

**EVALUATION OF GUMMOSIS POTENTIAL IN
ACACIA NILOTICA L. USING VARIOUS
CONCENTRATION OF ETHEPHON**

M.Sc. (Forestry) Thesis

by

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

2015

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ACACIA NILOTICA L. USING VARIOUS
CONCENTRATION OF ETHEPHON**

Thesis

Submitted to the

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

by

Abhishek Raj

**IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF**

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in

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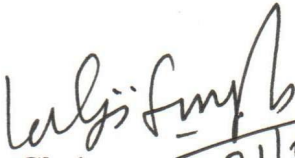
JULY, 2015

CERTIFICATE - I

This is to certify that the thesis entitled “**Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon**” submitted in partial fulfillment of the requirements for the degree of “**Master of Science in Forestry**” of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Abhishek Raj** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

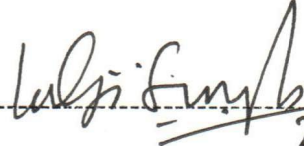
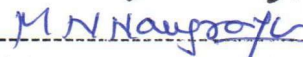

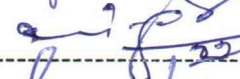

No part of the thesis has been submitted for any other degree or diploma or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Date: 21/07/2015


Chairman 21/07/15
(Dr. Lalji Singh)

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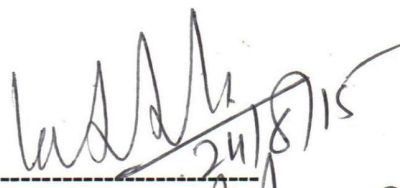
This is to certify that the thesis entitled “**Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon**” submitted by **Abhishek Raj** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **M.Sc. (Forestry)** in the **Department of Forestry** has been approved by the external examiner and Student's Advisory Committee after oral examination.

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Approved / Not approved

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Acknowledgement

“Education plays vital role in personal and social development and teacher plays a fundamental role in imparting education. Teachers have crucial role in shaping young people not only to face the future with confidence but also to build up it with aim and responsibility. There is no substitute for teacher pupil relationship”. I start in the name of God-who has bestowed upon me all the physical and mental attributes that I possess and skill to cut through and heal a fellow human.”

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IGKV, Raipur for providing necessary facilities, technical and administrative supports for conductance of my research work.

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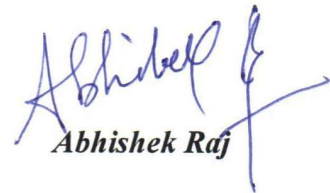

Abhishek Raj

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LIST OF NOTATIONS/SYMBOLS

R	Replication
A	Level
B	Girth class
C	Injury
D	Season
ml	Millilitre
cm	Centimeter
g	Gram
mg	Milligram
m	Meter
t	Ton
@	At the rate
\geq	More than equal to
\leq	Less than equal to
$^{\circ}\text{C}$	Degree Celsius
%	Percentage
a.i	Active ingredient
ha	Hectare
Eth	Ethephon
P	Probability
viz.	Namely

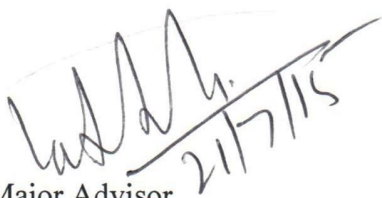
LIST OF ABBREVIATIONS

NS	Non significant
CD	Critical difference
CV	Coefficient of variance
SD	Standard deviation
SEm±	Standard error due to mean
EMS	Error mean of square
Fig.	Figure
No.	Number
C.G.	Chhattisgarh

THESIS ABSTRACT

- (a) Title of the Thesis : Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon
- (b) Full Name of the Student : Abhishek Raj
- (c) Major Subject : Forestry
- (d) Name and Address of the Major Advisor : Dr. Lalji Singh
Professor and Head
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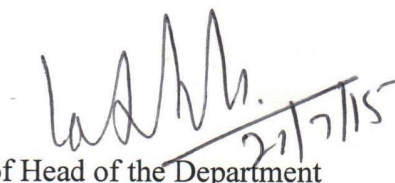
Signature of Major Advisor



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Date: 21/07/2015

Signature of the Student



21/7/15

Signature of Head of the Department

ABSTRACT

The present study entitled “**Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon**” was carried out in plantation area of babul trees at New Rajdhani area in Raipur district (Chhattisgarh) during rainy, winter and summer season of 2014-2015. Four factors viz., ethephon concentration (0, 2 and 4 ml), girth classes (≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm), injury (single and double) and seasons (rainy, winter summer) were subjected to statistical analysis of factorial CRD for understanding their interaction and combined effect on yield parameter of gum exudation. Quality parameter of gum such as pH, moisture content and ash content were 4.5, 15.2% and 2.63%.

The results of study on rate of gum exudation (mg/tree/day) revealed that gum exudation was in order: May (160.7) > April (129.2) > March (121.4) > Nov (97.5) > Oct (83.8) > Feb (82.1) > Sep (71.0) > Dec (65.7) > Jan (64.1). Significantly highest rate (22.502

and 20.382 mg/tree/day) of gum exudation was observed in summer season under the treatment of 4 ml of ethephon in ≥ 50.1 cm of girth class and same 4 ml treatment of ethephon in double injury of babool. Under controlled condition gum was produced only in the month of May. The rate of gum production under ethephon treatment was observed 0.140 g/tree/day, which is 7 times more than in controlled having 0.0207 g/tree/day in the month of May. Moreover, rate of gum production under ethephon treatment was 42 times more than controlled in rainy, winter and summer seasons.

The results of study on quantity of gum exudation (g/tree/month) revealed that exudation per plant (g/tree/month) was in order: May (5.0) > April (3.88) > March (3.77) > November (2.93) > October (2.60) > February (2.30) > September (2.13) > December (2.05) > January (1.99). Significantly highest quantity (0.690 and 0.625 g/tree/month) of gum exudation was observed in summer season under the treatment of 4 ml of ethephon in ≥ 50.1 cm of girth class and same 4 ml treatment of ethephon in double injury of babool.

Seasonally overall rate of gum exudation (mg/tree/day) and quantity of gum per tree (g/tree/month) were in order: summer (137.1, 4.21) > rainy (77.40, 2.36) > winter (77.35, 2.31). This was due to climatic factors *viz.*, temperature with relative humidity, ethephon with different concentration (from 0.78 to 1.56%) along with different doses (0, 2, 4ml), number of hole and girth of tree. Moreover, it was observed that chemical method using ethephon was safe and scientific techniques for gum production in sustainable way.

शोध ग्रंथ सारांश

- क) शोध ग्रंथ शीर्षक : अकेशिया निलोटिका में इथेफॉन के विभिन्न एकाग्रता के प्रयोग द्वारा गोंदार्ति (गमोसिस) क्षमता का मुल्यांकन
- ख) छात्र का पूरा नाम : अभिषेक राज
- ग) मुख्य विषय : वानिकी
डॉ. लालजी सिंह
- घ) मुख्य सलाहकार का नाम एवं पता : प्राध्यापक एवं विभागाध्यक्ष, वानिकी विभाग, कृषि महाविद्यालय, इ.गा.कृ.वि.वि., रायपुर (छ.ग.)
- ड.) उपाधि जिससे सम्मानित किया जाना है : एम. एस.सी. वानिकी

मुख्य सलाहकार के हस्ताक्षर

दिनांक: 21/07/2015

अभिषेक राज
छात्र के हस्ताक्षर 21/7/15

विभागाध्यक्ष के हस्ताक्षर 21/7/15

सारांश

वर्तमान अन्वेषण शीर्षक "अकेशिया निलोटिका" में इथेफॉन के विभिन्न एकाग्रता के प्रयोग द्वारा गोंदार्ति (गमोसिस) क्षमता का मुल्यांकन" रायपुर जिले (छ.ग.) के नई राजधानी क्षेत्र में बबुल पेड़ों के बगान क्षेत्र में वर्षा, शरद और ग्रीष्म ऋतु के दौरान सत्र 2014 - 15 में किया गया जिसमें चार कारकों अर्थात् इथेफॉन एकाग्रता (0, 2 और 4 मि.ली.), परिधि कक्षाएँ (≥ 30.1 से ≤ 50.0 सें.मी. और ≥ 50.1 सें.मी.), चोट (सींगल और डबल) और ऋतु (वर्षा, शरद और ग्रीष्म) को भाज्य पूर्णतया यादृच्छिकीकृत अभिकल्पना का सांख्यिकीय विश्लेषण के अंतर्गत उनके संबंध को समझने और गोंद स्त्राव की उपज घटक पर संयुक्त प्रभाव को विश्लेषित किया गया। गोंद के गुणवत्ता घटक जैसे पी.एच., नमी की मात्रा और राख की मात्रा क्रमशः 4.5, 15.2 % और 2.63 % को अनुसंधान प्रयोगशाला में विश्लेषित किया गया।

गोंद स्त्राव (मिली.ग्रा./पेड़/दिन) की दर पर अध्ययन के परिणामों से पता चला है कि स्त्राव मई (160.7) > अप्रैल (129.2) > मार्च (121.4) > नवम्बर (97.5) > अक्टूबर (83.8) > फरवरी (82.1) > सितम्बर (71.0) > दिसम्बर (65.7) > जनवरी (64.1) के क्रम में पाया गया था। सार्थक गम स्त्राव के उच्चतम दर (22.502 और 20.382 मिली.ग्रा./पेड़/दिन) को इथेफॉन के 4 मि.ली. को ≥ 50.1 सें.मी परिधि कक्षाएँ और दोहरी चोट में उपचार के तहत ग्रीष्म ऋतु में पाया गया। नियंत्रित हालत के तहत गोंद उत्पादन केवल मई के महिने में देखा गया था। इथेफॉन उपचार के तहत गोंद उत्पादन की दर मई महिने में 0.140 ग्रा./पेड़/दिन पाया गया जो कि नियंत्रित हालत वाले गोंद, 0.0207 ग्रा./पेड़/दिन

से सात बार अधिक थी। इसके अलावा इथेफॉन उपचार के तहत गोंद उत्पादन की दर वर्षा, शरद और ग्रीष्म ऋतु में नियंत्रित से 42 गुना अधिक थी।

