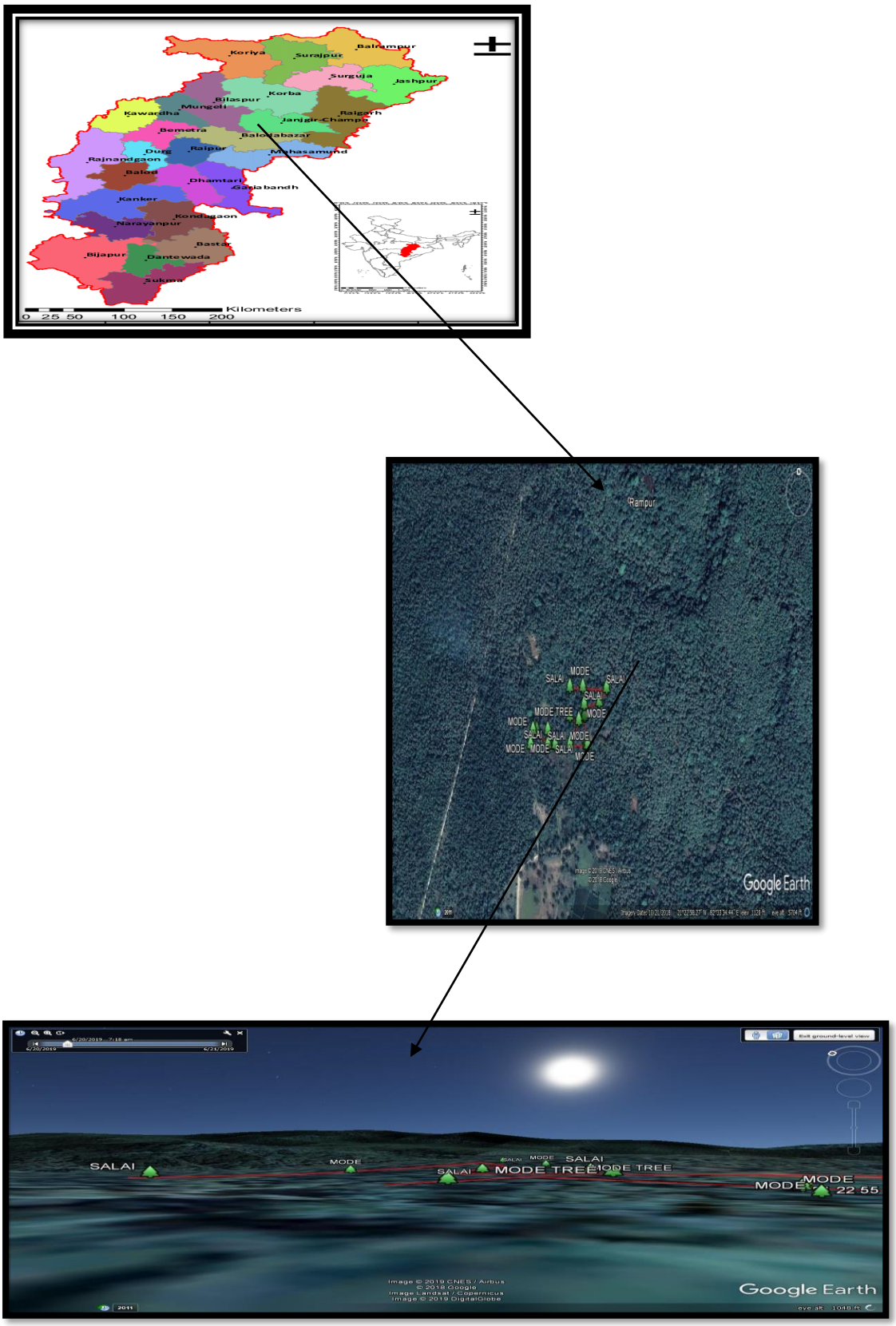
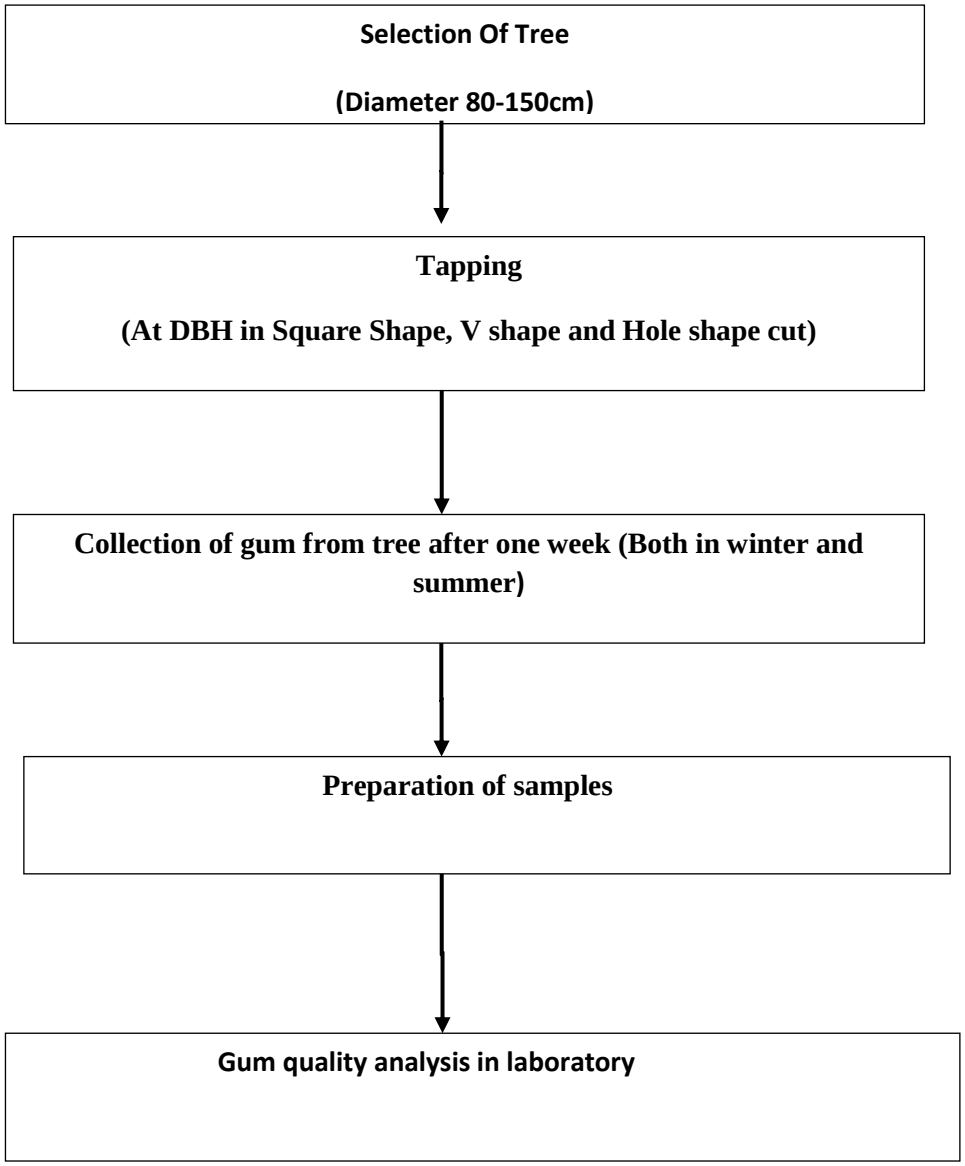


Fig 3.3 -Location of field at Compartment no 281,Deopur Forest Range, Balodabazar Forest Divison

3.3 Flow chart for Mechanical method:-



EXPERIMENTAL PROCESS FLOW CHART

3.4.2 Mechanical + Chemical tapping method:-

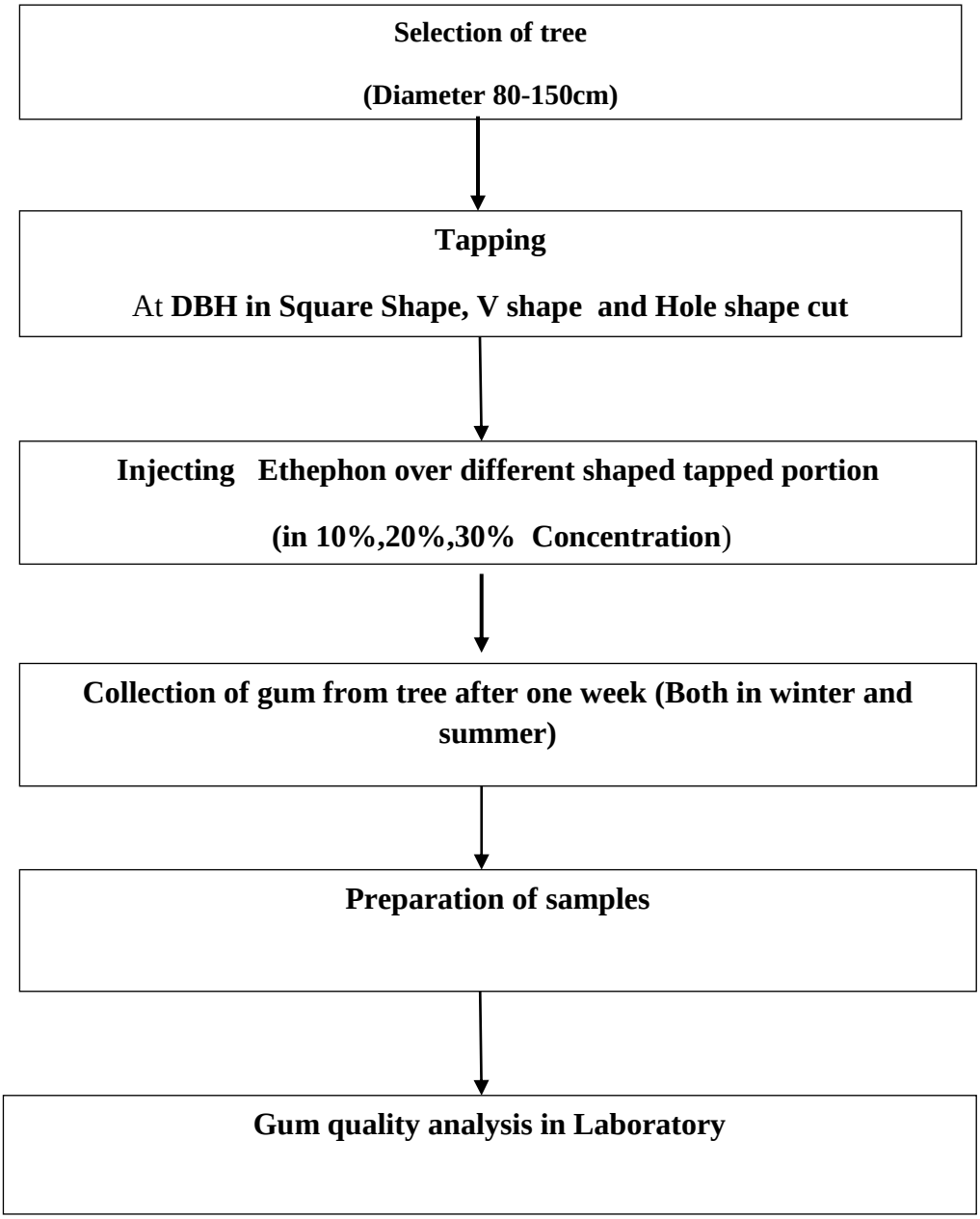
Nine chemical methods were used for each tree Salai (*Boswellia serrata)* and Mode *(Lannea coromandelica)* in each season**.** The chemical gum tapping of selected trees was initiated using different doses of gum enhancer Ethephone (2-chloro-ethyl-phosphonic acid) (trade name Ethrel) having 39% a.i in 10% ,20% ,30% concentration in the tree trunk by battery operated drill machine to induce gummosis process. The entire treatments were made through a syringe of 60 ml volume. The 4 ml gum enhancer was injected the whole period of tapping in each tree

1. Three square shape cut of each tree of dimension 8 cm length and 8 cm width with depth of 2 cm was made on trees of 80-150 cm girth and confined nearer to breast height with the help of wood Chisel set and chemical was applied on cut portion.

2. Three V shape cut of dimension 9 cm length and 3 cm width With depth of 2 cm was made on at least trees of 80-150 cm girth and confined nearer to breast height with the help of chisel and chemical was applied.

3. Three hole shape cut of dimension 2.5 * 2.5 cm width depth 2 cm was made on at least trees of 80-150 cm girth and confined nearer to breast height with the help of Battery operated drill machine 12 V and chemicals was applied.

3.4 Flow chart of Mechanical + Chemical tapping method:-



EXPERIMENTAL PROCESS FLOW CHART

Selection of site and selection of trees before start of Experiment during May 2018

Marking of trees from 80-150 cm girth class

Gums collected in cups

After extraction of gum incision was covered with mud paste to heal the incision in *B. serrata*(left) and *L. coromandelica*(Right)

Plate-III: Selection of experimental site and various operations during research work.

3.5 Observations:-

The observations included time of treatment application rate of gum exudation (g/month), time of gum exudation, quantity of gum exudation (g/tree/Season).The details of the observations are described below.

3.5.1 Time of treatment application:-

The chemical treatment were applied after 9O'clock in between 9-1 pm during the first week of October 2018 and March 2019 and mechanical treatments were also given at same time.

3.5.2 Rate of gum exudation (g/month)

The rate of gum exudation was measured by application of mechanical and Mechanical +Chemical treatment and collecting the gum at different time intervals in a month.

3.5.3 Time of gum exudation

The gum exudation was observed after application of treatment in the morning, afternoon after three to four days of the commencement of treatment.

3.5.4 Tree girth diameter (cm)

The tree girth was measured with the help of measuring tape. All the mechanical and chemical gum tapping techniques were made at DBH (i.e 1.37 m from the base of tree).

3.5.5 Quantity of gum exudation (g/tree/season)

The quantity of gum exudation was measured by collecting the gum at different time interval in a month and adds them to know total gum yield in eqach season. The yield data per year obtained was compared to check variation in gum exudates per month on the basis of weight.

3.5.6 Gummosis process in stem (Mechanism of gummosis)

The process of gummosis and traumatic duct formation was studied during their development after mechanical and Mechanical + Chemical tapping or injury.