गोंद स्त्राव (ग्रा./पेड़/माह) की मात्रा पर अध्ययन के परिणामों से पता चला है कि स्त्राव प्रति पेड़ मई (5.0) > अप्रैल (3.88) > मार्च (3.77) > नवम्बर (2.93) > अक्टूबर (2.60) > फरवरी (2.30) > सितम्बर (2.13) > दिसम्बर (2.05) > जनवरी (1.99) के क्रम में पाया गया। सार्थक गोंद स्त्राव के उच्चतम मात्रा (0.690 और 0.625 ग्रा./पेड़/माह) को इथेफॉन के 4 मि.ली. को ≥ 50.1 सें.मी परिधि कक्षाएँ और दोहरी चोट में उपचार के तहत ग्रीष्म ऋतु के मौसम में पाया गया।

कुल मिलाकर गोंद स्त्राव की दर (मि.ग्रा./पेड़/दिन) और गोंद प्रति पेड़ की मात्रा (ग्रा./पेड़/माह.) ग्रीष्म (131.1, 4.21) > वर्षा (77.40, 2.36) > शरद (77.35, 2.31) ऋतु के क्रम में पाया गया। यह जलवायु संबंधी कारक अर्थात् सापेक्षिक आर्द्रता के साथ तापमान, इथेफॉन की विभिन्न एकाग्रता (0.78 से 1.56 %), उनके अलग – अलग खुराक (0, 2, 4 मि.ली.), छिद्र की संख्या और पेड़ की परिधि के कारण था। इसके अलावा, यह देखा गया कि गोंद के सतत उत्पादन के लिए रसायनिक विधि के अन्तर्गत इथेफॉन का उपयोग एक सुरक्षित और वैज्ञानिक तकनीक साबित हुआ।

CHAPTER- I INTRODUCTION

Acacia nilotica (L.) Willd. ex Del commonly known as babul, kikar or Indian gum Arabic tree has been recognized worldwide as a multipurpose tree (National Academy of Sciences, 1980). It is estimated that there are roughly 1380 species of *Acacia* worldwide, about two-third of them are native to Australia and rest are spread over tropical and subtropical regions of the world (Maslin *et al.*, 2003; Orchard and Maslin, 2003). It is a medium sized, almost evergreen thorny tree, sometimes attaining a height of 15 meter and comes under family Mimosaceae. It grows well in areas with rainfall ranging between 500 and 1250 mm. It thrives well on alluvial, sandy loam soil. The bark, a tinge of orange and/or green (young tree), but older trees have dark, rough bark and tend to lose their thorns (Beniwal *et al.* 1992; Mann *et al.* 2003; Khan *et al.* 2009). New leaves appear in spring (March-April). It may be leafless for short period during April-May in very poor sites. The seeds are 8-12 per pod, compressed, ovoid, dark brown shining with hard testa (Iman *et al.*, 2007). Flowers are globular heads, 1.2-1.5 cm in diameter of a bright golden yellow colour, develop either in axillary or whorly pattern on peduncles, 2-3 cm long located at the end of branches (Bargali and Bargali, 2009). Flowering is irregular, generally during rainy season from June to September. The peak fruiting occurs in June and February. It has been widely planted on farms throughout the plains of the Indian subcontinent and a species of Southern Tropical dry deciduous forests and Southern Tropical thorn forests as distinguished by Champion and Seth (1968). *Acacia* species contains secondary metabolites including amines and alkaloids, cyanogenic glycosides, cyclitols, fatty acids and seed oils, fluoroacetate, gums, non-protein amino acids, terpenes (including essential oils, diterpenes, phytosterol and triterpene genins and saponins), hydrolyzable tannins, flavonoids and condensed tannins (Seigler, 2003). The plant is rich source of cystine, methionine, threonine, lysine, tryptophan, potassium, phosphorus, magnesium, iron and manganese (Singh *et al.*, 2008). The plant chemical compounds are like diester, pentacosane dioic acid dihexadecyl ester and are alcohol, heptacosane 1, 2, 3-triol (Banso, 2009).

Gum is one of the important non-timber forest produce (NTFP) and viable source of income for thousands of forest dwellers, especially tribals in India. Gum production is a pillar of family economy and considered as an income-generating source that requires only a low input of work after the rainy season (Gaafar, 2005). The major commercially important gums in good quantity are sourced from the central Indian forests, comprising of Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Orissa, Jharkhand and Bihar and to some extent Gujarat and Rajasthan. Chhattisgarh is a predominantly tribal region in the eastern part of India comprising total geographical area of 13.79 million ha (4.1% of country geographical area). The geographical location of Chhattisgarh is 17 degree 46 min north to 24 degree 5 min north latitude and from 80 degree 15 min east to 84 degree 20 min east longitude. The total area of eastern plateau and hill region agro-climatic zone is 23.29 lakh ha, which is 24.90% of the total geographical area of the state. Annual rainfall varies from 1100-1700 mm. Chhattisgarh Plain Zone comprises Durg, Raipur, Rajnandgaon, Bilaspur, Raigarh, Kanaker, Sarangarh and Gharghoda tehils of Raigarh. Chhattisgarh topography includes landforms of mountain ranges, plateau region and plain land areas. The gradient of the Chhattisgarh Plain is generally flat. The elevation of the plain land varies from 250 meter to 330 meter. The loamy and clayey soil of this plain area is very fertile and climate generally varies from moist sub-humid to dry sub-humid.

Chhattisgarh state is rich in forest and has vast variety of minor forest produce to favourable agro climatic conditions resulting in good forest area i.e. 43.6 % of total. Gums are primarily categorized as Grade-I of Karaya (*Sterculia urens*) and Grade-II of Dhawada (*Anogeissus latifolia*), Babool (*Acacia indica*) and Khair (*Acacia catechu*) in the Chhattisgarh state. The above four gums are nationalized gums in the state. The other important gums of the state are Saja (*Terminalia tomentosa*), Char (*Buchanania lanzan*), Dikamali (*Gardenia gummifera*), Bahera (*Terminelia belerica*) and Jhingan (*Lavea grantis*) and these gums are under the category of non-nationalized minor forest produce items. The important gum yielding trees are *Acacia nilotica* (Babul), *Acacia catechu* (Khair), *Anogeissus latifolia* (Dhaura), *Shorea robusta* (sal), *Azadirachta indica* (Neem), *Acacia senegal* (Gum arabic), *Acacia nilotica* (Indian gum arabic), *Moringa*

oleifera (Drumstick), *Sterculia urens* (Gum Karaya), *Commiphora mukul* (Guggal).

A gum in general, is any water-soluble or water-swellaable polysaccharide. Exudate gums are produced by some trees, shrub and herbaceous perennials and are generally produced either naturally or in response to injury. The gum exudes from trees and shrubs in tear-like, striated nodules or amorphous lumps. It dries in contact with air and sunlight and forms hard, glass like lumps. Gum production increases at high temperature and limited moisture. Babul gum is known as 'Indian gum Arabic'. It exudes from the wounds in bark. It generally exudes between March and May. It occurs in the form of rounded or ovoid tears and size up to 1cm and color varies from pale-yellow to brown or almost black. Its physicochemical properties comprises of 13% moisture, 38% solubility, 300-320°C melting temperature, 3.54% ash, 0.4% nitrogen, 2.71% protein, 78.15% total soluble fibre, 0.70g/100g Ca, 0.30g/100g Mg, 0.004g/100g Fe, 0.016g/100g Na and 0.78g/100g K. The gum of *Acacia nilotica* has a higher molecular weight (Mw, 2.3×10^6) than *Acacia senegal* (Mw, 600,000). The gum contains galactose, L-arabinose, L-rhamnose, and four aldobiouronic acids. It contains a high percentage of phenolic constituents consisting of m-digallic acid, gallic acid, its methyl and ethyl esters, protocatechuic and ellagic acids, leucocyanidin, m-digallic dimer 3,4,5,7-tetrahydroxy flavan-3-ol, oligomer 3,4,7- trihydroxy flavan 3,4-diol and 3,4,5,7-tetrahydroxy flavan-3-ol and (-) epicatechol. Fruit also contains mucilage and saponins. Also is rich in phenolics consisting of condensed tannins and phlobetannin, gallic acid, protocatechuic acid pyrocatechol, (+) – catechin, (-) epigallocatechin-5,7-digallate, apigenin, 6-8-bis-D-glucoside, and rutin (Seigler, 2003). The gum production is up to maximum of 1 kg/tree/year, but the average is only in few grams. In traditional method of gum tapping in different parts of the world, a number of tapping spots on tree trunks and branches depending on its size are made and in the process plants get injured at various points and produce only few amounts of gum. (Awouda, 1989; Tadesse *et al.*, 2007). Traditionally trees are tapped by blazing, stripping of the bark or making deep cuts in the base of the tree with axe. Trees are tapped to increase gum yield by making incisions in the bark or treating with stress hormone ethylene or ethylene-releasing compounds such as

ethephon (2-chloroethylphosphonic acid). Ethephon is used to stimulate latex flow in Para rubber (*Hevea brasiliensis*), resin enhancement in pines (Peters *et al.*, 1978), gum production in *Acacia senegal* (Bhatt and Mohan Ram, 1990), *Anogeissus latifolia* (Bhatt, 1987), *Azadirachta indica* (Nair *et al.*, 1980, 1985). It also increases gumresinosis in *Mangifera indica* (Bhatt and Shah, 1985) and *Commiphora wightii* (Bhatt *et al.*, 1989). The idea to use ethephon as gum inducer came from the thought that if ethylene is supplied artificially to the tree *via* the application of ethephon, the developmental response to stress could be accelerated, and, consequently, more gum exudates could be obtained. Ethephon can mimic the effect of water stress, as it releases the stress hormone ethylene in plant tissues. Summer season is the preferable time for tapping. Incisions made (6cm x 1cm and 10cm x 0.5cm) have shown maximum yield 12 g/tree/annum. The gum yield increase with increase in concentration of ethephon. Treatment of trees with ethephon exceeding the optimum amount may cause die back and death. Ethephon concentration above 960 mg/4ml in *Acacia senegal* induces shoot desiccation and dieback. However, gum tapping using scientific methods of gum exudation not only increase the life span of the tree but also yields good quality gum of high international value (Gupta *et al.*, 2012). This may go a long way in raising the socio-economic status of tribal belt of Chhattisgarh state. In view of above the study was aimed with following objectives.

1. To access the impact of chemical methods for gum tapping in *Acacia nilotica*.
2. To evaluate the impact of temperature and relative humidity on gum exudation in *Acacia nilotica*.
3. To study the yield potential of *Acacia nilotica* and its correlation with girth classes and levels of ethephon.

CHAPTER- II REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the work done on Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon.

Alland (1944) has reported that gum arabic is the oldest and the best known of all the natural gums, its uses are date back to about 4000BC in inks, paintings, cosmetics, clothing, medicine and mummification process.

Purkayastha (1959) observed that the formation of ducts in the xylem or wood in response to injury which exude gum profusely and called these ducts as 'traumatic' ducts.

As per Esau (1965) the production of gums in plants is not well understood, these substances often accumulate in response to stress, injury, or bacterial, fungal or insect attack on the plant. Degeneration of cells resulting in the formation of complex, variable gums occurs in a broad range of species. This process, called gummosis, results in the depletion of starch in cells and in many cases appears to involve breakdown of cell walls. Gums are usually associated with xylem cells and special structures called gum ducts.

Gupta (1970) has concluded that the gum of *A. nilotica* is sometimes used as a substitute for gum arabic (obtained from *A. senegal*) although the quality is inferior.

As per Stosser (1979), gum duct formation is one of the processes involved in cell wall decomposition. This means that it is associated with living tissue. In cherry shoots, the beginning of gum duct formation can usually be seen in the non-lignified tissue formed by the cambium during lateral growth. The cells from which form the gum ducts are called the initial cells. They can be identified by their dense cytoplasm and by the more intense staining of their cell walls with the

periodic acid-Schiff's (PAS) reaction for carbohydrates. The dissolution of cells starts in the center of the initial cells. Gum ducts of different sizes finally form in the wood. After the gum ducts form, the cambium remains active, and the ducts finally become enclosed in the wood.

Boothby (1983) reported that gums are complexes of different substances, mostly polysaccharides of diverse structure. The composition of gum polysaccharides varies from species to species and from cultivar to cultivar.

Duke (1983) has reported that the gum obtained from *A. nilotica* is pharmaceutically used as suspending and emulsifying agent and in preparation of many formulations. Its resins repel insects and water.

Misra and Singh (1985) conducted an experiment in the Kukrail Forest of Uttar Pradesh. Blazes of 5X10 cm were made 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; all other treatments (except mud paste and N/5 NaOH) also stimulated production compared with control values.

Morrison and Polito (1985) have reported that gum ducts have been found in both woody tissues and fruits in all cultivated *Prunus* species. Gum ducts form naturally in healthy fruit trees. However, gum production intensifies after treatment with ethylene or ethylene releasing compounds, infection, insect attack, mechanical damage, and environmental stress.

Bhatt (1987) reported the improved gum tapping method by ethephon treatment in trunk by injecting a syringe into holes made by increment borer. Gummosis is enhanced by ethephon application and 466 fold increase in gum yield was observed in plants treated with 1600 mg of active ethephon substance during April- May when plants becomes leafless. The ethephon application leads to 'schizo-lysigenous' formation of gum cavities in the axial parenchyma of sapwood and these results in the clogging of vessels of secondary xylem with gummy material.

Babu and Menon (1989) observed the trees of the two species from the Sardar Patel University Botanical Garden, Gujarat. Trees were treated by injecting 2 ml of ethephon solution into the stem at 1.5 m above ground. Concentrations used per 2 ml water were 0, 240, 480 or 720 mg for *Bombax ceiba* and 0, 96, 192, 480, 768 or 960 mg for *Sterculia urens*. Injections were made into holes made with an increment borer reaching through to the xylem. Control treatments comprised the injection of 2 ml distilled water into holes on the opposite side of treated trees, and into separate trees. The holes were sealed with wax after injection. The resulting gum exudation was measured. In *B. ceiba* exudation started from treated holes after 10-12 days. The highest yields were from 240 mg (282 g gum) and 480 mg (378 g gum) treatments; there was no exudation from the 0 mg treatment. Exudation stopped after 7-10 days but further (lower) yields were obtained from holes or injuries made near the treated region for several days; yields were lower from fresh holes made below the original hole than from holes made above it. Exudation also occurred from holes made opposite the treatment hole at different heights. In *S. urens* exudation from treated holes also started after 10-12 days. The highest yield was from the 768 mg treatment (64.5 g gum), followed by the 960 mg treatment (38 g gum); there was a small exudation (0.5 g gum) from the 0 mg treatment. Exudation stopped after about 10 days, but a fresh hole made near the treatment site gave further exudation. Copious exudation was also obtained from holes made opposite and above and below the treatment site; exudation from holes vertically above the treatment site was immediate, in contrast to that from below, which was not.

Bhatt and Ram (1990) studied the six *Acacia senegal* trees growing in the Chambal ravines, near Barhi, Madhya Pradesh. Five trees were treated with ethephon by introducing 4 ml solution (containing 480, 720 or 960 mg active ingredient) through a hole of 5 cm deep and 2.5 cm wide, slanting downwards, and made using a hammer and chisel at 1.0-1.5 m above ground, in April/May. Little or no gum was produced by control trees (holes bored but no Ethephon added), and the most gum exudation (806-950 g/tree) occurred in the 960 mg treatment. Exudation started 4-8 days after treatment.

Srivastava and Srivastava (1992) have studied the physico-chemical properties (including NMR spectra, viscosity and optical rotation) of gum and are reported from analyses of six Indian gum arabic (*Acacia nilotica*) samples (from Maharashtra, Andhra Pradesh, Madhya Pradesh and Uttar Pradesh) and two African samples (from Sudan and Nigeria). Significant differences were found between the samples.

Menzies *et al.* (1996) analyzed the physicochemical and immunological properties of three Sudanese gum arabic samples and four gum tahla samples (two Sudanese, one West African and one Tanzanian-*Acacia seyal* var.*seyal*) were compared. The optical rotation (*ca* -30°) and rhamnose (12–14%), arabinose (24–29%), galactose (36–42%), glucuronic acid (16–17%), nitrogen (0.327–0.365%) and protein (2.16–2.41%) contents of the gum arabic samples were consistent with the specification for *Acacia* gum. In contrast the gum tahla samples had positive $[\alpha]_D$ values (+45° to +54°), lower rhamnose (3–4%) and higher arabinose (41–45%) contents and lower nitrogen (0.147–0.175%), and hence protein (0.97–1.15%), contents. All of the gum arabic samples precipitated with β -glucosyl Yariv reagent and hence were shown to contain arabinogalactan-protein(s) (AGPs), whereas in all but one of the gum tahla samples AGPs were not detected. The strong interaction of gum tahla with a monoclonal antibody known to recognize arabinose residues present in AGPs and arabinogalactans (AGs) was consistent with the observed higher levels of arabinose present in the gum tahla samples relative to the gum arabic samples. The data presented confirm that there are a number of physicochemical and structural differences between gum arabic (*A. senegal* gum) and gum tahla (*A. seyal* gum), and that a quick and simple immunological technique (immunodot blots) using an antiAGP/AG monoclonal antibody (MAC 207) could be used to screen for the presence of gum tahla in gum arabic consignments.

Islam *et al.* (1997) observed the chemical composition of Gum Arabic as complex and consists of a group of macromolecules characterized by a high proportion of carbohydrates (~97%), which are predominantly composed of D-galactose and L-arabinose units and a low proportion of proteins (<3%).

Baldwin *et al.* (1999) analysed a simple immunology of plant cell wall component epitopes present in 16 gum exudates obtained from 13 species of *Acacia* trees and observed that each of the gum samples studied had a unique composition. These analyses demonstrated that in some cases gums harvested from species in the same taxonomic group exhibited wider differences in their composition of cell wall component epitopes than gums from taxonomically unrelated species. Furthermore, gums obtained from different sub-species of a single species (e.g. *A. nilotica* and *A. nilotica* sp. *nilotica*) were shown to have very distinct chemical compositions. The results also demonstrated the presence of hydroxyproline-rich glycoprotein (HRGP) epitopes in the gum exudates of *Acacia tortilis*, *Acacia nilotica*, *Acacia nilotica* sp. *nilotica*, *Acacia microbotrya*, *Acacia pycnantha* and *Acacia campylacantha* for the first time. These clearly demonstrate the utility of such immunological tests in chemotaxonomic analyses of this economically important class of plant gum exudates.

Arya and Chaudhary (2002) reported that at the same age of 52 months irrigated trees with greater 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.

Hagybaghercandy *et al.* (2003) analysed quantitative and qualitative character of carbohydrate in gum of *Acacia nilotica*, collected from a research farm of medicinal plants in Booshehr province, Iran. The quantitative determination of carbohydrate was performed by spectrophotometry (HITACHI 340) at 625 nm. The total carbohydrate in gum arabic was 6.51%. The qualitative analysis by thin layer chromatography revealed the presence of pentoses, hexoses and uronic acid in gum arabic. In this method, the best reagents and solvents were formic acid-tertiary butanol-water and anisidine-phthalic acid-ethanol.

Gamal el-din *et al.* (2003) have reported the medicinal value of gum arabic. In folk medicine, Gum arabic has been reported to be used internally for the treatment of inflammation of the intestinal mucosa, and externally to cover inflamed surfaces.

Verbeken *et al.* (2003) concluded that progressive loss of foliage and the entry in state of dormancy are indicators of periods of tapping.

Nair (2004) concluded that gum karaya is vital for tribal economy and its trade value is substantial, there is a pressing need to develop a scientific and sustainable tapping method to increase the yield and ensure the survival of the tapped trees. A simple and safe technique of tapping with substantial increase in the yield is developed using ethephon to enhance gum yield and wound healing. After 45 days of ethephon application a thick wound tissue has developed at the injured region and nearly replaced the damaged tissue. The wound is completely healed 60 days after tapping.

Ballal *et al.* (2005a) found that 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. Late tapping reduced the production of gum.

Ballal *et al.* (2005b) and Raddad and Luukkanen (2006) showed a positive relationship between gum yield and rainfall in the season preceding tapping and/or between gum yield and soil water content at the end of the rainy season.

Gaafar (2005) showed that gum production was positively correlated to soil water at 75-150 cm soil depth.

Saniewski *et al.* (2005) reported that Gums are induced by infection, insect attack, mechanical and chemical injury, water stress, and other environmental stresses in some plant species. All of these factors are believed to act *via* ethylene produced in plant tissues. Ethylene is believed to be the main factor responsible for the induction of gummosis. Ethylene or ethylene releasing compounds such as ethephon (2-chloroethylphosphonic acid) substantially stimulate gum formation in stone-fruit trees and their fruits of the *Rosaceae* family, such as cherries, ornamental Japanese cherries, plums, apricots, peaches and almonds. Gums consist mostly of polysaccharides, although they contain several other substances as well.

According to Trommer and Neubert (2005) gum arabic is used in pharmaceutical preparations and as a carrier of drugs since it is considered a physiologically harmless substance. Additionally, recent studies have highlighted GA antioxidant properties.