Mechanism of Gummosis/gum production

The process of gum production usually related to abiotic as well as biotic stress of tree. Plant plays important role in production of various biopolymers like gum/resin. The impact of gum enhancer ethephon was found significantly superior, regarding the production of various biopolymers. It was observed that the application of ethephon enhanced the process of gummosis in trees , due to formation of gum ducts and histological change the Sap wood. Small gum ducts are present in tissues and surrounded by epithelial cells of plant. The number of gum/ resin ducts always varied with the tree girth. The gum is formed in the gum ducts distributed in the tissue near the bark. Gum ducts are formed after incision or due to use of ethephon. Application of ethephon creates stress condition internally similar to process of senescence under water stress conditions and develops traumatic ducts of irregular lumen without and distinct epithelial cells within 30-40 minutes in salai and it is present in sapwood section (2 hrs).(kurwansi 2017)

3.6 Quality parameter

The study of quality analysis of gum samples was done in Department of Forestry ,College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

3.6 .1 Colour:

The collected gum sample was analyzed visually for colour determination.

3.6 .2 Odor:

The collected gum sample was analyzed by aroma for odor determination.

3.6.3 pH:

pH of 25% aqueous gum solution (w/v) was measured with the help of glass electrode pH meter in which 10 g of gum sample was dissolved in 40 ml of distilled water and then solution was used for pH measurement as described by Yusuf (2011).

3.6.4 Moisture content:

Moisture content of gum samples was determined by drying 5g of the gum sample to constant weight at 80 ^{0}C using hot air oven. Dried samples were cooled in desiccators before weighing. Moisture content was expressed as % of mass loss from the original mass as described by Yusuf (2011).

$$\mathbf{MC} = \frac{\mathbf{Wt\ of\ total\ sample - Wt\ of\ dry\ sample} \times \mathbf{100}}{\mathbf{Wt\ of\ total\ sample}}$$

3.6.5 Ash content:

Ash content of the gum samples was determined by burning 1g of gum sample in a muffle furnace at 550 ^{o}C for 4 hour. The ash content was expressed as % ratio of the weight of ash to weight of the sample.

Ash value is designed to measure the total amount of material remaining after ignition. It includes both physiological(derived from plant tissue itself) and non physiological(residue of the extraneous matter like sand that are adhering to plant substances. It also used to determinethe critical levels of foreign matter, acid insoluble matter, salts of calcium, potassium and magnesium (Mocak et al., 1998).

$$\mathbf{Ash\ content} = \frac{\mathbf{W3-W1} \times \mathbf{100}}{\mathbf{W2-W1}}$$

Where, W1 = weight of the empty crucible W2 = weight of crucible + sample and W3 =weight of crucible + ash

3.7 Statistical analysis

Design of experiment=Factorial R.B.D

Mechanical Treatment(M)=one

Chemical + Mechanical Treatment(C)=Three

Season of collection(S)=Two

Replication=Two

Table: 3.5 Skeleton of anova is as follows

Source of variation	**DF**	**SS**	**MSS**	**F cal**	**F tab 5%**
Replication (r)	1	SSr	SSr/DFr	$MSSr/MSS_E$	
Shape (S)	2	SSs	SSs/DFs	$MSSs/ MSS_E$	
Chemical (C)	3	SSc	SSc/DFc	$MSSc/ MSS_E$	
S× C	6	SSs*c	SSs*c/DFsc	$MSSs*c/MSS_E$	
Season(Se)	1	SSse	SSse/DFse	$MSSse/MSS_E$	
S×Se	2	SSs*se	SSs*se/DFs*se	$SSs*se/MSS_E$	
C×Se	3	SSc*se	SSc*se/DFc*se	$MSSc*se/MSS_E$	
S×C×Se	6	SSs*c*se	SSs*c*se/DFs*c*se	$MSSs*c*se/MSS_E$	
Error	23	SS_E	SS_E/DF_E		
Total	47				

The significance of difference among treatment means were tested by F test at 5% level of significance. If significant F value was found, critical difference was calculated to test the significance of difference between any two treatment mean as follows:

1.Critical Difference

CD = S Ed x t value at 5 % at error degree of freedom

SEd =$\sqrt{2EMS}/r$

Where,

SEd = Standard error of difference between two treatment means

EMS = Error mean sum of square , r = Number of replications

CHAPTER – IV
RESULTS AND DISCUSSION

The present investigation entitled as **"Standardization of Sustainable Gum Tapping Techniques in *Boswellia serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** was carried out at Deopur forest range in Balodabazar Forest Division (Chhattisgarh) during the year 2018-2019. The main objective of the experiment was to standardize and develop a sustainable & scientific tapping technique of *Boswellia serrata and Lannea coromandelica* during winter and summer season. The results of the present investigation have been described under the following heads:

4.1 Gum tapping through mechanical methods
4.2 Gum tapping through Mechanical + Chemical method
4.3 Season wise and Treatment wise gum production by Mechanical method
4.4 Season wise and Treatment wise gum production by Mechanical+Chemical method.
4.5 Quality parameters of the tapped gum

4.1 Gum tapping through mechanical method

The population of various gum yielding trees is reducing day by day due to unsustainable harvesting methods by the collectors. Hence, the study was made *via* using various sustainable methods viz*;* Square shape cut,V shape cut and Hole shape cut at DBH (diameter at breast height) and compared with different incision and yield of tapped gum during summer and winter season . The study was carried out in two consecutive years 2018 and 2019 started from October up to May.

The different size of cuts on tree trunk made for tapping of gum healed automatically after few weeks. The rate of exudation *via* different mechanical methods was compared and results presented in (Table 4.1 and 4.2). The treatment

applied on both the tree species in first week of October 2018 in winter and second treatment was applied in first week of April 2019.The gum exudation was continued up to December for winter and last week of May for summer 2019. After that the cuts made on trees were sealed with the wet mud to cover the injury on tree.

4.1.1 Effect of mechanical methods of tapping and rate of gum exudation (g) in *Lannea coromandelica* during year 2018 and 2019.(g/month)

In present investigation the maximum rate of gum production in mechanical method was observed in the month of May in summer season i.e 7.35 g and 3.88 g in the month of October in winter season. It was due to gum production was positively correlated with low relative humidity and high temperature. The average temperature during month of May and October was comparatively higher than other months so the gum yield was more in this two month. The debarked area was freshened with manual iron Chisel at regular interval of 3-4 days. The maximum quantity of gum produced in square shape cut however, not a single drop of gum produce in other shape of cuts in winter and summer season of 2018 and 2019. Ballal *et al.* (2005) also reported in his experiment that the Gum yield was positively correlated with tapping intensity, rainfall, and minimum and maximum temperatures. The results obtained by the present experiment confirmed with the result of above worker that when the temperature is maximum and low relative humidity the gum ooze out in more quantity.

The result on effect of mechanical tapping in rate of gum exudation for month of October to May both the seasons presented in Fig. 4.1

Table-4.1 Effect of temperature and relative humidity on rate of gum exudation (g) in *Lannea coromandelica* by mechanical method (g/month)

Treatment	2018(Winter)			Total	2019(Summer)			Total
	Oct	Nov	Dec		Mar	Apr	May	
Temp(^{0} C)	27.10	23.65	19.15		27	32.4	35.2	
Rh(%)	66.5	60.0	65.0		50.5	35.5	32.5	
T1	3.88	3.55	2.12	7.43	4.93	4.21	7.35	16.49
T2	0	0	0	0	0	0	0	0
T3	0	0	0	0	0	0	0	0
Total	3.88	3.55	2.12	7.43	4.93	4.21	7.35	16.49

T1-Square shape cut , T2-V Shape cut, T3-Hole shape cut

*** S = Square cut, V= V shape cut, H= hole shape**

.

4.1.2 Effect of mechanical methods of tapping and rate of gum exudation in *Boswellia serata* during year 2018 and 2019.(g/month)

The result on effect of mechanical tapping in rate of gum exudation for month of October to May both the seasons presented in Fig. 4.2. The highest rate of gum production of 8.75g in mechanical method was observed in the month of May and 2.39 gm in the month of October in winter season. In winter season in the month of December the temperature was 19.15 ^{0}C so the rate of gum production was very less. Similarly in the month of March of temperature was comparatively lower than other two month so the gum exudation rate was also less in that month. The debarked area after incision made on tree was freshened with the help of chisel at the regular interval of 3-4 days for better gum yield.

Out of the three shape cut made on tree the maximum quantity of gum produced in Square shape cut, followed by V shape cut and no gum exudation obtained in hole shape cut. The maximum quantity of gum obtained in square shape cut method 6.53g/tree in winter, 2018 and 10.82 gm/tree in summer 2019,Wheeras by using V shape cut in Summer season in *Boswellia serrata* tree a small amount of gum was ooze out from tree ,Similar V shape treatment when applied in winter month no gum was ooze out from *B.serrata* tree.

Results obtained by using mechanical method of tapping in both the tree species Square shape incision was better for sustainable gum tapping in both the season although the amount of gum yield was lower than Mechanical + Chemical method of tapping but this method does not hamper the tree health.

Table- 4.2 Effect of temperature and relative humidity on rate of gum exudation in *Boswellia serrata* by mechanical method (g/month)

Traetment	**2018(Winter)**			**Total**	**2019(Summer)**			**Total**
	Oct	Nov	Dec		Mar	Apr	May	
Temp (^{0}C)	27.10	23.65	19.15		27	32.4	35.2	
Rh (%)	66.50	60.00	65.00		50.5	25.5	32.5	
T1	2.39	1.86	2.28	6.53	1.9	2.56	6.41	10.82
T2	0	0	0	0	0	2.22	2.34	4.56
T3	0	0	0	0	0	0	0	0
Total	2.39	1.86	2.28	6.53	1.9	4.78	8.75	15.38

T1-Square shape cut , T2-V Shape cut, T3-Hole shape cut

*** S = Square cut, V= V shape cut, H= hole shape cut**

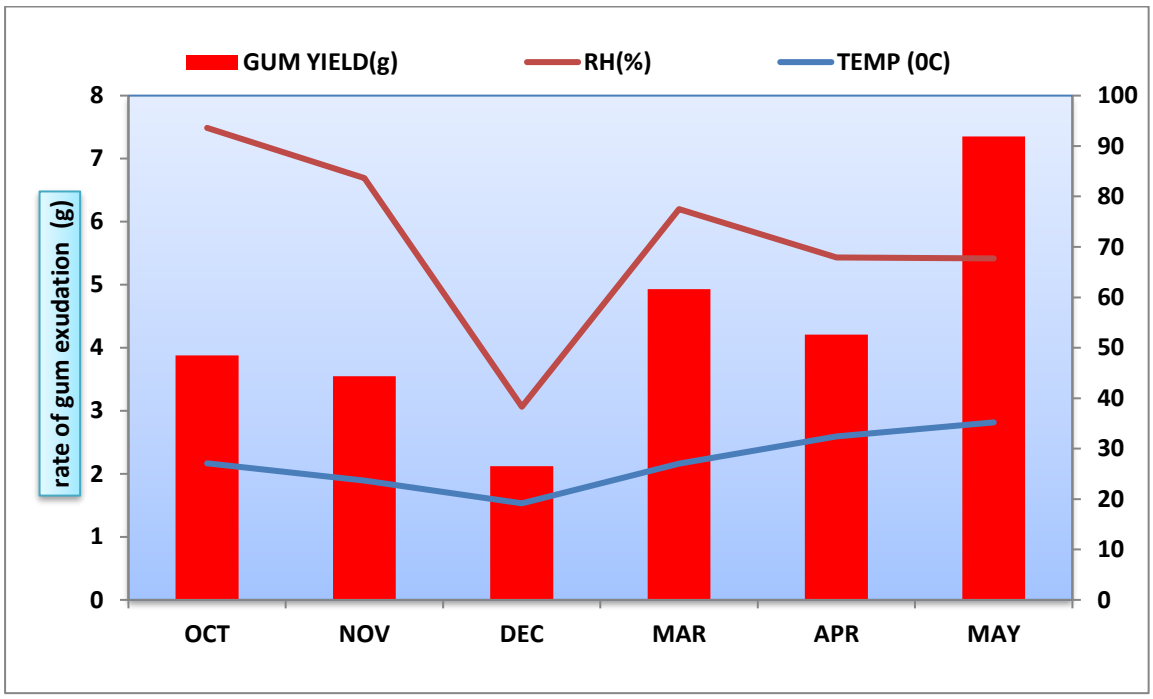


Fig. 4.1: Month wise rate of gum exudation from *L. coromandelica* by Various Mechanical method during Winter Oct-Dec and Summer March to May (g/month)

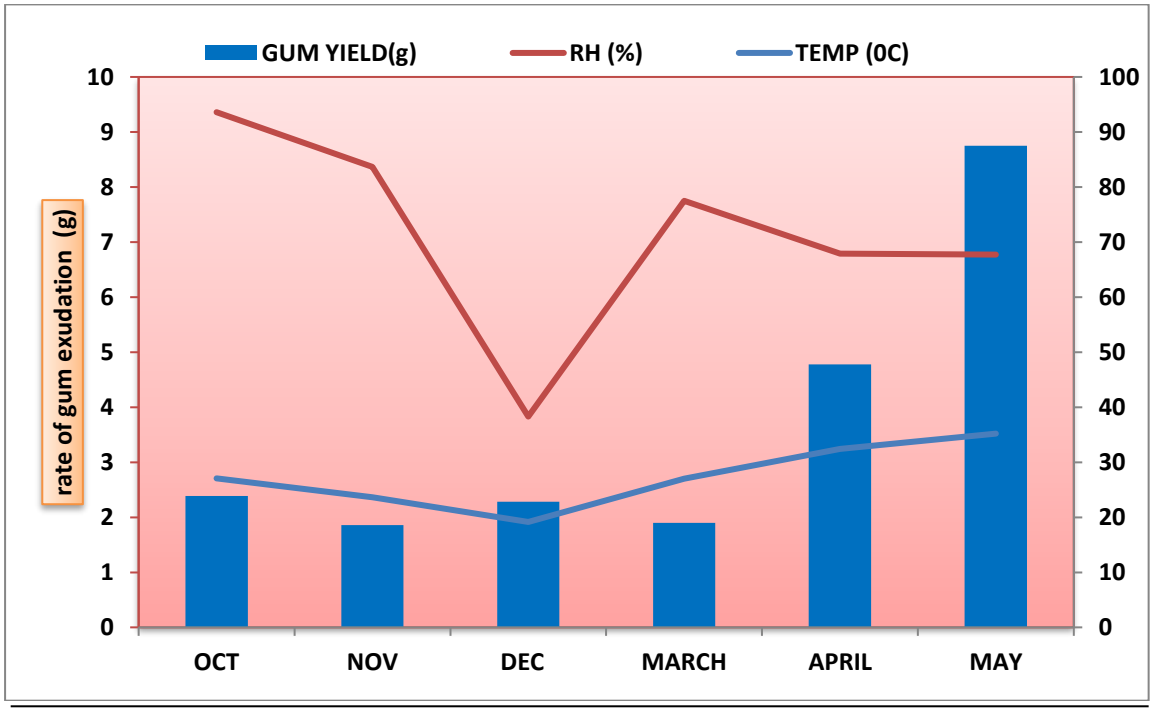


Fig. 4.2: Month wise rate of gum Exudation from *B. serrata* by Various Mechanical tapping method during Winter Oct-Dec and Summer March to May (g/month)

4.2 Gum Tapping through Mechanical +Chemical Method.

4.2 .1 Effect of Mechanical+ Chemical method on tapping and rate of gum exudation in *Lannea coromandelica*.(g/month)

The variation in rate of gum exudation was observed during October 2018 to May 2019. The highest rate of gum exudation was obtained in October month of winter season i.e Maximum 180.41g and month of May i.e Maximum 377.55g.In winter season during December month 53.78g was the minimum value. Similarly, the minimum rate of gum exudation was observed in month of March 131.53g of summer season .However, in mechanical and chemical method ethephon was used as gum enhancer. Bhatt *et.al*. (1989) also reported that application of ethephon in gum yielding trees increases the amount of gum exudation and total yield of gum/tree. The Maximum Average temperature rises up high in the month of May 2019 (35.2^0C) and RH was (32.5 %). During summer season month of May observed the best month for significantly higher gum exudation followed by April and March month of the year. Ballal *et al.* (2005) also reported that the gum yield was positively correlated with tapping intensity, rainfall, and minimum and maximum temperatures at tapping time, and negatively correlated with tapping time, and minimum and maximum temperatures at gum collection. Katiyar *et.al* (2014) also observed that 4ml E-Super (0.39% ethephon) was significantly effective to produce high quantity of gum in the month of May in *Acacia nilotica* (33.32 g/plant). The results reported by the above workers are similar as in the month of May the gum exudation rate is high with the use of ethephon , however in present study the quantity of gum is more than 5 times high as Katiyar *et.al* (2014) observed in case of *Acacia nilotica* it may be the DBH of the tree was 90-125 cm compared with the *Lannea coromandelica* the DBH was in the range of 80-150 this variation in quantity was recorded in our experiment the soil type and microclimate also responsible for the exudation rate of gum. The difference in tree species also responsible for the yield this hypothesis confirm the results obtained in the study.

The data of gum exudation depicted in Table 4.3

Table- 4.3 Effect of temperature and relative humidity on rate of gum exudation in *Lannea coromandelica* during summer & winter seasons 2018-2019 by using Various Mechanical+ Chemical Treatments. (g/month)

Treatment	2018(Winter)			Total yield	2019(Summer)			Total yield
	Oct	Nov	Dec		Mar	Apr	May	
Temp(^{0}C)	27.10	23.65	19.15		27	32.4	35.2	
Rh(%)	66.5	60	65		50.5	35.5	32.5	
T4	7.42	6.25	4.78	18.45	13.83	15.12	20.04	49.09
T5	5.69	4.15	2.87	12.71	13.02	25.06	30.49	68.57
T6	13.92	10.47	3.94	28.33	4.25	3.12	8.20	15.57
T7	18.07	4.02	3.98	22.05	10.92	13.45	38.89	63.26
T8	30.14	6.25	6.36	42.75	20.06	21.63	70.67	112.36
T9	21.62	5.21	6.66	33.49	11.31	14.25	35.29	60.85
T10	15.48	7.24	12.62	35.14	22.64	18.16	34.81	75.61
T11	31.18	12.81	7.14	51.13	20.12	27.82	92.65	140.59
T12	36.89	5.12	5.63	47.64	15.38	14.29	46.51	76.18
Total	180.41	61.52	53.78	291.69	131.53	152.9	377.55	662.08

T4-S210% T7-S320% T10-S430%
T5-V210% T8-V320% T11-V430%
T6-H210% T9-H320% T12-H430%

S = Square cut, V= V shape cut, H= hole shape cut.

4.2.2 Effect of Mechanical+ Chemical method on tapping and rate of gum exudation (g) in *Boswellia serrata*

In this method ethephon was used as gum enhancer and it was applied in different concentration on trees. The maximum rate of exudation was recorded in the month of May followed by April and lowest in March of Summer season. Similarly maximum rate of exudation was recorded in the month of October followed by November and lowest in December of winter season This is due to the variation in temperature and relative humidity in different months this is important on tapping time related to gum yield. The highest quantity of gum produce during the month of October was 61.39 g in winter season ,however in summer season highest amount gum exuded in the month of May 152.2 g. During the month of December average temperature was 19.15 (^{0}C) so the amount of gum yield was minimum in this month ,similarly in summer season the lowest amount of gum yield was obtained in the month of march and the value was 62.9 g due to low temperature and high relative Humidity.

The total yield of gum obtained in both the season from Mechanical+Chemical method was 21 times more than Mechanical method of tapping on *Boswellia serrata* ,this variation of gum yield was due to use of ethephon. Prasad *et al.*(2012*)* reported that use of ethephon as gum inducer increase the yield of gum in *Butea monosperma 303.8g/tree.* The results of the above worker almost similar as use of ethephon working like a catalyst to enhance the physiological activity in the tree this is confirming the results of present study carried out in experimental field of Chhattisgarh.

The rate of gum exudation in chemical method of gum tapping in *Boswellia serrata* was observed since October 2018 to May 2019 shown in Table 4.4.

Data collection work in Experimental field at Deopur Forest Stand

Application of ethephon injection with the help of syringe

Gum collection from tree during Winter and Summer season.

Plate-IV : Mechanical and Mechanical+Chemical Treatments applied on both the trees during experiment.

Table 4.4 Effect of temperature and relative humidity on rate of gum exudation in *Boswellia serrata* during Summer & Winter Seasons 2018-2019 (g/month).

Treatment	2018(Winter)			Total yield	2019(Summer)			Total yield
	Oct	Nov	Dec		Mar	Apr	May	
Temp(^{0}C)	27.10	23.65	19.15		27	32.4	35.2	
Rh(%)	66.5	60	65		50.5	35.5	32.5	
T4	2.08	0	0	2.08	9.83	11.10	14.25	35.18
T5	10.12	3.54	2.39	16.05	3.20	8.72	11.65	23.57
T6	7.48	3.20	3.28	13.93	20.52	6.95	7.07	34.54
T7	9.52	4.26	3.43	17.21	7.30	9.83	20.45	37.58
T8	14.32	6.61	5.25	26.18	4.41	14.36	18.65	37.42
T9	4.39	2.48	0	6.89	6.41	14.28	20.46	41.15
T10	5.12	2.45	0	7.57	1.30	14.85	26.10	42.25
T11	3.02	0	0	3.02	0	3.16	3.42	6.48
T12	5.34	0	0	5.34	9.93	12.86	30.15	52.94
Total	61.39	22.54	14.35	98.27	62.9	96.11	152.2	311.11

T4-S210% T7-S320% T10-S430%
T5-V210% T8-V320% T11-V430%
T6-H210% T9-H320% T12-H430%

S = Square cut, V= V shape cut, H= hole shape cut.

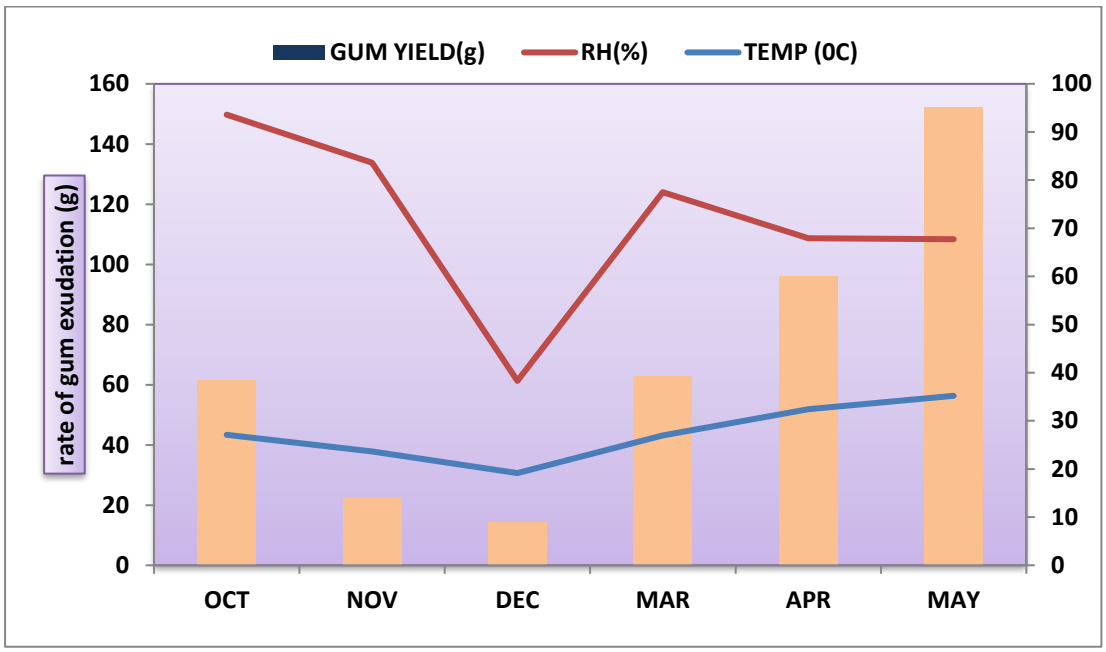


Fig. 4.3:Month Wise rate of Gum Exudation(g) in *B. serrata* by Mechanical+ Chemical Method during Winter Oct-Dec and Summer March to May (g/month)

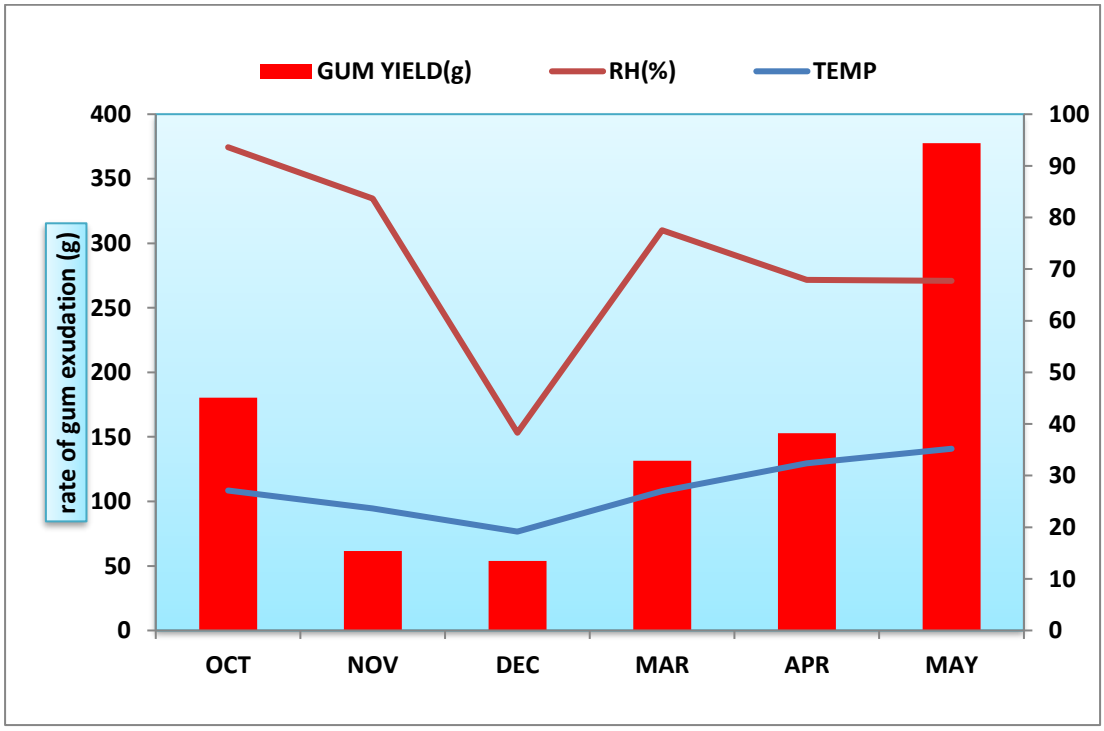


Fig. 4.4 : Month Wise rate of Gum Exudation(g) from *L. coromandelica* by Mechanical+ Chemical Method during Winter Oct-Dec and Summer March to May (g/month)

4.3 Season and Treatment wise gum Production by Mechanical Method.

4.3.1 Season wise gum exudation in *Boswellia serrata* & *Lannea coromandelica* in winter 2018 and summer 2019 by mechanical tapping Method (g/tree/season).

In summer season of 2019 maximum quantity of gum produce from *B.serrata* i.e 10.82 gm/tree by using square shape cut ,Similarly in Winter season of 2018 minimum amount of gum was obtained was 6.53g/tree because of low temperature as compared to summer season. whereas in *L.coromandelica* maximum amount of gum produce 16.49 g/tree by using similar square shape cut and in winter the gum exudation was rate was lowest 7.43 g/tree due to temperature difference. By using other mechanical method of cutting in trees of *B.serrata* and *L. coromandelica* gum produce was in very less in quantity so the other two method i.e V shape and Hole shape not much effective for sustainable production of gum. Square shape tapping method is better for sustainble gum production in both the season. Bhatt *et al.*(1989) reported in *Commiphora wightii* that April and May are peak months for gum tapping.