Fadl and Gebauer (2006) have worked on *Acacia seyal* (talha) gum by using a two-factor experiment at Umfakarín forest reserve in 2001/02. The first factor was the time of tapping, which was tested in three levels (1 November, 15 November and 1 December). The second factor was tapping intensity, which was tested in four levels (2, 4, 6 and 8 branches). The tapping date had a significant effect on the amount of gum production. Trees in this experiment produced the highest gum yield when they were tapped on the 1st of November. However, the tapping intensity did not show a clear effect on the gum yield. Therefore, a tapping intensity of 2-4 branches is recommended in order to minimize the likelihood of damaging the tapped trees.

Meena *et al.* (2006) reported the chemopreventive activity of aqueous extracts gum, flower and leaf of *Acacia nilotica* on 7,12-dimethylbenz(a)anthracene (DMBA) induced skin papillomagenesis in male swiss albino mice. The activity of the leaf extract was most significant followed by the flower extract and then by gum.

Al-Assaf *et al.* (2007) showed that molecular associations in Gum Arabic can lead to an increase in molecular weight in the solid state by maturation under controlled heat and humidity.

As per Jain *et al.* (2007) *Sterculia* is a genus colloquially termed as tropical chestnuts, (*Sterculia foetida*). It contains a mixture of D-galactose, L-rhamnose and D-galactouronic acid. The galctouronic acid units are the branching points of the molecule.

Saini (2008) have reported that babul plant is therapeutic used as anti-cancer, anti tumours, antiscorbutic, astringent, anti-oxidant, natriuretic, antispasmodial, diuretic, intestinal pains and diarrhea, nerve stimulant, cold,

congestion, coughs, dysentery, fever, hemorrhages, leucorrhea, ophthalmia and sclerosis.

Adam *et al.* (2009) carried out a study at El Demokeya Forest Reserve over two seasons (2006\2007 and 2007\2008) to determine the effect of tapping direction in relation to sun light on the yield of gum arabic from *Acacia senegal*. A randomized complete block design experiment with three replications was conducted. The treatments consisted of tapping on the eastern, western, northern and southern sides of the tree. The number of trees per treatment was 10 and 15 in the first and second seasons, respectively. A highly significant difference between tapping direction ($P \leq 0.001$) was obtained in all pickings except the third picking in the first season and the first picking in the second season. The gum yield increased by 60% when the tapping was on the eastern and western sides towards direct sun light. The combined analysis showed significant differences ($P \leq 0.05$ and $P \leq 0.001$) on total gum yield (g/tree) and the number of trees yielding gum. Therefore, tapping of *Acacia senegal* tree on the eastern and western sides is recommended.

Ali *et al.* (2009) suggested a possible use of gum arabic in dentistry because it enhances dental remineralisation and has some antimicrobial activity. Other commercial uses of Acacia gum include utilization in inks production, pottery pigments and glazing for colour thickening in water-colours and paints, wax polishes or for giving lustre to silk and crepe in textiles and lithography.

Al-Assaf *et al.* (2009) analyzed the role of protein components in gum arabic to promote molecular association when the gum is subjected to different processing treatments such as maturation, spray drying and irradiation.

Chiveu *et al.* (2009) reported that the plantations could keep a significant signal of their provenance for some characteristics such as the quantity of gum produced and it has been proven by tests of origin.

Unanaonwi (2009) conducted a research to estimate gum Arabic production from Zamfara State, Nigeria. The study was carried out in ten locations

which lie along the shelter belt and natural forest in Zamfara State. Multistage sampling technique was used in selecting ten samples from plantation and ten from natural forest. Tapping, collection and weighing of exudates were done simultaneously in both sites. Data were analyzed through descriptive statistics. Results shows that yield/tree for plantation was 85g, while it was 87.7g for natural forest. A tree in the natural forest occupies an average area of 47.12 m², about 33.96% of sample area. The State contributes 0.013% of the national production from plantation and 0.015% of national gum production from natural forest. Yield/ha was 53.125 kg for plantation and 18.592 kg/ha for natural forest. Total estimated gum Arabic production was 3.62 tons, which is 0.3% of the national production.

Kariuki and Njoroge (2011) tested extracts of *Acacia nilotica* against three test organism: *Staphylococcus aureus*, *Streptococcus pneumoniae* and *Escherichia coli* for their antimicrobial properties by bioassay method using the disk diffusion test. The findings indicated that *A. nilotica* have antimicrobial property.

Ngaryo *et al.* (2011) have investigated the effect of tapping characteristics such as length, width, depth, height and tree diameter on *Acacia senegal* gum production and to provide a model to predict the gum production. The model explained 51% of gum production including the stem diameter class, the crown diameter class, the date, the height and the depth of tapping. The ability of tree to produce gum is related to its size and diameter. Furthermore, gum production and stem diameter are positively related. The gum production is also significantly and positively related to crown diameter and tapping height and negatively to its depth.

Rabah (2011) has studied the rheological data of gum arabic and reported that density of *A. senegal* gum at room temperature is found to be higher than that of water only at higher concentration (>5 g/l). The density is also found to be strong function of temperature. At medium temperature >45 °C becomes lower than that of water even at low concentration (<2.5 g/l). The viscosity is found to be shear rate independent indicating Newtonian behavior. At low concentration *Acacia senegal* gum viscosity varies linearly with concentration and at high concentration (>10 g/l) varies exponentially.

Ali *et al.* (2012) reported that *Acacia nilotica* is a medicinal plant acknowledged to be rich in phenolics, consisting of condensed tannin and phlobatannin, gallic acid, protocatechuic acid, pyrocatechol, (+)-catechin, (-) epigallocatechin-7-gallate and (-) epigallocatechin-5, 7-digallate. Different parts of this plant such as the leaves, roots, seeds, bark, fruits, flowers, gum and immature pods act as anti-cancer, antimutagenic, spasmogenic, vasoconstrictor, anti-pyretic, anti-asthmatic, cytotoxic, anti-diabetic, anti-platelet agregatory, anti-plasmodial, molluscicidal, anti-fungal, inhibitory activity against Hepatitis C virus (HCV) and *human immunodeficiency virus* (HIV)-I and antioxidant activities, anti-bacterial, anti-hypertensive and anti-spasmodic activities, and are also engaged for the treatment of different ailments in the indigenous system of medicine.

Harmand *et al.* (2012) observed the best time to gum tapping in trees was at the beginning of the dry season, when the relative humidity dropped. Depending on the location along the climatic gradient.

Adam *et al.* (2013) conducted a two-factor experiment in randomized complete block design with four replications during 2004 in El Demokeya Forest Reserve and El Himaira Natural Forest, North Kordofan State, Sudan. The objective was to develop the understanding of the ecological effects of under-story vegetation and tapping date on the productivity of gum arabic from *Acacia senegal* as over story cover. The first factor was grass cover which was tested in four levels (100% and 50% grass cover in addition to bare and burnt). The second factor, date of tapping was tested in three levels namely (1st Oct, 15th Oct and 1st Nov). The first picking was done after 45 days from tapping and the gum yield up to seven pickings was collected at intervals of 15 days. Gum yield from each picking was collected and weighed using sensitive balance. Analysis of variance was carried out using MSTAT-C statistical package, and the Tukey test was applied for mean comparisons. The results showed highly significant differences ($p < 0.01$) of grass cover on gum arabic yield in the two sites for most of the first consecutive pickings (1st-4th out of seven) in addition to total yield (kg/ha). With exception to the 4th pickings, the interaction effect between the grass densities and tapping date was not significantly different. The total gum yield

was significantly ($p<0.05$) increased in only two pickings (third and fourth) in El Demokeya Forest Reserve and two pickings (1st and 2nd) at El Himaira Natural Forest. The density of grass cover significantly ($p<0.05$) affected the number of pickings at both sites; the number of gum pickings was directly proportional to grass density. The number of gum pickings was found to be significantly ($p<0.05$) increased at the early date of tapping.

Abib *et al.* (2013) examined low yield with higher concentration (120 mg/tree) of Ethephon and high yield under lower concentration (40 mg/tree) of Ethephon.

Harsh *et al.* (2013) have worked on thirty gum arabic trees of similar age (14 years), size (average height 4.9m; collar girth 67.8 cm) and vigour with different doses of Ethephon in a season and reported that the trees started exuding gum tears 8–10 days after the Ethephon treatment. Mean gum yields were 39.9, 67.7 and 140.6 g per tree, under Ethephon treatment at 9.75%, 14.62% and 19.5% concentrations, respectively. They also suggest that March to June is the best season for Ethephon-induced gum exudation technique in India.

As per Mirhosseini and Amid (2013) a large number of plants can produce the complex polysaccharides commercially known as ‘plant-based gums’. Several studies on various plant-based gums (mainly plant gum exudates and seed sums) have resulted in the identification of valuable natural sources of complex carbohydrate polymers that promote the desired quality, stability, texture and appearance. The plant gum exudates and seed gums are the complex polysaccharides/carbohydrate polymers commonly used as a dietary fiber, thickening agent, foaming agent, film, emulsifier, stabilizer and drug delivery agent. The physical and functional properties of plant-based gums depend on their chemical compositions and molecular structures. Recently, there is a substantial interest to elucidate the relationship between the chemical composition, molecular structure and physical characteristics and functional properties of plant gum exudates and seed gums. The present study also summarized the molecular

structure, chemical composition and functional properties of various types of plant gum exudates.

Unanaonwi and Bada (2013) investigated the effects of height and girth on gum yield of *Acacia senegal* L. in the natural forests. Three heights and girth classes were purposely selected. Descriptive and ANOVA results showed that when total tree height was lower than 2.0 m, gum yield increased as tree girth goes higher from 35-54 cm (163.6-209.7 g). Tree girth significantly affected gum yield ($p < 0.05$) and trees which total heights were lower than 2.0 m (maximum of 1.95 m) and girth higher than 54 cm (maximum of 65 cm) produced the highest mean gum yield.

Sharma and Prasad (2013) have selected nine trees of *Sterculia urens* for experimentation. Out of nine trees, three were used for gum tapping through semicircular blazing and remaining six trees were tapped through gum inducer technique. After one month, each blaze and hole made on the trees were again treated following same technique/method for gum collection. Treatment was done eleven times at an interval of one month during the period of experiment. To know the effect of treatment and treatment interval on gum yield, collection of gum was carried out from each tree separately at monthly interval just before beginning of subsequent treatment operation. Higher diameter tree yielded more gum in both the techniques of gum tapping; however, gum yield was maximum in case of gum inducer technique. The gum inducer technology was found suitable for karaya gum tapping from *Sterculia urens* in Jharkhan region with less harm (17 times by volume) on the trees and more gum production (about 200%) in comparison to semi circular blazing technique of gum tapping.