The below table 4.5 represent quantity of gum produce in gm/tree/season from both the season

Table- 4.5 Season and treatment wise gum exudation from *Boswellia serrata and Lannea coromandelica* by mechanical tapping Method by using Square Shape,V shape and Hole shape Cut.(g/tree/season)

SL.NO	Mechanical Treatments	SEASON	TREE SPECIES	OBSERVATIONS IN (g/tree)
	SQUARE SHAPE			
1	S1	Winter	*Boswellia serrata*	6.53
2	S1	Summer	*Boswellia serrata*	10.82
3	S1	Winter	*Lannea coromandelica*	7.43
4	S1	Summer	*Lannea coromandelica)*	16.49
	V SHAPE			
5	V1	Winter	*Boswellia serrata*	0
6	V1	Summer	*Boswellia serrata*	4.56
7	V1	Winter	*Lannea coromandelica*	0
8	V1	Summer	*Lannea coromandelic)*	0
	HOLE SHAPE			
9	H1	Winter	*Boswellia serrata*	0
10	H1	Summer	*Boswellia serrata*	0
11	H1	Winter	*Lannea coromandelica*	0
12	H1	Summer	*Lannea coromandelica*	0

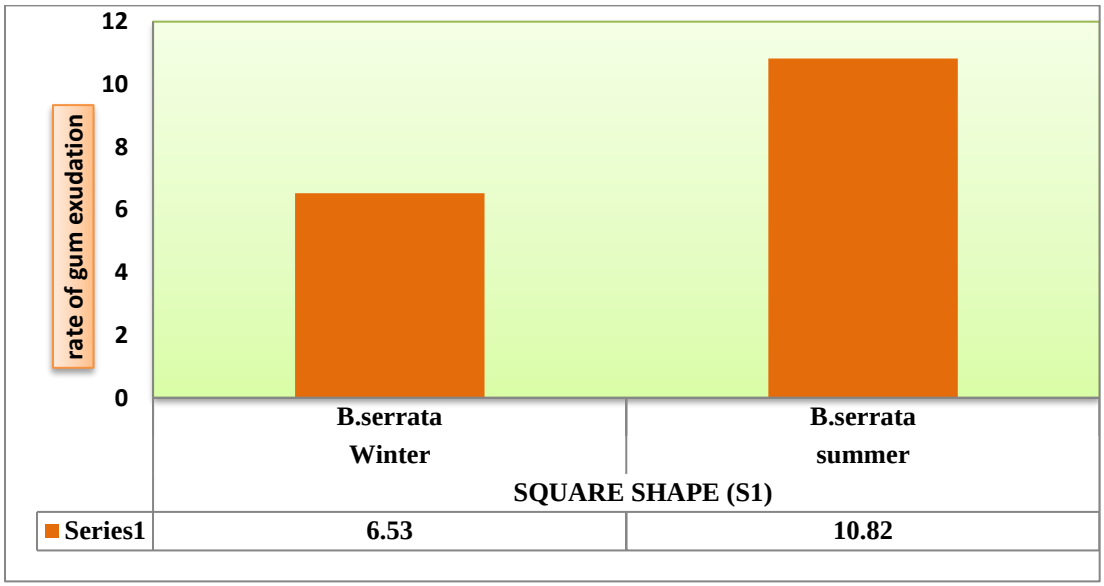


Fig 4.5: Season wise Gum production in *Boswellia serrata* by mechanical method of tapping in winter 2018 and summer 2019 by Square shape cut.(g/tree/season)

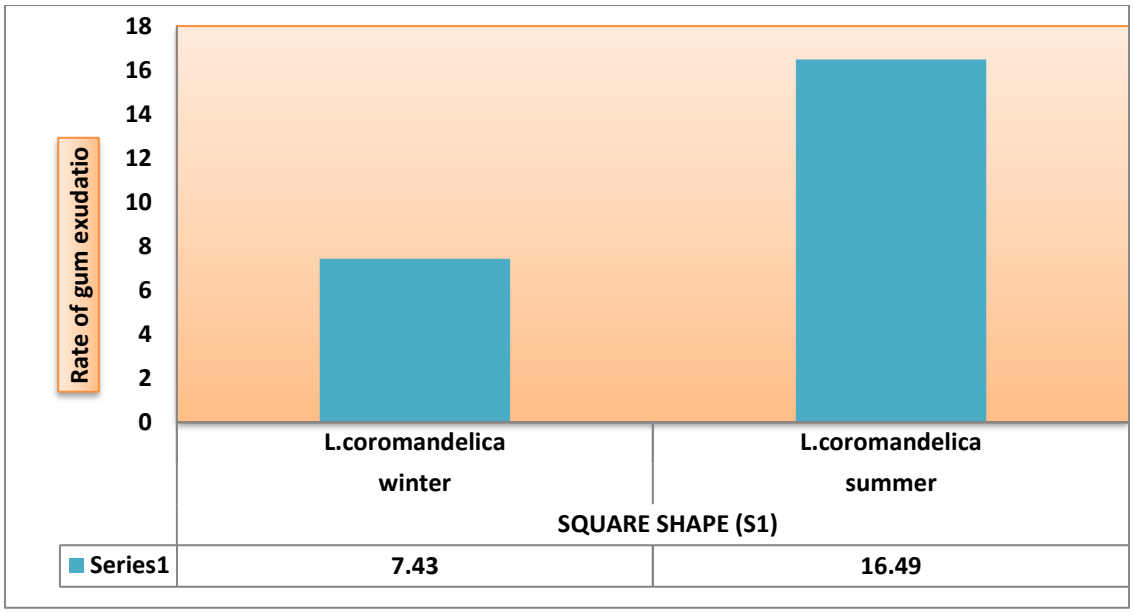


Fig 4.6: Season wise Gum production in *Lannea coromandelica* (g) by Mechanical method of tapping in winter 2018 and summer 2019 by Square shape cut. .(g/tree/season)

4.4 Season wise and Trearment gum exudation by Mechanical+ Chemical tapping Method.

4.4.1 Season wise and Treatment gum exudation in *Boswellia serrata* & *Lannea coromandelica* in winter 2018 and summer 2019 by Square shape Method. (g/tree/season)

For *B. serrata* in In square shape cut highest amount of gum produce in summer season by using $S_4$30% Concentration followed by $S_3$20% conc. and minimum amount of gum produce by using $S_2$10% conc. the minimum value was 35.18 gm/tree, whereas in winter season highest gum yield was obtained from $S_3$20% 17.21gm/tree followed by $S_4$30% i.e 7.57gm/tree

.

In *L. coromandelica* maximum quantity of gum produce by using $S_4$30% i.e 75.61gm/tree in summer season followed by 63.26 gm/tree the minimum amount of gum obtained by using and by using $S_2$10% and the yield was 49.09 g/tree . Improved gum tapping method by using ethephon chemical treatment in tree trunk by injecting through a syringe into holes with the help of increment borer is developed by Bhatt (1987). Bhatt *et.al*. (1989) also reported that application of ethephon in gum yielding trees increases the amount of gum exudation and total yield of gum/tree. The similar results obtained in the present study that the gum exudation increases with the application of higher concentration of Ethephon i.e 30% injected in tree trunk gave maximum yield as compared with the 10% confirms the results with the above worker. Babu and Menon (1989) reported that Ethephon induces gummosis in *Sterculia urens* without adversely affecting health of the tree. The similar results obtained in the present study that use of ethephon does not affect the tree health and after the gum exudation incision portion was covered with wet mud to prevent from further infection. Due to this technique the bark growth easily cover the incision made on the tree trunk.

Table- 4.6 Season wise and Treatment gum exudation from *Boswellia serrata* and *Lannea coromandelica* by Square shape cut (g/tree/Season)

Sl no	shape	Mechanical+Chemical treatments	Season	Tree species	observation gum yield in (g/tree)
13	Square shape	$S_2$10%	winter	*B. serrata*	2.08
14`	Square shape	$S_3$20%	winter	*B. serrata*	17.21
15	Square shape	$S_4$30%	winter	*B. serrata*	7.57
16	Square shape	$S_2$10%	summer	*B. serrata*	35.18
17	Square shape	$S_3$20%	summer	*B. serrata*	37.58
18	Square shape	$S_4$30%	summer	*B. serrata*	42.25
19	Square shape	$S_2$10%	winter	*L. coromandelica*	18.45
20	Square shape	$S_3$20%	winter	*L coromandelica*	22.05
21	Square shape	$S_4$30%	winter	*L coromandelica*	35.14
22	Square shape	$S_2$10%	summer	*L coromandelica*	49.09
23	Square shape	$S_3$20%	summer	*L coromandelica*	63.26
24	Square shape	$S_4$30%	summer	*L coromandelica*	75.61

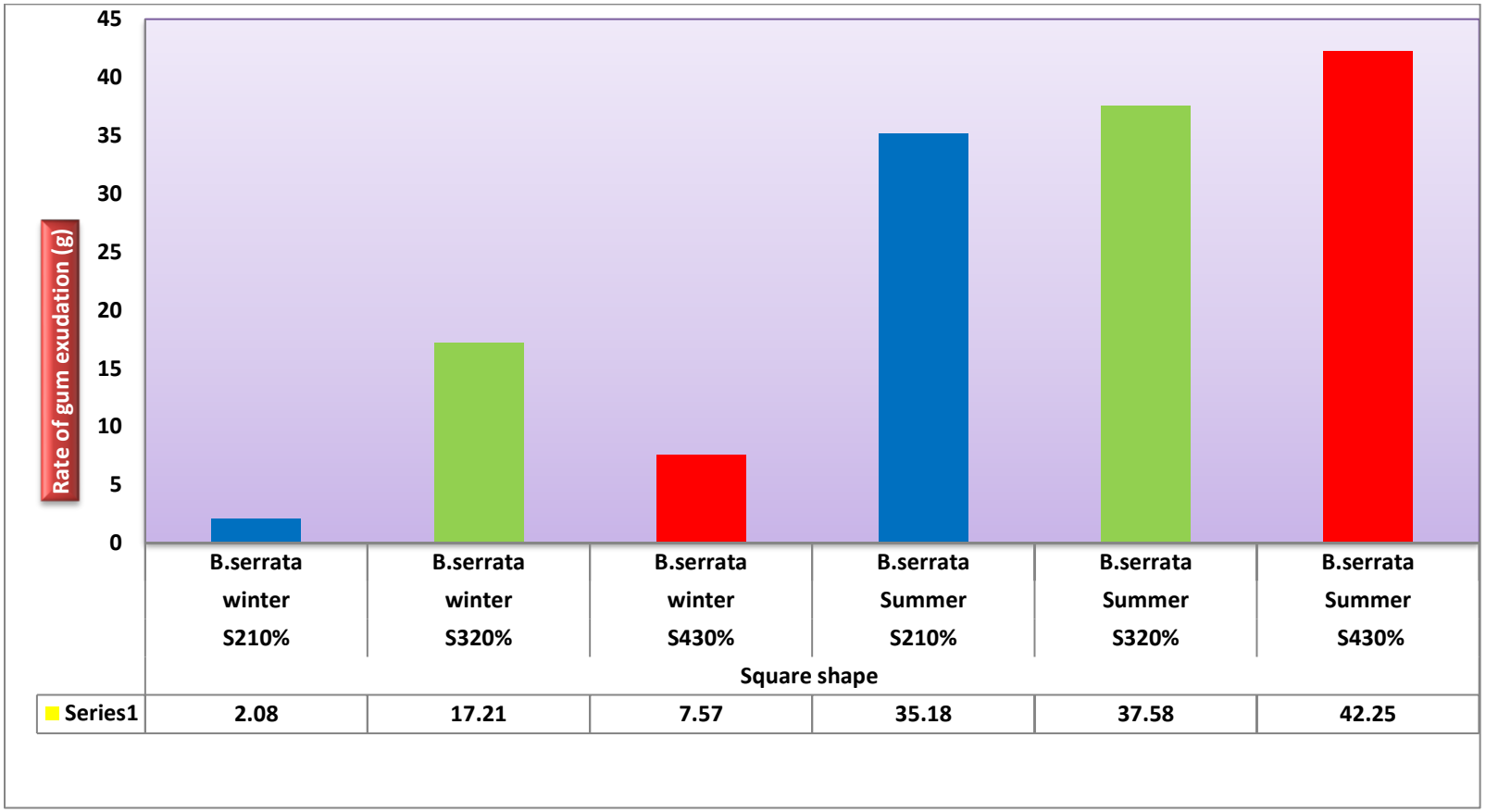


Fig. 4.7: Season and Treatment Gum production from *Boswellia serrata* by Mechanical + Chemical method of tapping in winter 2018 and summer 2019 by square shape cut (g/tree/season).

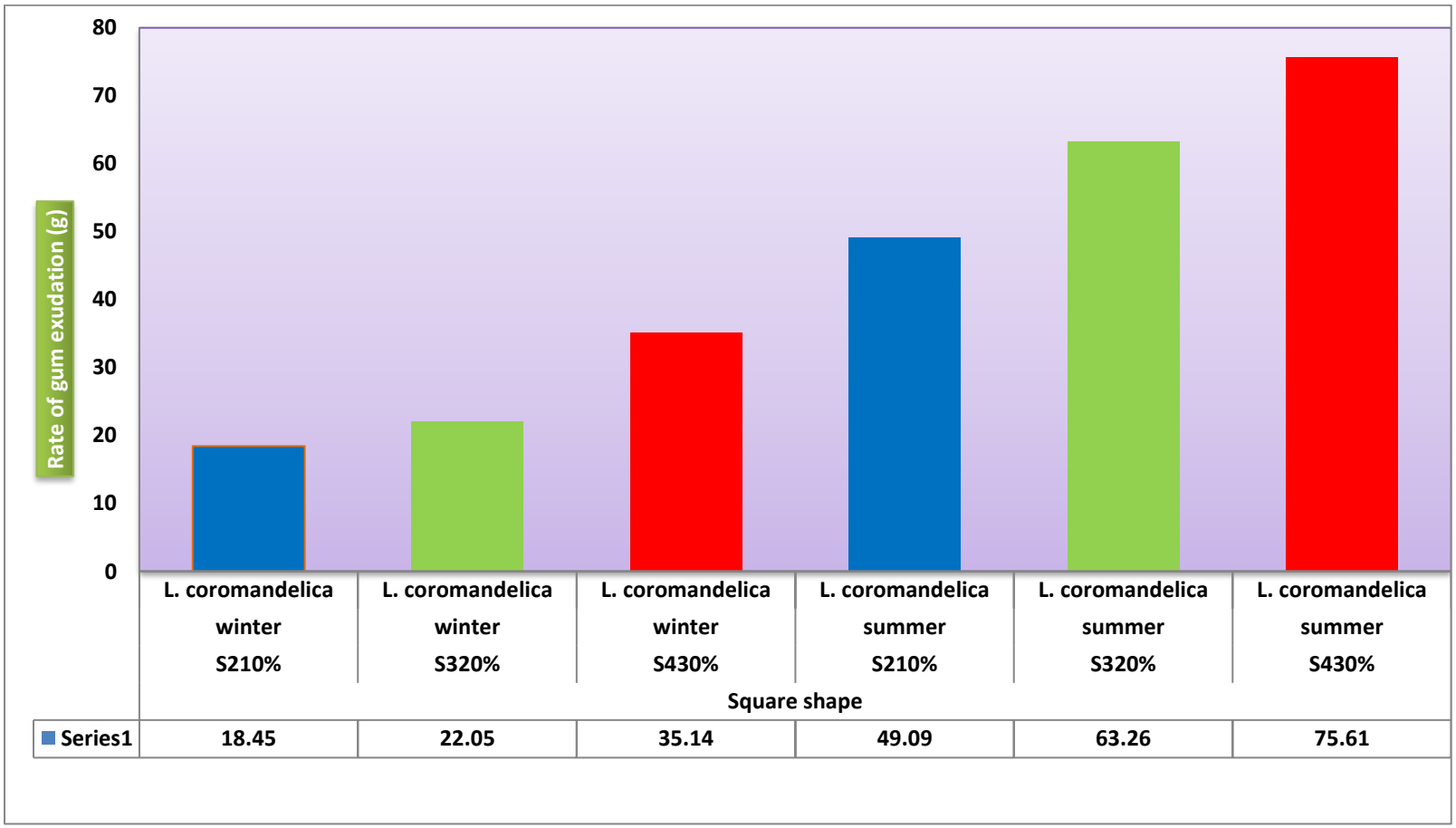


Fig. 4.8: Gum production from *Lannea coromandelica* by mechanical + Chemical method of tapping in winter 2018 and summer 2019 by square shape cut (g/tree/season).