Abayomi *et al.* (2014) determined the material and tableting properties of *Azadirachta indica* gum (NMG) relative to Acacia gum (ACA). The morphological properties were assessed with size and shape factors of aspect ratio, roundness, irregularity and equivalent-circle-diameter. The tabulating properties of the gums were determined using compressional characteristics, tensile strength (TS), brittle fracture index (BFI) and crushing strength- friability/disintegration-time ratio

(CSFR/DT). The results suggest that NMG possesses larger, irregular and more elongated particles than acacia gum. The onset and amount of plastic deformation occurring in NMG was faster and higher, respectively, than in Acacia gum. The result shows that, although Acacia gum tablets were stronger, their tendency to cap/laminate was higher than in *Azadirachta indica* gum tablets.

Das *et al.* (2014) concluded that gum production was depending upon the girth of tree, relative humidity and temperature. Gum production was positively correlated with tree girth, tapping intensity, rainfall, and minimum and maximum temperatures at tapping time, and negatively correlated with low temperatures and high relative humidity.

CHAPTER-III

MATERIALS AND METHODS

The study on “Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon” was carried out at New Rajdhani area in Raipur district (Chhattisgarh) during the year 2014-2015. The details of the study site, climate, geology, soils and other features of land along with the methodologies adopted are described below.

3.1 Study site

The study was conducted in naturally growing babul trees at New Rajdhani area in Raipur (Chhattisgarh) during the year 2014-2015. The details of the study site, climate, soils, flora, fauna and other features of study area with the methodologies used are described below.

3.1.1 Geographical location

Raipur is situated nearly in the central part of Chhattisgarh and lies between 21°16' N latitude and 81°36' E longitude with an altitude of 298 m above the mean sea level.

3.1.2 Climate

The climatic condition of experimental site is sub-humid dry tropical. The region receives an average annual rainfall of 1200-1400 mm, of which 80% occurs during rainy season from June to end of September and occasional rainfall during October to February. May is the hottest and December is the coolest month of the year. The mean monthly maximum temperature ranges between 27°C in December and 42°C in May and minimum temperature varies between 13.2°C in December and 28.3°C in May. The maximum temperature sometime even rises as high as 46°C in May and minimum as low as 6°C in December. The relative humidity is high from July to August, which reaches up to 80% while minimum relative humidity of 29% is observed during April-May while wind velocity is high from May to August. Sunshine period in a day prolong more than 9 hours in summer and less than 7 hours in winter.

Evaporation remains higher during April to June (10-13 mm day⁻¹) and low during July to February (2.4 to 5.0 mm day⁻¹).

3.1.3 Physiography

In Chhattisgarh central plains agro climatic zone, there are 10 districts *viz.*; Bilaspur, Dhamtari, Durg, Janjgir-Champa, Korba, Kavardha, Mahasamund, Rajnandgaon, Raigarh and Raipur, which is also known as saucer-shaped upper Mahanadi basin. The longer part of this basin is undulating, flat terrain, and gentle slopes from west to east. The general geological features of the zone comprises of laterites, alluvium capping over horizontally bedded sequence of sedimentary rocks of limestone and dolomite on the top followed by limestone shade, quartzite sand stone, granite, gneisses and meta sediments of old age. These formations have very limited primary porosity and permeability to water.

3.1.4 Geology

Raipur has three distinct geological formations *viz.*, Bijapur, Cuddapha, Pharwar and Archean, Lithographically, it is classified into seven areas, namely, Raipur shale and limestone, Gunderdhi shale, Khairagarh and Ston, Cuddapha Chamar limestone, Chandrapur and Stone grit, Bharwar rock, granite and gneisses.

3.1.5 Soils

The soil of Raipur belongs to four different orders *viz.* Entisols, Vertisols, Inceptisols and Alfisols. The black clayey soils of the experimental field belong to the order Vertisols and are locally known as Kanhar. Kanhar soils are characterized by fine texture, sticky nature, angular blocky structure, low to medium nitrogen, high potassium and low to medium phosphorus with low organic matter.

3.1.6 Tree vegetation in Chhattisgarh

The total geographical area of Chhattisgarh is 137.90 lakh ha (4.15% of the geographical area of the country) which covers 63.55 lakh ha (46 percent of forest cover of its total geographical area) of forest area. Further, the state is well known in the country for its sal forests, which occupy nearly 36 percent of total forest cover. Teak forests are also abundant here but mainly in western and southern parts

of the state. Forests of Chhattisgarh are either tropical moist deciduous forests or tropical dry deciduous forests.

3.1.7 Weather condition during crop growth period

The meteorological data of rainfall, temperature, relative humidity, sunshine and evaporation from September 2014 to May 2015 are furnished in Appendix-C and Fig 3.1.

3.2 Experimental details

3.2.1 Method

After the complete survey of the plot 36 trees of each replication were selected on the basis of 36 different treatment combination which are given in Table 3.1 and layout plan in Fig 3.2 and each treatment combination repeated three times (36X3=108 trees). Each replicate were grouped into two girth classes including ≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm with the help of measuring tape. A 45° downward slanted hole of about 1.5 to 2 cm diameter with 1 to 1.5 inch deep was made at the height of 1 m in the trunk of tree with the help of drill machine. The E-super trade of ethephon (2-chloroethylphosphonic acid) 39% was used to induce gummosis. As per Nair *et al.* (1995) ethephon enhances gum formation and wound healing in *Sterculia urens*. This 39% ethephon was divided into two different concentrations by diluting 2 ml of 39% ethephon with addition of 98 ml of water to make a volume of 100 ml (0.78% ethephon concentration) and diluting 4 ml of 39% ethephon with addition of 96 ml of water to make a volume of 100 ml (1.56% ethephon concentration). The 2 ml of 0.78% ethephon (containing 15.6 mg active ingredient) and 4 ml of 1.56% ethephon (containing 62.4 mg active ingredient) were used into single and double injury (hole), respectively.

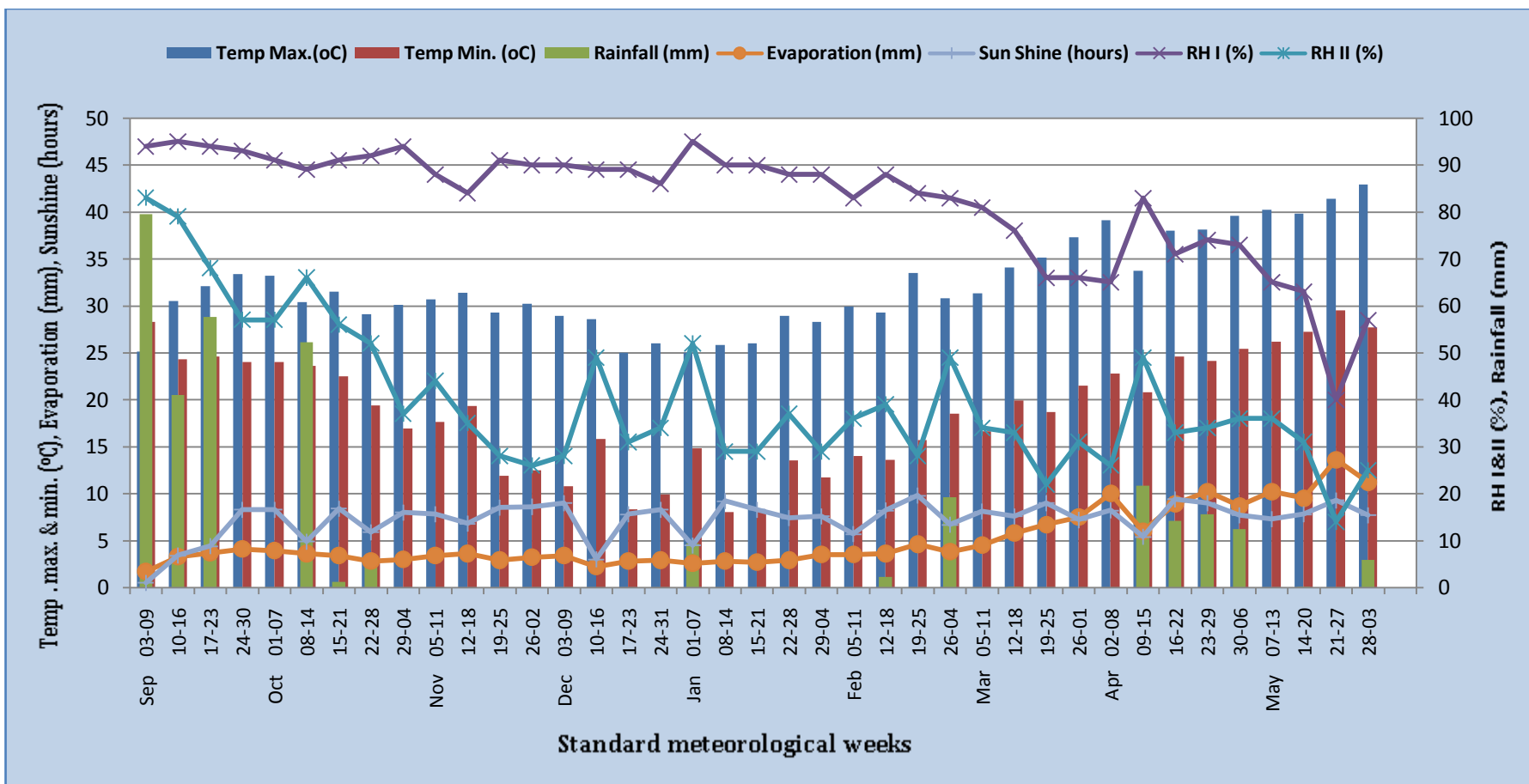


Fig 3.1 Weekly meteorological data during crop growth period

Fig 3.2 Layout plan of research plot:

Total number of treatment combination: 36

Number of replication: 3 (R1, R2 and R3)

Number of trees required for present study: 36X3 (108)

11 R2	2R3	1R1	10R2	6 R1	14 R2	19 R1	19 R2	20 R1
33 R2	34 R2	20 R3	32 R2	9 R3	5 R1	19 R3	33 R1	7 R3
6 R3	2R1	9 R2	1 R3	4 R1	13 R2	18 R3	12 R2	21 R3
17 R3	3R1	23 R3	31 R2	14 R1	3 R3	22 R3	15 R1	8 R3
8 R2	30 R2	7 R2	5 R3	16 R3	16 R1	34 R1	35 R2	18 R2
10 R1	15 R3	29 R2	15 R2	17 R1	7 R1	4 R3	17 R2	24 R3
21 R1	23 R1	9 R1	28 R2	8 R1	10 R3	18 R1	13 R1	6 R2
32 R1	13 R3	33 R3	22 R1	3 R2	35 R1	30 R1	5 R2	25 R3
16 R2	25 R2	29 R1	14 R3	11 R1	36 R1	32 R3	27 R2	11 R3
21 R2	2 R2	26 R2	36 R3	24 R1	12 R3	12 R1	26 R1	29 R3
27 R1	27 R3	36 R2	28 R1	31 R3	22 R2	25 R1	1 R2	23 R2
31 R1	35 R3	28 R3	30 R3	26 R3	24 R2	34 R3	4 R2	20 R2