4.4.2 Season wise and Treatment gum exudation in *Boswellia serrata* & *Lannea coromandelica* in winter 2018 and summer 2019 by V shape Method (g/tree/season).

For V Shape Cut in *B. serrata* highest amount of gum produce by using $V_3$20% in summer season i.e 37.42 gm/tree followed by 23.57 gm/tree by using $V_2$10% conc. Whereas in winter maximum quantity of gum produce by using treatment $V_3$20% and the yield was 26.18 gm/tree and minimum amount of gum produce is by using treatment of $V_4$30% i.e 3.02 gm/tree. Sinha *et al.* (2016) reported in his experiment based on *Boswellia serrata* tree at Gujarat Out of various tapping methods, only two methods, the first, V-cut method along with a hole on the lower side & treated with ethephon and the second, hole method treated with ethephon & patched up with clay were suggested to adopt for sustainable and high yield of oleo-gum-resin.

In *L. coromandelica* maximum gum yield obtained from $V_4$30% i.e 140.59 gm/tree in summer season followed by 51.13 gm/tree by using $V_4$30% treatment in winter season of 2018. Vasishth (2017) reported in Gujarat that by using V shape cut in *L. coromandelica* there was significant production of gum 209.0 g/tree by using 200mg/ml ethephon. To obtaining maximum gum from *Lannea coromandelica* tree species, two tapping techniques have been applied i.e V shape method and Bore hole method. In bore hole tapping method, a hole of 5 cm is made on tree stem yielded higher gum than V shape mechanical method reported by Sharma *et.al* (2012) .Yield of gum showed statistically significant ($P<0.05$) by use of chemical ethephon as compared to Mechanical Treatment because the ethephon act as a catalyst which activate the gummosis processes in tree.

Oozing out of gum in Hole shape cut on both the tree species

Gum exudation from *B. serrata* and *L. coromandelica* in Square shape cut

Gum exudation from *B. serrata* (R) and *L. coromandelica* (L) in V shape cut

Plate-V: Gum exudation from trees after application of various Mechanical and Mechanical +Chemical Treatment.

Table -4.7 Season and Treatment wise gum exudation from *Boswellia serrata and Lannea coromandelica* by V shape tapping. In winter 2018 and summer 2019.(g/tree/season)

Sl no	Shape	Mechanical+Chemical Treatment	Season	Tree Species	Gum yield in(g/Tree)
25	V Shape	$V_2$10%	Winter	*B. serrata*	16.05
26	V Shape	$V_3$20%	Winter	*B. serrata*	26.18
27	V Shape	$V_4$30%	Winter	*B. serrata*	3.02
28	V Shape	$V_2$10%	Summer	*B. serrata*	23.57
29	V Shape	$V_3$20%	Summer	*B. serrata*	37.42
30	V Shape	$V_4$30%	Summer	*B. serrata*	6.48
31	V Shape	$V_2$10%	Winter	*L. coromandelica*	12.71
32	V Shape	$V_3$20%	Winter	*L. coromandelica*	42.75
33	V Shape	$V_4$30%	Winter	*L. coromandelica*	51.13
34	V Shape	$V_2$10%	Summer	*L. coromandelica*	68.57
35	V Shape	$V_3$20%	Summer	*L. coromandelica*	112.36
36	V Shape	$V_4$30%	Summer	*L. coromandelica*	140.59

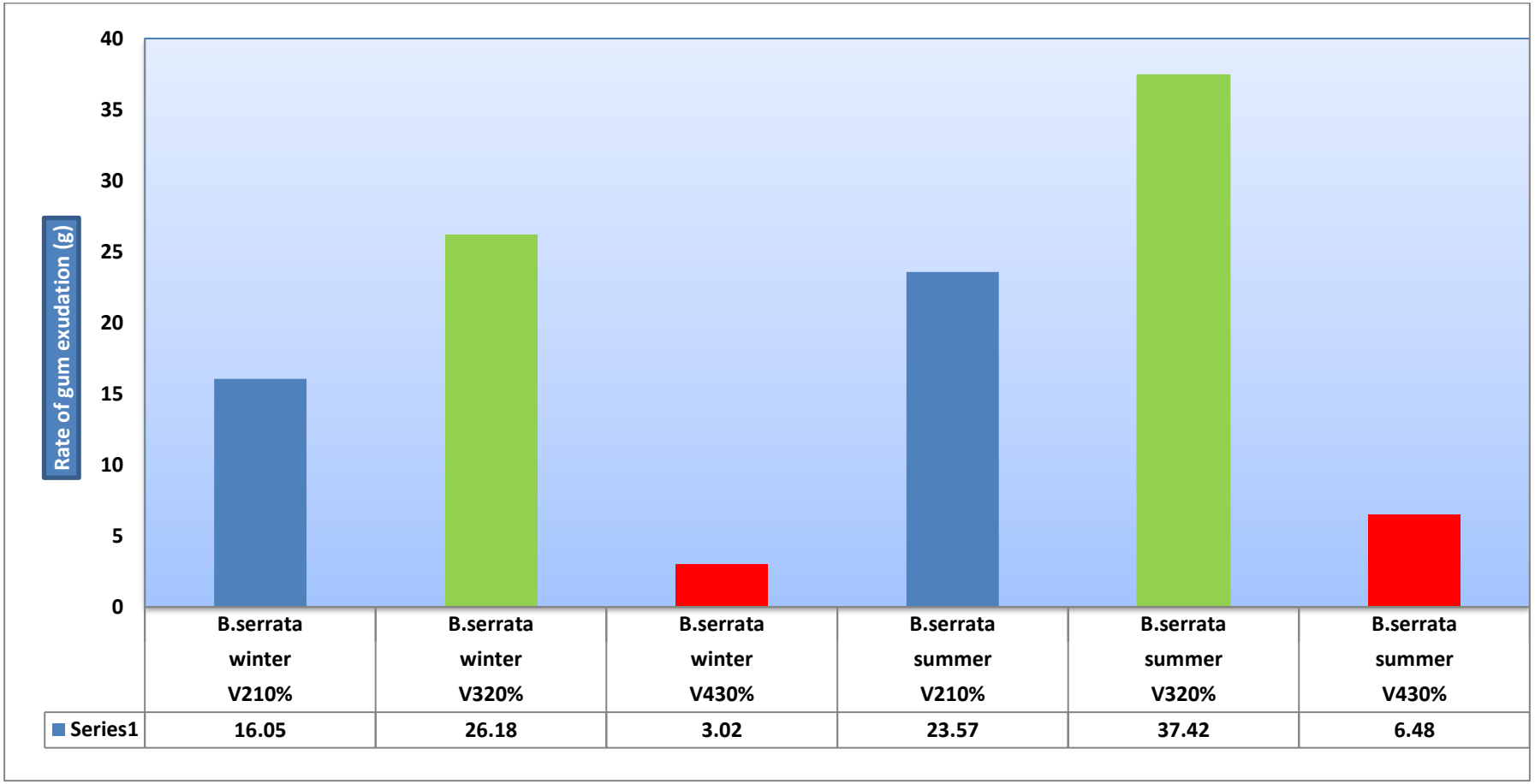


Fig. 4.9 :Gum production from *B. serrata* by mechanical +Chemical method of tapping in winter 2018 and summer 2019 by V shape cut.(g/tree/season)

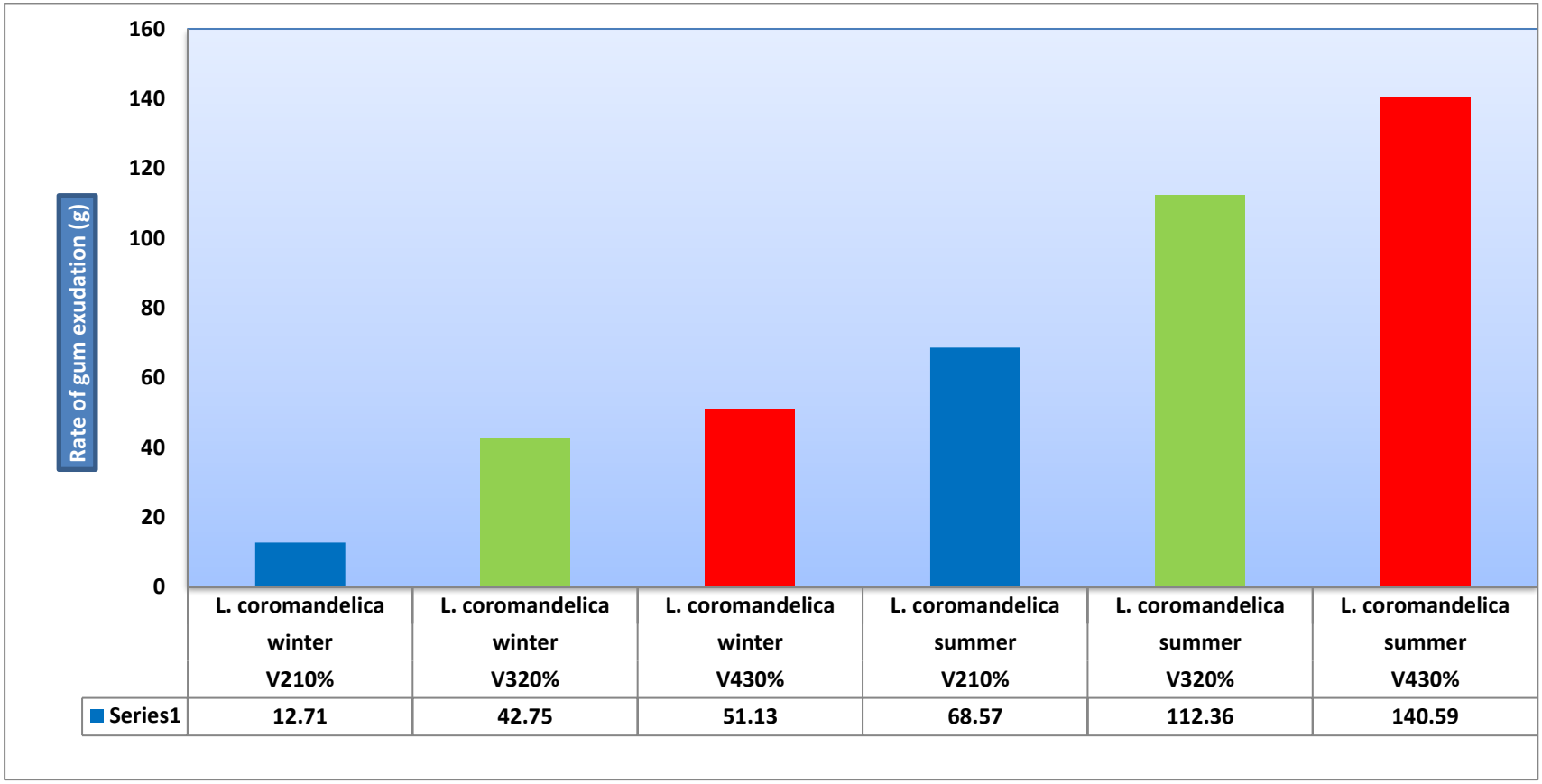


Fig. 4.10: Gum production from *L.coromandelica* by mechanical +Chemical method of tapping in winter 2018 and summer 2019 by V shape cut (g/tree/season).

4.4.3 Season wise and Treatment gum exudation in *Boswellia serrata* & *Lannea coromandelica* in winter 2018 and summer 2019 by Hole shape Method(g/tree/season).

For *B serrata* maximum quantity gum obtained by using $H_4$30% treatment i.e 52.94 gm/tree in summer season and in winter season maximum amount of gum produce by $H_2$10% i.e 34.54 gm/tree in winter season. Similarly for *L. coromandelica* maximum amount of gum produce by using $H_4$30% treatment but in winter highest amount of gum was produce from $H_4$30% treatment i.e 47.64 gm/tree. Raj *et.al.* (2017) observed that chemical method using ethephon in *Acacia nilotica* tree by using hole shape cut in Chhattisgarh was safe and developed scientific techniques for gum production in sustainable way. He selected tree species having girth class of 30-50 cm and maximum gum yield was obtained in the month of March 4.21 gm/tree 2ml of 0.78% ethephon application. The gum yield of *B. serrata* was 78g/tree recorded if we compare with *A nilotica* yield was 8.88 g/tree as reported by the above worker this variation in yield might be because of different tree species and different DBH classes of tree and forest site. Arya 2018 also reported in *Commiphore wightii* the maximum yield was found in hole shape cut with 225mg. ethyl acetate in irrigated plants 66.33g/tree our results showed 79.12g/tree in case of *B serrata* the higher yield may be because of soil, specie and microclimate is better in the present study confirms the results obtained in present study.Season was also showed statistically significant ($P<0.05$) the difference was due to high temperature and low relative RH and the maximum amount of obtained from both the trees in the month of May,2019.

Table -4.8 Season and Treatment wise gum exudation from *Boswellia serrata and Lannea coromandelica* by Hole shape tapping. In winter 2018 and summer 2019.(g/tree/season)

Sl NO	Shape	Mexhanical+Chemical Treatment	Season	Tree Species	Gum yield in(g/tree)
37	Hole Shape	$H_2$10%	winter	*B. serrata*	13.93
38	Hole Shape	$H_3$20%	winter	*B. serrata*	6.89
39	Hole Shape	$H_4$30%	winter	*B. serrata*	5.34
40	Hole Shape	$H_2$10%	summer	*B. serrata*	34.54
41	Hole Shape	$H_3$20%	summer	*B. serrata*	41.15
42	Hole Shape	$H_4$30%	summer	*B. serrata*	52.94
	Hole Shape				
43	Hole Shape	$H_2$10%	winter	*L. coromandelica*	28.33
44	Hole Shape	$H_3$20%	winter	*L. coromandelica*	33.49
45	Hole Shape	$H_4$30%	winter	*L. coromandelica*	47.64
46	Hole Shape	$H_2$10%	summer	*L. coromandelica*	15.57
47	Hole Shape	$H_3$20%	summer	*L. coromandelica*	60.85
48	Hole Shape	$H_4$30%	summer	*L. coromandelica*	76.18

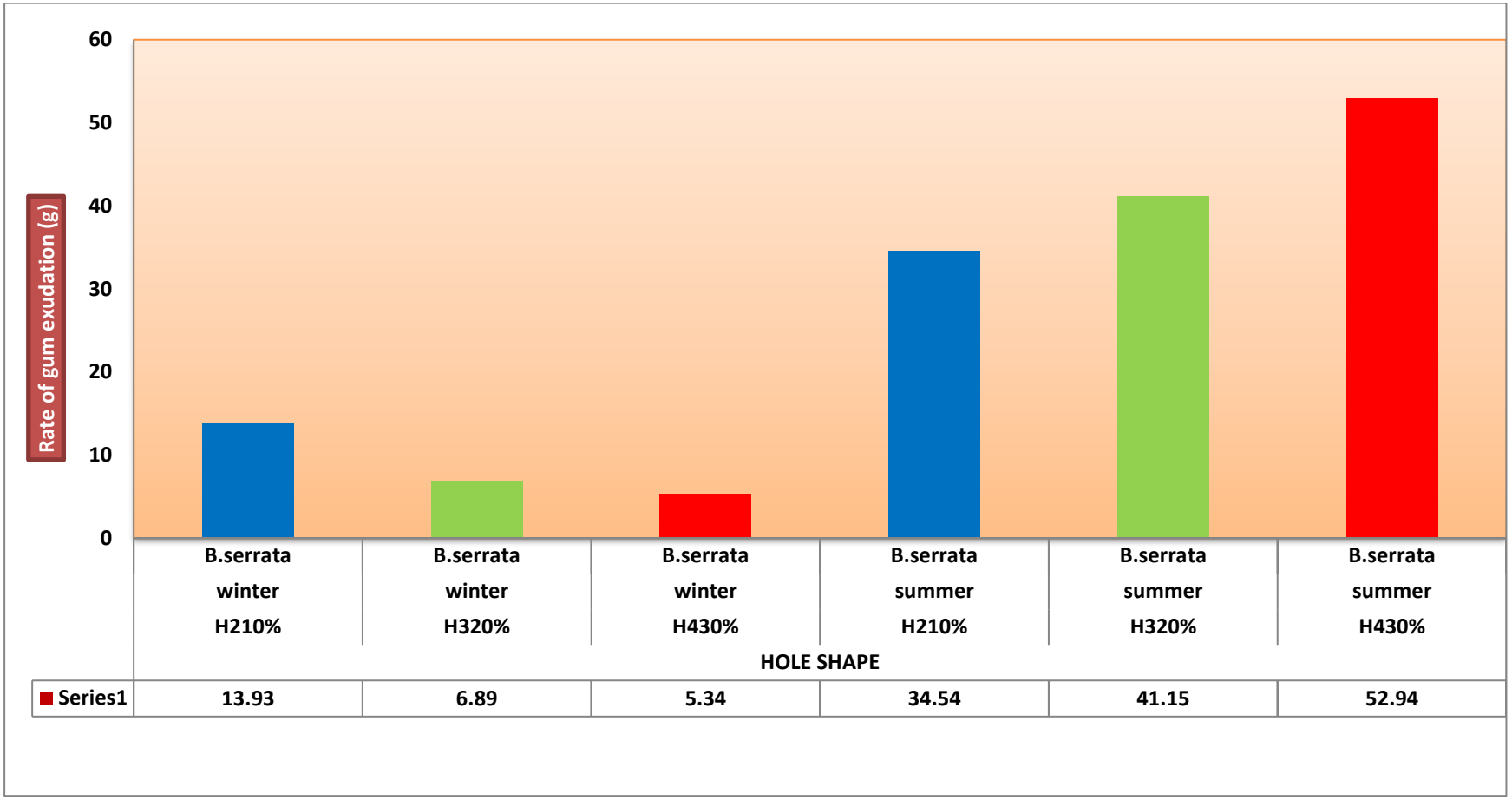


Fig. 4.11: Season and Treatment wise gum production from *Boswellia serrata* by Mechanical +Chemical method of tapping in winter 2018 and summer 2019 by Hole shape cut (g/tree/season).

10% 20% 30%

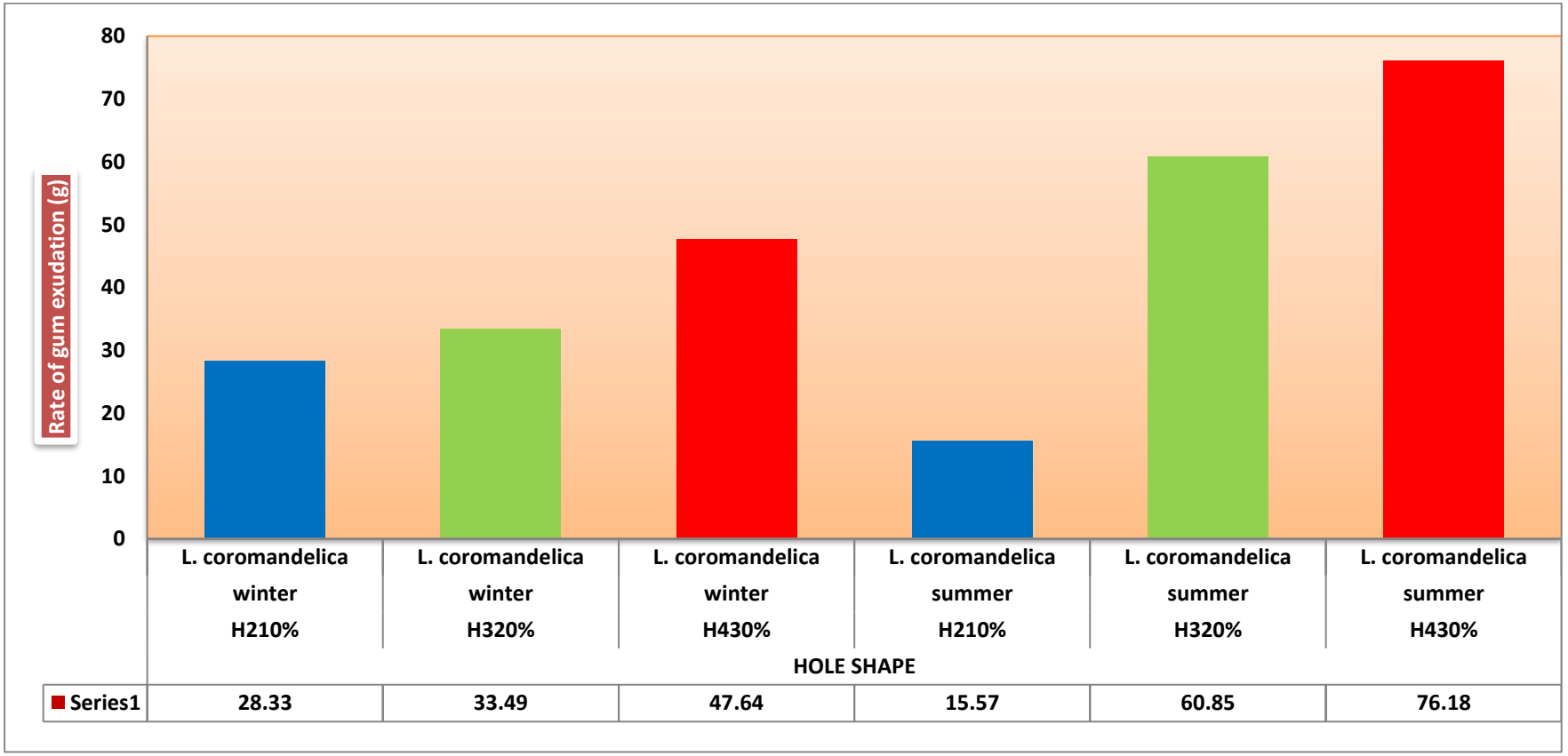


Fig. 4.12: Season and Treatment Gum production from Boswellia serrata by mechanical +Chemical method of tapping in winter 2018 and summer 2019 by Hole shape cut (g/tree/season).

4.5 Quality Parameter

4.5.1Colour

The gum colour in case of *Boswelia serata* was noted as white yellow and in *Lannea coromandelica* was brown in color The similar colour also determined by visual observation of *Boswelia serata* gum is white yellow reported by Gupta P.K *et al.* (2011*)* and *Lannea coromandelica* was brown.as reported by (Waghmare 2014). The results obtained in the experiment was almost same confirms the finding is correct and there is no difference or variation was recorded.

4.5.2 Odour

Odour of *Boswellia serata* was noted as Sweet balsamic aromatic as reported by Gupta (2011) confirms the odour whereas, *Lannea coromandelica* have no odour as Kaur R *et. al* (2012) also reported the same observations in case of Jhingan gum.

4.5.3 pH

pH value of both the tree species showed slightly acidic. The pH value of Salai gum in the present experiment was 4.6. Chandola *et. al* (2011) analyze the phyto-chemical evaluation of *Boswellia serrata* and found that the ph was 6.09 gum. The value of pH variation in case of *Boswellia serrata* (Salai gum) was low value as compared by above author may be due to availability of salts in the soils, rainfall pattern and microclimate of Chhattisgarh. These factors are affecting the acidity of the gum. The pH value of Jhingan gum was 3.4. recorded in our experiment as Duppala *et.al* (2017) reported in his report microbial studies of *Lannea coromandelica* gum and the pH obtained from this gum was 6.1-6.5 The acidity of plant gums is not unexpected since many of them contain various salts like (Ca, Mg, K, Na and Fe) of acidic polysaccharides, the acidity of which is due to uronic acids in their structures reported by Abu Baker *et al.* (2007). The same reason of will be considered for *Lannea coromandelica* gum. The pH value off *Boswellia serrata* Salai and *Lannea coromandelica* gum was observed more acidic than the above workers report.

4.5.4 Moisture content:

The moisture content of *Boswellia serrata* Salai was 17.32 % recorded in our experiment as Gupta (2011) observed 20.74% there is 3.4 % variation in moisture content may be because of soil moisture, acidity of soil and age of tree may be the reason of collected gum from the tree. In case of *Lannea coromandelica* 16.9 %. Moisture was recorded. However Duppala 2017 reported

8.52% moisture content the higher moisture content in our experiment may be rain showers occurred during collection of gum as reported by the author.

4.5.5 ASH CONTENT:-

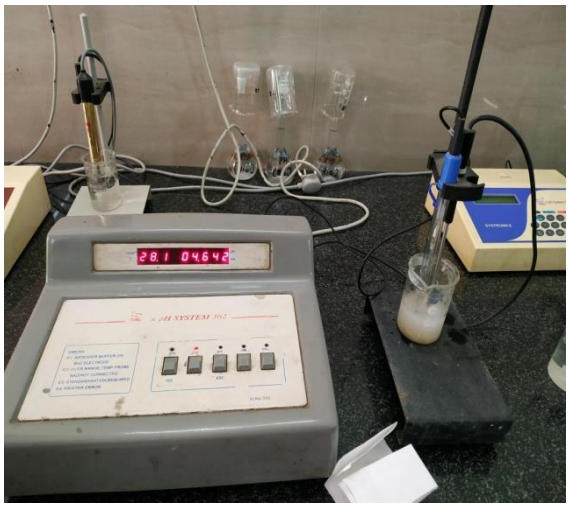
The ash content of gum in *Boswellia serrata* Salai was 1% and *Lannea coromandelica* it was 2.5% . As Gupta (2011) observed the value of ash content 0.6% this variation may be because of polysaccharide available in the gum sample. The results confirm the results obtained by the above worker.

Table- 4.10 Quality parameter tests *of Boswellia serrata* and *Lannea coromandelica*.

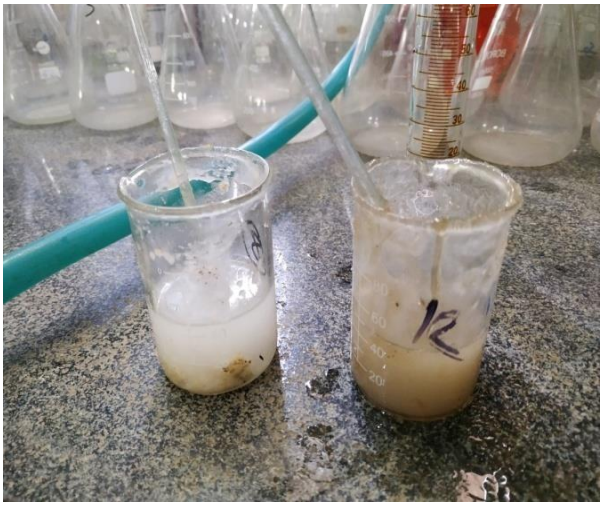
Parameters	*B. serrata*	*L. coromandelica*
1. pH	4.6	3.4
2. Odour	Sweet balsamic aromatic	Without any characteristic odour
3. Colour	White yellow	Brown
4. Moisture content	17.32%	16.9%
5. Ash Content	1%	2.5%

Gum Sample placed in muffle furnace

Picture of muffle furnace



Analysis of pH through pH meter



Gum solution prepared for pH Measurement

Weighing of Gum samples

Gum samples after drying in hot air oven

Plate –VI: Quality parameter analysis in Laboratory at IGKV.