Table 3.1: Treatment combination

S. No.	Treatment combination	A (level)	B (girth class)	C (Injury)	D (season)
1	A1B1C1D1	0ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Rainy
2	A1B1C1D2	0ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Winter
3	A1B1C1D3	0ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Summer
4	A1B1C2D1	0ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Rainy
5	A1B1C2D2	0ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Winter
6	A1B1C2D3	0ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Summer
7	A1B2C1D1	0ml	≥ 50.1 cm	1 injury	Rainy
8	A1B2C1D2	0ml	≥ 50.1 cm	1 injury	Winter
9	A1B2C1D3	0ml	≥ 50.1 cm	1 injury	Summer
10	A1B2C2D1	0ml	≥ 50.1 cm	2 injury	Rainy
11	A1B2C2D2	0ml	≥ 50.1 cm	2 injury	Winter
12	A1B2C2D3	0ml	≥ 50.1 cm	2 injury	Summer
13	A2B1C1D1	1ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Rainy
14	A2B1C1D2	1ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Winter
15	A2B1C1D3	1ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Summer
16	A2B1C2D1	1ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Rainy
17	A2B1C2D2	1ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Winter
18	A2B1C2D3	1ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Summer
19	A2B2C1D1	1ml	≥ 50.1 cm	1 injury	Rainy
20	A2B2C1D2	1ml	≥ 50.1 cm	1 injury	Winter
21	A2B2C1D3	1ml	≥ 50.1 cm	1 injury	Summer
22	A2B2C2D1	1ml	≥ 50.1 cm	2 injury	Rainy
23	A2B2C2D2	1ml	≥ 50.1 cm	2 injury	Winter
24	A2B2C2D3	1ml	≥ 50.1 cm	2 injury	Summer
25	A3B1C1D1	3ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Rainy
26	A3B1C1D2	3ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Winter
27	A3B1C1D3	3ml	≥ 30.1 to ≤ 50.0 cm	1 injury	Summer
28	A3B1C2D1	3ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Rainy
29	A3B1C2D2	3ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Winter
30	A3B1C2D3	3ml	≥ 30.1 to ≤ 50.0 cm	2 injury	Summer
31	A3B2C1D1	3ml	≥ 50.1 cm	1 injury	Rainy
32	A3B2C1D2	3ml	≥ 50.1 cm	1 injury	Winter
33	A3B2C1D3	3ml	≥ 50.1 cm	1 injury	Summer
34	A3B2C2D1	3ml	≥ 50.1 cm	2 injury	Rainy
35	A3B2C2D2	3ml	≥ 50.1 cm	2 injury	Winter
36	A3B2C2D3	3ml	≥ 50.1 cm	2 injury	Summer

Therefore, each concentrated solution was applied on 3 replicate of babool (*Acacia nilotica*) of one and two injury of each girth class. The exudates gum was picked by hand as large stalactic mass. The whole treatments were conducted through a syringe of 10 ml volume. Under the control condition, 0 ml concentration of ethephon i.e. distilled water was applied. This practice was followed in all the three seasons *viz.*; rainy, winter and summer to understand the seasonal variation in the yield.

3.3 Observations

The observation parameter includes time of treatment application, rate of gum exudation (g/tree/day), time of gum exudation, quantity of gum exudation (g/tree/month), effect of temperature and relative humidity on gum exudation and quality of gum. The details of the observation are described below:

3.3.1 Rate of gum exudation

The rate of gum exudation was measured by applying the chemical treatment and the date of gum exudation and its collection. It was calculating by weighing the exudates and divided it by time.

3.3.2 Time of treatment application

The treatment was given after 10 o'clock in between 10-12 am.

3.3.3 Time of gum exudation

The gum exudation was observed after applying of treatment in the morning, noon, afternoon and evening.

3.3.4 Effect of temperature and relative humidity on gum exudation

The research was conducted at varies temperature and relative humidity in three seasons *viz.*, rainy, winter and summer to understand the impact of seasonal variation on gum exudation.

3.3.5 Quantity of gum exudation per plant

The quantity of gum exudation was measured by collecting the gum at different time interval in a month and adds them, which was divided by number of

treated trees. The yield data obtained was compared to check monthly variation in gum exudation per plants.

3.3.6 Quality parameter :

3.3.6.1 Colour

The collected gum sample was analyzed visually for colour determination.

3.3.6.2 Odour

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

3.3.6.3 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).

3.3.6.4 Moisture content

Moisture content of gum samples was determined by drying 5g of the gum sample to constant weight at 80°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).

3.3.6.5 Ash content

Ash content of the gum samples was determined by burning 5 g of gum sample in a muffle furnace at 550 °C for 4 hour. The ash content was expressed as a % ratio of the weight of ash to weight of the sample.

3.4 Statistical analysis

Yield observation recorded with respect to combination and interaction of various factors comprises ethephon concentration, girth classes, number of injury and season, were subjected to statistical analysis as per the procedure laid down by Gomez and Gomez (1984). Four factor factorial experiments in completely randomized design were used.

Exp.1 Rate of gum exudation (mg/tree/day)**The Skeleton of ANOVA is as follows:**

Source	DF	SS	MSS	F cal	F tab
Ethephon	2	SS_{A^*}	SS_A/DF_A	MSS_A/MSS_E	
Girth class	1	SS_B	SS_B/DF_B	MSS_B/MSS_E	
Ethephon X Girth class	2	SS_{AB}	SS_{AB}/DF_{AB}	MSS_{AB}/MSS_E	
Injury	1	SS_C	SS_C/DF_C	MSS_C/MSS_E	
Ethephon X Injury	2	SS_{AC}	SS_{AC}/DF_{AC}	MSS_{AC}/MSS_E	
Girth class X Injury	1	SS_{BC}	SS_{BC}/DF_{BC}	MSS_{BC}/MSS_E	
Ethephon X Girth class X Injury	2	SS_{ABC}	SS_{ABC}/DF_{ABC}	MSS_{ABC}/MSS_E	
Season	2	SS_D	SS_D/DF_D	MSS_D/MSS_E	
Ethephon X Season	4	SS_{AD}	SS_{AD}/DF_{AD}	MSS_{AD}/MSS_E	
Girth class X Season	2	SS_{BD}	SS_{BD}/DF_{BD}	MSS_{BD}/MSS_E	
Ethephon X Girth class X Season	4	SS_{ABD}	SS_{ABD}/DF_{ABD}	MSS_{ABD}/MSS_E	
Injury X Season	2	SS_{CD}	SS_{CD}/DF_{CD}	MSS_{CD}/MSS_E	
Ethephon X Injury X Season	4	SS_{ACD}	SS_{ACD}/DF_{ACD}	MSS_{ACD}/MSS_E	
Girth class X Injury X Season	2	SS_{BCD}	SS_{BCD}/DF_{BCD}	MSS_{BCD}/MSS_E	
Ethephon X Girth class X Injury X Season	4	SS_{ABCD}	SS_{ABCD}/DF_{ABCD}	MSS_{ABCD}/MSS_E	
Error	72	SS_E	SS_E/DF_E		
Total	107				

*A, B, C, D and E as subscripts respectively, indicates ethephon concentration, girth class, injury, season and error respectively.

Exp.2 Quantity of gum exudation (g/tree/month)**The Skeleton of ANOVA is as follows:**

Source	DF	SS	MSS	F cal	F tab
Ethephon	2	SS_{A^*}	SS_A/DF_A	MSS_A/MSS_E	
Girth class	1	SS_B	SS_B/DF_B	MSS_B/MSS_E	
Ethephon X Girth class	2	SS_{AB}	SS_{AB}/DF_{AB}	MSS_{AB}/MSS_E	
Injury	1	SS_C	SS_C/DF_C	MSS_C/MSS_E	
Ethephon X Injury	2	SS_{AC}	SS_{AC}/DF_{AC}	MSS_{AC}/MSS_E	
Girth class X Injury	1	SS_{BC}	SS_{BC}/DF_{BC}	MSS_{BC}/MSS_E	
Ethephon X Girth class X Injury	2	SS_{ABC}	SS_{ABC}/DF_{ABC}	MSS_{ABC}/MSS_E	
Season	2	SS_D	SS_D/DF_D	MSS_D/MSS_E	
Ethephon X Season	4	SS_{AD}	SS_{AD}/DF_{AD}	MSS_{AD}/MSS_E	
Girth class X Season	2	SS_{BD}	SS_{BD}/DF_{BD}	MSS_{BD}/MSS_E	
Ethephon X Girth class X Season	4	SS_{ABD}	SS_{ABD}/DF_{ABD}	MSS_{ABD}/MSS_E	
Injury X Season	2	SS_{CD}	SS_{CD}/DF_{CD}	MSS_{CD}/MSS_E	
Ethephon X Injury X Season	4	SS_{ACD}	SS_{ACD}/DF_{ACD}	MSS_{ACD}/MSS_E	
Girth class X Injury X Season	2	SS_{BCD}	SS_{BCD}/DF_{BCD}	MSS_{BCD}/MSS_E	
Ethephon X Girth class X Injury X Season	4	SS_{ABCD}	SS_{ABCD}/DF_{ABCD}	MSS_{ABCD}/MSS_E	
Error	72	SS_E	SS_E/DF_E		
Total	107				

*A, B, C, D and E as subscripts respectively, indicates ethephon concentration, girth class, injury, season and error respectively.

The skeleton of ANOVA was depicted in appendix A and appendix B for rate of gum exudation (mg/tree/day) and quantity of gum exudation per tree (g/tree/month). Higher order significance interaction only is considered for mean comparison. Therefore, the interaction of ethephon concentration, girth class and season and ethephon concentration, injury and season was considered for mean comparison.

To test the significance of treatment, the calculated value of 'F' was compared with tabular value of 'F' at 5 and 1 per cent levels of probability against error degree of freedom.



Fig 3.3: GUM TAPPING IN ACACIA NILOTICA BY DRILL METHOD

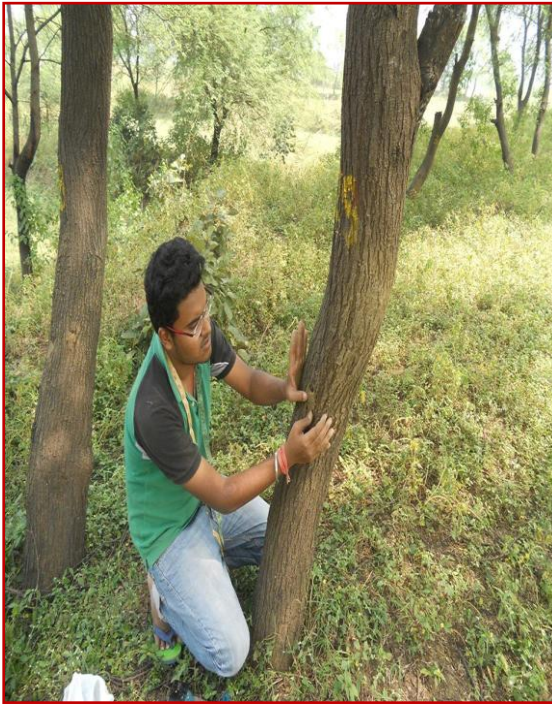


Fig 3.4: GUM TAPPING IN *ACACIA NILOTICA* BY DRILL METHOD

CHAPTER-IV

RESULTS AND DISCUSSION

The result on **Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon** have been discussed in this chapter. The field experiment was conducted during three seasons viz. rainy, winter and summer at New Rajdhani area in Raipur district (Chhattisgarh). The observations recorded on various aspects of study revealed some interesting facts, which are briefly discussed in this chapter. The experimental findings are statistically analysed and are presented in appropriate tables, graphs and few are also depicted through figures. The experimental findings of present work have been grouped under the following heads.

4.1 Quality parameters

4.1.1 Colour

The collected gum sample was orange-brown in colour.

4.1.2 Odour

The collected gum sample was odourless.

4.1.3 pH

pH measurement showed that sample was slightly acidic. The pH value of babool gum was 4.5. The acidity of plant gums is not unexpected since many of them are known to contain salts (Ca, Mg, K, Na and Fe) of acidic polysaccharides, the acidity of which is due to uronic acids in their structures (Abu Baker *et al.*, 2007; Ahmed *et al.*, 2009; Elnour *et al.*, 2009).

4.1.4 Moisture content

Moisture content of gum samples was 15.2%.

4.1.5 Ash content

Ash content (2.63%) falls within the 4% maximum limit reported by FAO (1998) for food and pharmaceutical quality gum arabic.

4.2 Rate of gum exudation

The rate of gum exudation in babul trees in their respective seasons are describe below:

4.2.1 Rate of gum exudation in rainy season

In the present study chemical treatment was found to be effective for gum exudation in second week of October when temperature and relative humidity were 26.8 °C and 76.3% as compared to rest, which are depicted in Table 4.1 and 4.2. The maximum gum exudation rate (0.0158 g/tree/day) was observed when 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) was applied into double injury in higher (≥ 50.1 cm) girth class as compared to girth class of ≥ 30.1 to ≤ 50.0 cm having 0.0061 g/tree/day under the 2 ml dose of 0.78% ethephon (containing 15.6 mg active ingredient) applied into single injury. It was observed that rate of gum exudation increased when the concentration (0.78% to 1.56%) of ethephon was increased with their respective level (0, 2, 4 ml) and increasing girth class. But in the controlled condition, the gum exudation was nil. That might be due to low girth class along with low temperature and high relative humidity. Arya and Chaudhary (2002) have reported five times more gum (88 g) yield in 52 months old irrigated trees for higher girth than in control (18 g). Therefore, girth along with age might be suitable criteria for selecting a tree for gum. Similarly number of injury also played a significant role on rate of gum exudation. Further, it also ensures minimum injury to the trees so that the tree is regenerated easily, thus guaranteed sustainable production of gum (Nair, 2004). The rate of gum exudation was increased from single injury (0.0122 g/tree/day) to double injury (0.0158 g/tree/day) when applying 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) in the month of October 2014 in ≥ 50.1 cm girth class. Similar pattern of exudation rate was observed in the month of September (Table 4.3 and 4.4). Therefore, the rate of gummosis increased proportionally with increasing concentration from 0.78 to 1.56% along with different doses (0, 2, 4 ml), number of injury and girth of tree (Table. 4.5).

Table 4.1: Rate of gum exudation in *Acacia nilotica* in the month of October 2014
in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
1-10	28.3	74.1	-	-	-	-	-	-
11-20	26.8	76.3	-	-	0.59	0.71	1.14	1.34
21-31	24.2	70.8	-	-	-	-	-	-
Total gum (gm)			-	-	0.59	0.71	1.14	1.34
Average gum/ tree (gm)			0.00	0.00	0.19	0.23	0.38	0.44
Average gum/ tree/ day (gm)			0.00	0.00	0.0061	0.0074	0.0122	0.0141

* 1 and 2 respectively represent injury one and injury two

Table 4.2: Rate of gum exudation in *Acacia nilotica* in the month of October 2014
in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
1-10	28.3	74.1	-	-	-	-	-	-
11-20	26.8	76.3	-	-	0.64	0.87	1.14	1.47
21-31	24.2	70.8	-	-	-	-	-	-
Total gum (gm)			0.00	0.00	0.64	0.87	1.14	1.47
Average gum/ tree (gm)			0.00	0.00	0.21	0.29	0.38	0.49
Average gum/ tree/ day (gm)			0.00	0.00	0.0067	0.0093	0.0122	0.0158

* 1 and 2 respectively represent injury one and injury two

Table 4.3: Rate of gum exudation in *Acacia nilotica* in the month of September 2014 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
1-10	26.3	88.6	-	-	-	-	-	-
11-20	28.0	84.3	-	-	-	-	-	-
21-30	28.5	76.9	-	-	0.21	0.39	0.51	0.72
Total gum (gm)			0.00	0.00	0.21	0.39	0.51	0.72
Average gum/ tree (gm)			0.00	0.00	0.07	0.13	0.17	0.24
Average gum/ tree/ day (gm)			0.00	0.00	0.0023	0.0043	0.0056	0.008

* 1 and 2 respectively represent injury one and injury two

Table 4.4: Rate of gum exudation in *Acacia nilotica* in the month of September 2014 in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
1-10	26.3	88.6	-	-	-	-	-	-
11-20	28.0	84.3	-	-	-	-	-	-
21-30	28.5	76.9	-	-	0.99	1.02	1.2	1.35
Total gum (gm)			0.00	0.00	0.99	1.02	1.2	1.35
Average gum/ tree (gm)			0.00	0.00	0.33	0.34	0.40	0.45
Average gum/ tree/ day (gm)			0.00	0.00	0.011	0.0113	0.0133	0.015

* 1 and 2 respectively represent injury one and injury two

Table 4.5: Relationship of gum production with girth class, number of injury and ethephon concentration in rainy season

Month	Gum yield as per girth class		Total gum yield (mg/tree/day)
	≥ 30.1 to ≤ 50.0 cm	≥ 50.1 cm	
September	20.2	50.6	71.0
October	39.8	44.0	83.8
	Gum yield as per number of injury		
	1*	2*	
September	32.2	38.6	71.0
October	37.2	46.6	83.8
	Gum yield as per ethephon concentration		
	0.78%	1.56%	
September	28.9	41.9	71.0
October	29.5	54.3	83.8

* 1 and 2 respectively represent injury one and injury two

4.2.2 Rate of gum exudation in winter season

It was observed that chemical treatment was found to be effective for gum exudation in the month of November when temperature was maximum (24.4°C) with low relative humidity (61.2%) as compared to rest, which are depicted in Table 4.6 and 4.7. The maximum gum exudation rate (0.0183 g/tree/day) was observed when 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) applied into double injury in higher girth class (≥ 50.1 cm) as compared to girth class of ≥ 30.1 to ≤ 50.0 cm having 0.004 g/tree/day when 2 ml dose of 0.78% ethephon (containing 15.6 mg active ingredient) was applied into single injury. Similar pattern of gum exudation rate was observed in the month of December (Table 4.8 and 4.9), January (Table 4.10 and 4.11) and February (Table 4.12 and 4.13) respectively. The maximum gum exudation rate was observed in the month of November (0.0183 g/tree/day) followed by February (0.0164 g/tree/day) > January (0.0138 g/tree/day) > December (0.0122 g/tree/day) under 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) applied into double injury in higher girth class (≥ 50.1 cm) as compared to girth class of ≥ 30.1 to ≤ 50.0 cm having 0.0048 g/tree/day (December) followed by 0.0043 g/tree/day (January) > 0.004 g/tree/day (November) > 0.0035 g/tree/day (February) under the 2 ml dose

of 0.78% ethephon (containing 15.6 mg active ingredient) applied into single injury.

Therefore, the rate of gummosis increased proportionally with increasing concentration (from 0.78 to 1.56%) along with different doses (0, 2, 4 ml), number of injury and girth of tree (Table. 4.14)

Table 4.6: Rate of gum exudation in *Acacia nilotica* in the month of November 2014 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
1-10	23.5	63.7	-	-	-	-	-	-
11-20	24.4	61.2	-	-	0.36	0.93	1.05	-
21-30	20.9	58.4	-	-	-	-	-	1.17
Total gum (gm)			0.00	0.00	0.36	0.93	1.05	1.17
Average gum/ tree (gm)			0.00	0.00	0.12	0.31	0.35	0.39
Average gum/ tree/ day (gm)			0.00	0.00	0.004	0.0103	0.0116	0.013

* 1 and 2 respectively represent injury one and injury two

Table 4.7: Rate of gum exudation in *Acacia nilotica* in the month of November 2014 in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	23.5	63.7	-	-	-	-	-	-
11-20	24.4	61.2	-	-	1.02	1.17	1.44	1.65
21-30	20.9	58.4	-	-	-	-	-	-
Total gum (gm)			0.00	0.00	1.02	1.17	1.44	1.65
Average gum/ tree (gm)			0.00	0.00	0.34	0.39	0.48	0.55
Average gum/ tree/ day (gm)			0.00	0.00	0.0113	0.013	0.016	0.0183

* 1 and 2 respectively represent injury one and injury two

Table 4.8: Rate of gum exudation in *Acacia nilotica* in the month of December 2014 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	20.4	59.2	-	-	-	-	-	-
11-20	19.8	65.7	-	-	0.45	0.54	0.45	0.48
21-31	17.8	60.1	-	-	-	-	0.33	0.45
Total gum (gm)			0.00	0.00	0.45	0.54	0.78	0.93
Average gum/ tree (gm)			0.00	0.00	0.15	0.18	0.26	0.31
Average gum/ tree/ day (gm)			0.00	0.00	0.0048	0.0058	0.0083	0.010