CHAPTER – V
SUMMARY AND CONCLUSIONS

The present investigation entitled **Standardization of Sustainable Gum Tapping Techniques in *Boswelli serrata* (Roxb.) and *Lannea coromandelica* (Merr.) to Obtain Higher Gum Production in Tropical Dry Deciduous Forests"** was carried out at Deopur forest Range, Balodabazar Forest Division(Chhattisgarh) and the laboratory work was carried out in Department of Forestry, IGKV, Raipur CG. during the year 2018-2019. Gum is a natural biopolymer having various applications in food and pharmaceutical industries. It is one of the most important non-timber forest produce (NTFP), provide viable income source of forest dwellers. Oleo gum resin From *Boswellia serata*, Gum from *Lannea coromendelica* have high medicinal value both these tree species are not tapped in Chhattisgarh though these tree species found abundantly in patches in various forest stands of the state.

Looking to this there is urgent need that to develop a sustainable method of gum tapping for these gum yielding trees to increase the sustainable yield and safe method of tapping as well better management of Forest stands. Several unscientific method used locally for local methods of gum tapping causes death of the tapped trees due to deadly incisions made for tapping of gum. Therefore, the study was carried out to examine various mechanical methods, Mechanical +Chemical methods of tapping for their quantification of yield and safety of the tree health. To undertake the study the above experimental sites were found suitable and appropriate because of availability of both the tree species naturally growing on same elevation and sites. The available trees *viz.*, *Boswellia seratta* , *Lannea coromandelica* were selected on the basis of their girth ranges from 80-150 cm and tapping incision made at breast height treated with mechanical tapping and Mechanical+Chemical tapping in incision like Square shape cut ,V shape cut, Hole shape cut.The study was undertaken in two season winter & summer in the month of October 2018 to December 2018 and March 2019 to May 2019

respectively. Mechanical Method three types of incision made for tapping one was Square Shape, second one was V shape cut and third one was Hole shape cut. Whereas in Mechanical+Chemical methods of tapping, various concentrations of gum enhancer Ethephon having 39% active ingredient was used in nine treatments i.e T4($S_2$10%), T5 ($V_2$10%), T6 (H210%), T7 ($S_3$20%) ethephon T8($V_3$20%) and T9 ($H_3$20%), T10(S_4 30%), T11 (V_4 30%),T12 ($H_4$30%) were used in *Boswellia serrata* and in *Lannea coromandelica*. Then gum enhancers were injected in various cuts made at DBH i.e 1.37 m from base of tree by drill machine(battery operated) and iron Chisel. The quantity of gum enhancer injected 4 ml in each tree during Mechanica+ Chemical method of tapping. The experiment was designed in Factorial RBD with three replications based on mechanical methods of tapping and nine replications in Mechanical +chemical method of tapping in each season in each tree. First winter season treatment carried out in the month of October 2018 to December 2018 and second summer season treatment carried out in the month of March 2019 and Continue up to May 2019. The monthly data of ooze out gum was recorded for both the season. The quality parameters were analyzed after collection of gum in laboratory conditions

CONCLUSIONS

Based on the results obtained in my experiment the following conclusions are drawn

1. The rate of gum exudation (g) was found maximum in the month of May in summer season and October in winter season In both the experiment these Mechanical and Mechanical +Chemical Treatment showed highest yield .
2. Among the mechanical method of tapping, Square shape cut was found significantly superior in both the tree species and maximum gum production was obtained by this cut.
3. However, in Mechanical + Chemical methods of gum enhancer ethephon was used to increase the yield of gum. It was observed that the concentration of *20*% ethephon was found significantly superior over other two concentration in Gum of Salai *Boswellia serrata* and total amount of gum produced in both

the season was highest by using $V_3$20% chemical concentration and the value was 63.6 gm. The minimum gum obtained in $V_4$30% and the value was 9.5g. According to season wise gum production $V_3$20% Chemical conc. was much effective for highest gum production in the winter season .The yield was 26.18 g/tree. However, in summer season $H_4$30% Conc. was much effective for highest gum production and the yield was 52.94 g/tree.

4. Similarly, in *Lannea coromandelica* total quantity of gum produced was highest in both the season by using $V_4$30% conc. the value yield was 191.72 g followed by $H_4$30% conc. 123.82g and minimum gum obtained was 110.75g in $S_4$30% conc. According to season wise gum production $V_4$30% chemical conc. was much effective in production of gum in winter season and the yield was 51.13g/tree. However, in summer season similar treatment $V_4$30% Conc. was found effective and yielded 140.59 g/tree gum. Temperature and RH play a significant role in flow of gum through gum canals available in sap wood.
5. In both the method of tapping studied the Mechanical +Chemical method of tapping was found superior in both the tree species. The Ethephon gum enhancer found significantly superior over mechanical method. It was observed that ethephon 30% conc. in case of *Lannea coromandelica* and 20% conc of Ethephon in *Boswellia serrata* was found significantly in both the season.
6. The secretion of gum was started quite earlier within 3-4days was observed in *Lannea coromandelica.* However, in *Boswellia serrata* it takes little bit more time (5-6 days) after injection of ethephon. The ethephon used as a gum enhancer it is non toxic in nature, eco-friendly and easily available growth regulator .It induce slow release of ethylene in tree and develops artificial stressful environment in internal tissues of wood.
7. The quality parameters of gums obtained of both the trees were carried out in laboratory and observed that pH value for both these gums are acidic in nature .The pH of *Boswellia serrata* was 4.6 and pH *Lannea coromandelica was* 3.4.
8. The moisture content of *Boswellia serrata* and *Lannea coromandelica* recorded was 17.32 % and 16.9% ,respectively in this experiment.

9. The ash content of *Boswellia serrata* (Salai gum) was 1% and in case of *Lannea coromandelica (Jhingan* gum) it was 2.5%.

10. In both the tree species, the quantum of gum yield showed an increasing trend with increase in girth size with mechanical +chemical treatment and maximum amount of gum obtained from both the trees having girth of 100-140 cm.

11. The girth size of tree below 100 cm and more than 150 cm did not showed sustainable yield of gum *in B. serrata* while, in case of *L. coromandelica* girth class 90 cm to 130 cm showed sustainable gum yield.

12. The peak period of summer when temperature was >35-40^{0}C and RH was < 30% significantly better for potential production of gum in *Boswellia serrata* as well as in *Lannea coromandelica*.

13. All these techniques are simple and safe ensure sustainable yield, and there is nonnegative effect on regeneration and survival of the tapped trees. There is need to train the gum collectors who are unskilled and collecting NTFP from the forest regarding the technology developed in this experiment for sustainable harvesting of gum of the both tree species.

SUGGESTIONS FOR FUTURE RESEARCH WORK

The following relevant suggestion highlighted for future scope of the investigation.

- The experiment conducted to find out the sustainable harvesting methods of *Lannea coromandelica* and *Boswellia serrata* may be repeated at least two more years so that the technology will be confirm for dissemination to the NTFP collectors.
- There is a urgent need of standardization for tapping technology for other commercially important gum yielding tree species for sustainable gum production. This technology would improve the socio-economic status of tribal's

- There is urgent need to improve tapping, collection, processing, grading, classification and marketing for the betterment of gum industries and the collectors. The industry completely depends on traditional and certain improvised examination by individuals
- There is need to create awareness among people who are the stake holder of NTFP that gum of *Boswellia serrat*a *and Lannea coromandelica* having good market of gum produced by these species become a source of income for their livelihood.

Abu Baker, A., Tahir, A. and Sabah Elkheir, M.K. 2007. Effect of tree and nodule Academic Press, New York. Academic Press, New York. pp. 277-316.

Adam, I.M., Ballal, M.E.L.M. and Fadl, K.E.M. 2009. Effect of tapping direction in relation to sun light on gum arabic *Acacia senegal* (L.) Wild yields in North age on some physicochemical properties of gum from *Acacia senegal* (L.)

Ali, A.H., Fadl, K. E. M. and Adam, I. M. 2009. Effect of position of tapping, tree stem diameter and tapping tools on Frankincense yield of *Boswellia papyrifera* in South Kordofan, Sudan. Forest, Trees and Livelihoods. 19: 19-26.

Ali, B.H.. Ziada, A. and Blunden, G. 2009. Biological effect on gum arabic: A review of some recent research. Food and Chemical Technology, (47):1-8.

Ameh., P.and Ocheje. 2012. Physico-chemical properties and rheological behavior of *Ficus glumosa* gum in aqueous solution. International J. of Modern Chemistry, 2(3):84-89.

Anon. 2005. The wealth of India: Raw materials. Council of Scientific & Industrial Research. VI: 27-30.

Anonymous. 2013. Chhattisgarh State Minor Forest Produce Co-operative Federation Ltd, Raipur, Chhattisgarh.

Ayub , M.A , Hanif, M.A , Sarfraz R.A. & Shahid, M.2018. International Journal of Food Properties 2018, Vol. 21, NO. 1, 808–820.

Babu, A.M., and Menon, A.R.S. 1989. Ethephon induced gummosis in Bombax

ceiba L. and Sterculia urens Roxb. Indian Forester, 115(1): 44-47

Ballala, M.E., Siddig., E.A., Elfadl ,M.A, Luukkanen., O. 2005. Relationship between environmental factors, tapping dates, tapping intensity and gum Arabic yield of an *Acacia senegal* plantation in western Sudan. Journal of Arid Environments, 63 :379–389.

Bhatt, J. R. , M. N. B. Nair and H. Y. Mohan Ram 1989. Enhancement of oleo-gumresin production in *Commiphora wightii* by improved tapping technique. Current Science 58: 349-357.

Bhatt, J. R. and J. J. Shah 1885. Ethephon (2-chloroethyl phosphonic acid) enhanced gum resinosis in mango, *Mangifera indica L*. Indian Journal of Experimental Biology 23: 330-339.

Bhatt, J.R. and Mohan Ram, H.Y. (1990). Ethephon induced gum production in *Acacia senegal* and its potential value in the semi-arid regions of India. *Current Science,* 59: 1247-1250.

Bhatt, J.R. and Shah, J.J. 1985. Ethephon (2-chloroethyl phosphonic acid) bulletin, 01: 01-64.

Champion, H.G. and Seth, S.K. 1968. A Revised Survey of the Forest Types of India. Government of India Publications, New Delhi, 404 p.

Dadswell, H.E. and Hillis, W.E. 1962. "Wood Extractives." (W.E. Hillis, ed.). Academic Press, New York.

Das, I., Katiyar, P. and Raj, A. 2014. Effects of temperature and relative humidity on ethephon induced gum exudation in *Acacia nilotica*. Asian Journal of Multidisciplinary Studies, (10): 114-116.

Davison, R. L. 1980. Handbook of Water-Soluble Gums and Resins. McGrow Hill Book Company, New York.

Dawson, S. (2006) “Boswellia spp. Frankinscense Plant monograph”. Herbal medicine, class of September, 2003:1-20.

Dell, B. and McComb, A.J. 1978a. Plant resins their formation, secretion and possible functions. In: Advances in botanical research (ed. H.W. Woolhouse). Academic Press, New York. pp. 277-316.

Dione, M. and Vassal. J. 1998. Gummosis and gum production cycles in Acacia Senegal L. in: *Acacia senegal*, edited by Campa, C., Grignon, C., Guenye. M. and Hamons, S. 123-134.

Duppala, L. M., Durga, H. M. and Murthy, R. (2017). Physico-chemical and microbial studies of lannea gum. International research journal of pharmacy, 8(4):50-58.

El-Amin, E.E., Balall, M. E. and Mahmoud, A. E. 2013. Effect of soil type and rainfall on *Acacia senegal* (L.) Wild gum viscosity. Journal of Natural Resources and Environment Stu., (12):6-9.

Gaafar, A.M., 2005. .Improvement of traditional *Acacia Senegal* Agroforestry: um production in arid region. Current Agriculture, 26(1/2): 61-62.

Ghosh, S. S. and Purkayastha, S. K. 1959. An anatomical study of wood and bark of *Anogeissus latifolia* tree with special reference to gum exudation. Indian

Gundidza, M., Mmbengwa, V., Sibambo, S.R. and O. Mushisha .2011 Rheological, moisture and ash content analyses of a gum resin from *Commiphora Africana.* African Journal of Food Science Vol. 5(4),pp. 188 – 193

Gupta, L., Gupta, V., Parihar, V.,Ammon, H. P. 1998. Effects of Boswellia serrata gum resin in patients with bronchial asthma: results of a double-blind, placebo-controlled, 6-week clinical study. Eur J Med Res, 3(11):511-4.

Hall, M.A, Smith, A.R. 1995. Ethylene and the responses of plants to stress. Bulg J. Plant Physiol. 21 (2–3):71–79.

Harmand, J.M., Ntoupka, M., Mathieu, B., Njiti, C.F., Tapsou, J.M., Bois, J.C., Thaler, P. and Peltier, R. 2012. Gum arabic production in *Acacia Senegal* plantations in the Sudanian zone of Cameroon: Effects of climate, soil, tapping date and tree provenance. BOIS ET FORÊTS DES TROPIQUES, 311(1): 21-33.

Harsh, L.N., Tewari, J.C., Khan, H.A. and Ram, M. 2013. Ethephon-induced gum arabic exudation technique and its sustainability in arid and semi-arid regions of India. Forests, Trees and Livelihoods. 22(3): 204-211.

Joel, D.M. and Fahn, A. 1980a. Ultrastructure of resin ducts of *Mangifera indica* L. (Anacardiaceae). Differentiation and senescence of shoot ducts. Ann. Bot., 46: 225-235.

Kaitha ,A.K. and Sharma,A,K. 2019. Microwave assisted in situ synthesis of gum Salai guggal based silver nanocomposites- investigation of anti-bacterial properties.Cellulose, pp 991–1011.

Katiyar, P., Das, I.B. and Raj, A.2014.Effects of Temperature and Relative Humidity on Ethephon induced Gum Exudation in *Acacia nilotica*. Asian Journal of Multidisciplinary Studies,2(10). Arya, R. and Chaudhary, K.R. 2002. Morphological status of *Acacia nilotica* L. for gum production in arid region. Current Agriculture, 26(1/2): 61-62.

Kaur, R., Jaiswal, M.L.and Jain, V. 2012. Preliminary Pharmacognostical & Phytochemical investigation of Bark & Leaves of *Lannea coromandelica* Houtt. Merrill. International Journal of Pharmacognosy and Phytochemical Research, 4(3); 82-88.

Krishna-Murthy, T. & Shiva, M.P. (1977) Salai guggul from *Boswellia serrata*. Roxb. Its exploitation and utilization. Indian Forester, 103, 466–474.

Kurwanshi, V.B ., Katiyar, P., Khan, S. 2017. Scientific Approaches of Gum Tapping in Gum Karaya (Sterculia urens Roxb.) for High Gum Production. Int.J.Curr.Microbiol.App.Sci. 6(8): 3366-3374.

Lemenih, M., Abebe, T. and Olsson, M. 2003.Gum and resin resources from some Acacia, Boswellia and Commiphora species and their economic contributions in Liban, South-east Ethiopia. J. of Arid Environments. 55: 465-482.

Lohithasu D, Ramana Murthy KV. Isolation and evaluation of Binding property of *Lannea coromandelica* gum, Indian J Pharm Sci 2016; 78(2):224-30.

Mengistu. T., Sterck, F. and Fetene, M.and Bongers, F. 2013. Frankincense tapping reduces the carbohydrate storage of Boswellia trees. Tree Physiology, 33:601–608.

Mishra, Manish. 2005. Present ecology ical status of impact of harvesting of gum from Kullu (*Sterculia urens*) trees: A case study of three districts in Orissa. State Forest Research Institute (SFRI), 29(2):14-19.

Misra, C.M. and Singh, S.L. 1985. Suitable tapping technique of gum from *Acacia nilotica* (babool). Van-Vigyan, 23: 1-2.

Morrison, J.C. and Polito, V.S. 1985. Gum duct development in almond fruit, *Prunus dulcis* (Mill.). D. A. Webb. BOT. GAZ., 146: 15-25. Multidisciplinary Studies, (10): 114-116.

Murthy, T. K. and Shiva, M.P. 1977. Salai Guggul from *Boswellia serrata* Roxb. its exploitation and utilisation. The Indian Forester, 103 (7): 466–473.
Nair, B. (2000) Sustainable utilization of gum and resin by improved tapping technique in some species. In harvesting of nonwood, 293. FAO, Italy.

Nair, M. N. B. & Subrahmanyam, S. V. (1998) Ultrastructure of the epithelial cells and oleo-gum resin secretion in *Boswellia serrata (Burseraceae*), IAWA Journal; Vol. 19 (4):145-427.

Nair, M. N. B. and Subrahmanyam, S. V. 1998. Ultrastructure of the epithelial cells and oleo-gumresin secretion in *Boswellia serrata* (Burseraceae). IAWA J. 19(4): 415-427.

Niphadkar, S.S Rathod, V.K.2016 Extraction of acetyl 11-keto-*β*-boswellic acids (AKBA) from *Boswellia serrata* using ultrasound. Journal of Separation Science and Technology, Pages: 997-1005.

Prasad, N., Sharma, K. R., Tiwari, J. C., Gupta R. and Thomas, M. (2012). Mechanization of natural gum and resin tapping. J. Non –Timber Forest Products, 19(4):279-289.

Ramachandran, R., Bhuwan, C.J. 1968. Examination of The Gum From Lannea Coromandelica, Phytochemstry, 4(3):577-579.

Reddy, A.K., Jyothi, M.J., Kumar, A.C.K. 2011. *Lannea coromandelica*: The Researcher's Tree. Journal of Pharmacy Research , 4(3): 577-579.

Rijkers, T., Ogbazghi, W., Wessel, M. and Bongers, F. 2006. The effect of tapping for frankincense on sexual reproduction in *Boswellia papyrifera* .J. Applied Ecol. 43: 1188–1195.

Rupinder K., Jaiswal, M. L. and Jain., V. 2013. Protective effect of *Lannea coromandelica* Houtt. Merrill. against three common pathogens. J Ayurveda Integr Med, 4(4): 224–228, (2013).

Sao, K.P. 2012. Physico-chemical properties of some Indian plant gums of commercial importance. Indian Institute of Natural Resins and Gums, Indian Council of Agricultural Research, Namkun, Ranchi (Jharkhand). Technical bulletin, 01: 01-64.

Sathish R, Mohd., H. A, Natarajan K, Lalitha., K.G. 2010. Evaluation of wound healing and antimicrobial activity of *Lannea coromandelica (Houtt) Merr*. Journal of Pharmacy Research 2010; 3(6): 1225.

Shah, J.J. 1980. Gum, Resin and Gum-Resin Secretion in Plant. Acta Bot. Ind.II. pp. 91-96.

Sharma M.L, Kaul A. Khajuria A., Singh S., Singh G.B. Immunomodulatory activity of boswellic acid (pentacyclic triterpene acids) from *Boswellia serrata*. Phytother. Res. 1996; 10: 107-112.

Sharma, K. R. and Dutt, B. (2012). Networking Project on Harvesting, Processing and Value addition of Natural Resins and Gums. Department of Forest Products, Dr. Y. S. Parmar University of Horticulture and Forestry Nauni-Solan (HP).

Singh, P., Singh R., Chaturvedi, O.P., Prasad, R. Standardization of gum tapping

techniques for *Butea monosperma* L.: Effect of types and depth of incision on gum exudation Indian Journal of Agroforestry,18 (2):86-90.

Sinha, S.K., Pathak.J., Mehta, A. and Behera, L.(2016) .Tapping methods in salai guggal *(Boswellia serrata* Roxb*.)* for sustainable yield of oleo-gum resin a case study. Int. J. of Usuf. Mngt. 17 (2): 13-18.

Sunnichan, V.G., Mohan Ram, H.Y. & Shivanna, K.R. (2005) Reproductive biology of *Boswellia serrata*, the source of salai guggul, an important gum-resin. Botanical Journal of the Linnean Society, 147, 73–82.

Tahara, S., Sakasi M., and Islam M.T 2002.Zoosporicidal activity of polyflavonoid tannin identified in *Lannea coromandelica* stem bark against phytopathogenic oomycete Aphanomyces cochlioides. J Agric Food Chem, 50(23):6697-703.

Tewari, J.C., and Pareek, K., (2012) Annual Progress Report on Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums, CAZRI Centre, ICAR-CAZRI, Jodhpur, 17p.

Tiwari, J.C. and Ram M. 2010. Tree gum exudation techniques. Networking project on harvesting, processing and value addition of naturalresins and gums. CAZRI, Jodhpur (Rajasthan).

Upadhayay, A. 2006. Gums and Resins NTFP Unexplored, Community Forestry. 15-20.

Vasishth, A. 2017. Standardization of tapping techniques of gum extraction in *Lannea coromendelica*: a valuable gum yielding tree. Indian Forester, 143 (4) : 375-379.

Vollesen , K. 1989. Burseraceae. In: Hedberg, I. and Edward, S. (eds.) Flora of

Ethiopia. Volume 3, Addis Ababa, Ethiopia, pp.442– 478.

Waghmare, R.K ., Deokule, S.S. 2014 .Botanical Standardization of Bone setting Plant *Lannea coromandelica*. International Journal of Innovative Science, Engineering & Technology, 28 (4): 823 - 829.19.

Wahab, S.M., Aboutabl, E.A., El-zalabani, S.M., Fouad, H.A, De Pooter, H.L. and El-Fallaha Allaha, B. 1987. The essential oil of olibanum. Planta medica 53 (4): 382–384.

APPENDIX-A Table: ANOVA of Experiment.

Source of Variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F calculated**	**F Tabulated**	**C.D%**	**SEd±**
Replication (tree)	1	6219.853333	6219.853			45.91%	22.287
Shape (S)	2	565.5784625	282.7892	0.569280266			
Mechanical,Mechanical+ Chemical (C)	3	12830.87516	4276.958	*8.609903554	3.027998384		
Interaction Shape (S) x Chemical (C)	6	1000.408477	166.7347	0.335652105			
Season (Se)	1	7528.527075	7528.527	*15.15560503	4.27934426		
Interaction shape (S) x Season (Se)	2	305.534712	152.7674	0.307534487			
Chemical (C) x Season (Se)	3	2455.85589	818.6186	1.647953245	3.027998384		
Interaction Shape (S) x Chemical(C) x Season(S)	6	346.392943	57.73216	0.116220047			
Error	23	11425.22007	496.7487				
Total	47	42678.24613					

*** Significant at 5%,**

APPENDIX-B **incision cut and chemical concentration wise gum production from *b. SERRATA* in winter 2018and summer 2019**

SHAPE	MECHANICAL	*B. serrata g/tree* (Winter)	*B. Serrata gm/tree* (Summer)	TOTAL YIELD IN (g)
SQUARE SHAPE	S1-0%	6.53 g	10.82gm	17.35
	MECHANICAL+CHEMICAL			
	S2-10%	2.08 g	35.18g	37.26
	S3-20%	17.21 g	37.58g	54.79
	S4-30%	7.57 g	42.25g	49.82
V SHAPE	MECHANICAL			
	V1-0%	0 gm	4.56g	4.56
	MECHANICAL+CHEMICAL			
	V2-10%	16.05g	23.57g	39.62
	V3-20%	26.18g	37.42g	63.6
	V4-30%	3.02g	6.48g	9.5
HOLE SHAPE	MECHANICAL			
	H1-0%	0g	0g	0
	MECHANICAL+CHEMICAL			
	H2-10%	13.93g	34.54g	48.47
	H3-20%	6.89g	41.15g	48.04
	H4-30%	5.34g	52.94g	58.28

APPENDIX -C Incision Cut And Chemical Concentration Wise Gum Production From *L. Coromandelica* In Winter 2018 And Summer 2019

SHAPE	MECHANICAL	*L. coromandelica(winter) gm/tree*	*L.coromandelica(*summer) gm/tree	TOTAL YIELD (g)
SQUARE SHAPE	S1-0%	7.43	16.49	23.92
	MECHANICAL+CHEMICAL			
	S2-10%	18.45	49.09	67.54
	S3-20%	22.05	63.26	85.31
	S4-30%	35.14	75.61	110.75
V SHAPE	MECHANICAL			
	V1-0%	0	0	0
	MECHANICAL+CHEMICAL			
	V2-10%	12.71	68.57	81.28
	V3-20%	42.75	112.36	155.11
	V4-30%	51.13	140.59	191.72
HOLE SHAPE	MECHANICAL			
	H1-0%	0	0	0
	MECHANICAL+CHEMICAL			
	H2-10%	28.33	15.57	43.9
	H3-20%	33.49	60.85	94.34
	H4-30%	47.64	76.18	123.82

Appendix-D

Treatment wise gum production from *B.serrata and L. coromandelica* (g/tree/season)

SHAPE	MECHANICAL TREATMENTS	SEASON	*Boswellia serrta*	*Lannea coromandelica*
Square Shape	S_1-0%	Winter	6.53	7.43
		Summer	10.82	16.49
TOTAL			17.35	23.92
	S_2-10%	Winter	2.08	18.45
		Summer	35.18	49.09
TOTAL			37.26	67.54
	S_3-20%	Winter	17.21	22.05
		Summer	37.58	63.26
TOTAL			54.79	85.31
	S_4-30%	Winter	7.57	35.14
		Summer	42.25	75.61
TOTAL			49.82	110.75
V –Shape				
	V_1-0%	Winter	0	0
		Summer	4.56	0
TOTAL			4.56	0
	V_2-10%	Winter	16.05	12.71
		summer	23.57	68.57
TOTAL			39.62	81.28
	V_3-20%	Winter	26.18	42.75
		summer	37.42	112.36
TOTAL			63.6	155.11
	V_4-30%	Winter	3.02	51.13
		summer	6.48	140.59
TOTAL			9.5	191.72
Hole Shape				
	H_1-0%	winter	0	0
		summer	0	0

TOTAL			0	0
	H_2-10%	**winter**	**13.93**	**28.33**
		summer	**34.54**	**15.57**
TOTAL			**48.47**	**43.9**
	H_3-20%	**Winter**	**6.89**	**33.49**
		Summer	**41.15**	**60.85**
TOTAL			**48.04**	**94.34**
	H_4-30%	**Winter**	**5.34**	**47.64**
		Summer	**52.94**	**76.18**
TOTAL			**58.28**	**123.82**
Total yield from both the tree species during winter and summer			**431.29 g**	**1408.98 g**

APPENDIX -E

Weekly meteorological data during crop growing period (October 2018-December 2018 & Macrh 2019 to May 2019 at Deopur

MONTHS	TEMP(0C)	RH(%)	RF(mm)	VP(mm)	WS(kmph)	EP(mm)	SS(hr)
Oct-18	27.1	66.5	0	17.35	1.5	116.8	8.1
Nov-18	23.65	6	0	12.05	1.3	97.7	8.5
Dec-18	19.15	19.15	47.2	10	9.8	70.6	4.7
Mar-19	27	50.5	9.4	12.65	3.8	167.7	8.2
Apr-19	32.4	35.3	22	12.4	3.8	244	8.9
May-19	35.2	32.5	10.6	13.15	3.9	311	9.6

RESUME

Name : Amit Prakash Nayak
Date of birth : 30/03/1996
Present Address : Sundaram Boys Hostel, Room No. 1294, College of Agriculture, IGKV ,KrishakNager ,Jora, Raipur , (C.G)
Pin Code – 492012
Phone : 7978918695,8908104343
Fax : Nill
Email : amit30306@gmail.com
Permanent address : At/ Post – Biripata ,Via-Pritipur
District – Jajpur,Odisha
Pin Code – 755013

Academic Qualification :

Degree	Year	University/institute
10th	2011	BSE,Odisha
12th	2013	CHSE, Odisha
B. Sc. (Forestry)	2017	OUAT, Bhubaneswar,Odisha
M. Sc. (Forestry)	2019	IGKV, Raipur (C.G.)

Professional Experience : Forest Working Experience
Wildlife Census Experience

Membership of Professional Societies : Nill

Award / Recognitions : Consolation prize in Young Naturalist Awards Category, 2018

Publications : Nill

Amit Prakash Nayak
Signature