* 1 and 2 respectively represent injury one and injury two

Table 4.9: Rate of gum exudation in *Acacia nilotica* in the month of December 2014 in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	20.4	59.2	-	-	-	-	-	-
11-20	19.8	65.7	-	-	0.33	0.39	0.42	0.57
21-31	17.8	60.1	-	-	0.33	0.36	0.48	0.57
Total gum (gm)			0.00	0.00	0.66	0.75	0.9	1.14
Average gum/ tree (gm)			0.00	0.00	0.22	0.25	0.30	0.38
Average gum/ tree/ day (gm)			0.00	0.00	0.007	0.008	0.0096	0.0122

* 1 and 2 respectively represent injury one and injury two

Table 4.10: Rate of gum exudation in *Acacia nilotica* in the month of January 2015 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethepon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	19.1	69.1	-	-	-	-	-	-
11-20	16.8	59.5	-	-	0.408	0.45	0.348	0.39
21-31	20.6	62.4	-	-	-	-	0.48	0.54
Total gum (gm)			0.00	0.00	0.408	0.45	0.828	0.93
Average gum/ tree (gm)			0.00	0.00	0.136	0.15	0.276	0.31
Average gum/ tree/ day (gm)			0.00	0.00	0.0043	0.0048	0.0089	0.010

* 1 and 2 respectively represent injury one and injury two

Table 4.11: Rate of gum exudation in *Acacia nilotica* in the month of January 2015 in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethepon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	19.1	69.1	-	-	-	-	-	-
11-20	16.8	59.5	-	-	0.21	0.3	0.51	0.78
21-31	20.6	62.4	-	-	0.36	0.309	0.40	0.51
Total gum (gm)			0.00	0.00	0.57	0.609	0.91	1.29
Average gum/ tree (gm)			0.00	0.00	0.19	0.203	0.303	0.43
Average gum/ tree/ day (gm)			0.00	0.00	0.0061	0.0065	0.0097	0.0138

* 1 and 2 respectively represent injury one and injury two

Table 4.12: Rate of gum exudation in *Acacia nilotica* in the month of February 2015 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	21.1	58.2	-	-	-	-	-	-
11-20	22.0	62.4	-	-	-	-	-	-
21-28	25.1	55.6	-	-	0.32	0.51	0.6	0.72
Total gum (gm)			0.00	0.00	0.32	0.51	0.6	0.72
Average gum/ tree (gm)			0.00	0.00	0.10	0.17	0.20	0.24
Average gum/ tree/ day (gm)			0.00	0.00	0.0035	0.006	0.0071	0.0085

* 1 and 2 respectively represent injury one and injury two

Table 4.13: Rate of gum exudation in *Acacia nilotica* in the month of February 2015 in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	21.1	58.2	-	-	-	-	-	-
11-20	22.0	62.4	-	-	-	-	-	-
21-28	25.1	55.6	-	-	1.05	1.14	1.24	1.38
Total gum (gm)			0.00	0.00	1.05	1.14	1.24	1.38
Average gum/ tree (gm)			0.00	0.00	0.35	0.38	0.41	0.46
Average gum/ tree/ day (gm)			0.00	0.00	0.0125	0.0135	0.0146	0.0164

* 1 and 2 respectively represent injury one and injury two

Table 4.14: Relationship of gum production with girth class, number of injury and ethephon concentration in winter season

Month	Gum yield as per girth class		Total gum yield (mg/tree/day)
	≥ 30.1 to ≤ 50.0 cm	≥ 50.1 cm	
November	38.9	58.6	97.5
December	28.9	36.8	65.7
January	28.0	36.1	64.1
February	25.1	57.0	82.1
	Gum yield as per number of injury		
	1*	2*	
November	42.9	54.6	97.5
December	29.7	36.0	65.7
January	29.0	35.1	64.1
February	37.7	44.4	82.1
	Gum yield as per ethephon concentration		
	0.78%	1.56%	
November	38.6	58.9	97.5
December	25.6	40.1	65.7
January	21.7	42.4	64.1
February	35.5	46.6	82.1

* 1 and 2 respectively represent injury one and injury two

4.2.3 Rate of gum exudation in summer season

It was observed that chemical treatment was found to be effective for gum exudation in the month of May, when temperature was maximum (37.4°C) with low relative humidity (28.1%) as compared to rest, which are depicted in Table 4.15 and 4.16. The maximum gum exudation rate (0.0248 g/tree/day) was observed for 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) applied into double injury in higher girth class (≥ 50.1 cm) as compared to girth class of ≥ 30.1 to ≤ 50.0 cm having 0.0116 g/tree/day under the 2 ml dose of 0.78% ethephon (containing 15.6 mg active ingredient) applied into single injury. Similar

pattern of exudation rate was observed in the month of March (Table 4.17 and 4.18) and April (Table 4.19 and 4.20) respectively.

The maximum gum exudation was observed in the month of May (0.0248 g/tree/day) followed by April (0.0233 g/tree/day) > March (0.0229 g/tree/day) under 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) applied into double injury in higher girth class (≥ 50.1 cm) as compared to girth class of ≥ 30.1 to ≤ 50.0 cm having 0.0116 g/tree/day (May) followed by 0.0103 g/tree/day (April) > 0.0093 g/tree/day (March) under the 2 ml dose of 0.78% ethephon (containing 15.6 mg active ingredient) applied into single injury. Under controlled condition gum was produced in the month of May. The rate of gum production under ethephon treatment was observed 0.140 g/tree/day, which is 7 times more than control having 0.0207 g/tree/day in the month of May. Therefore, the rate of gummosis increased proportionally with increasing concentration (from 0.78 to 1.56%) along with different doses (0, 2, 4 ml), number of injury and girth of tree (Table 4.21).

Table 4.15: Rate of gum exudation in *Acacia nilotica* in the month of May 2015 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	32.8	53.5	-	-	-	-	-	-
11-20	33.2	47.7	-	-	0.60	0.74	0.98	1.12
21-31	37.4	28.1	0.39	0.46	0.48	0.53	0.64	0.69
Total gum (gm)			0.39	0.46	1.08	1.27	1.62	1.81
Average gum/ tree (gm)			0.13	0.15	0.36	0.42	0.54	0.60
Average gum/ tree/ day (gm)			0.0041	0.0048	0.0116	0.0135	0.0174	0.0193

* 1 and 2 respectively represent injury one and injury two

Table 4.16: Rate of gum exudation in *Acacia nilotica* in the month of May 2015 in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	32.8	53.5	-	-	-	-	-	-
11-20	33.2	47.7	-	-	0.67	0.76	0.97	1.09
21-31	37.4	28.1	0.51	0.60	0.72	0.77	1.12	1.23
Total gum (gm)			0.51	0.60	1.39	1.53	2.09	2.32
Average gum/ tree (gm)			0.17	0.20	0.46	0.51	0.69	0.77
Average gum/ tree/ day (gm)			0.0054	0.0064	0.0148	0.0164	0.0222	0.0248

* 1 and 2 respectively represent injury one and injury two

Table 4.17: Rate of gum exudation in *Acacia nilotica* in the month of March 2015 in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	23.5	64.7	-	-	-	-	-	-
11-20	26.5	52.1	-	-	0.54	0.64	0.75	0.86
21-31	28.6	46.9	-	-	0.33	0.40	0.54	0.63
Total gum (gm)			-	-	0.87	1.04	1.29	1.49
Average gum/ tree (gm)			-	-	0.29	0.34	0.43	0.49
Average gum/ tree/ day (gm)			-	-	0.0093	0.0109	0.0138	0.0158

* 1 and 2 respectively represent injury one and injury two

Table 4.18: Rate of gum exudation in *Acacia nilotica* in the month of March 2015
in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	23.5	64.7	-	-	-	-	-	-
11-20	26.5	52.1	-	-	0.81	0.93	1.12	1.30
21-31	28.6	46.9	-	-	0.41	0.56	0.75	0.85
Total gum (gm)			-	-	1.22	1.49	1.87	2.15
Average gum/ tree (gm)			-	-	0.40	0.49	0.62	0.71
Average gum/ tree/ day (gm)			-	-	0.0129	0.0158	0.020	0.0229

* 1 and 2 respectively represent injury one and injury two

Table 4.19: Rate of gum exudation in *Acacia nilotica* in the month of April 2015
in girth class (≥ 30.1 to ≤ 50.0 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	30.3	48.9	-	-	-	-	-	-
11-20	28.2	60.7	-	-	-	-	-	-
21-30	32.1	52.4	-	-	0.95	1.1	1.36	1.45
Total gum (gm)			-	-	0.95	1.1	1.36	1.45
Average gum/ tree (gm)			-	-	0.31	0.36	0.45	0.48
Average gum/ tree/ day (gm)			-	-	0.0103	0.012	0.015	0.016

* 1 and 2 respectively represent injury one and injury two

Table 4.20: Rate of gum exudation in *Acacia nilotica* in the month of April 2015
in girth class (≥ 50.1 cm)

Date	Temperature (°C)	Relative humidity (%)	Average gum yield in Ethephon (gm)					
			Control		0.78% (2 ml)		1.56% (4 ml)	
			1*	2*	1	2	1	2
01-10	30.3	48.9	-	-	-	-	-	-
11-20	28.2	60.7	-	-	-	-	-	-
21-30	32.1	52.4	-	-	1.28	1.56	1.92	2.1
Total gum (gm)			-	-	1.28	1.56	1.92	2.1
Average gum/ tree (gm)			-	-	0.42	0.52	0.64	0.7
Average gum/ tree/ day (gm)			-	-	0.014	0.0173	0.0213	0.0233

* 1 and 2 respectively represent injury one and injury two

Table 4.21: Relationship of gum production with girth class, number of injury and ethephon concentration in summer season

Month	Gum yield as per girth class		Total gum yield (mg/tree/day)
	≥ 30.1 to ≤ 50.0 cm	≥ 50.1 cm	
March	49.8	71.6	121.4
April	53.3	75.9	129.2
May	70.7	90.0	160.7
Gum yield as per number of injury			
	1*	2*	
March	56.0	65.4	121.4
April	60.6	68.6	129.2
May	75.5	85.2	160.7
Gum yield as per ethephon concentration			
	0%	0.78%	1.56%
March	-	48.9	72.5
April	-	53.6	75.6
May	20.7	56.3	83.7

* 1 and 2 respectively represent injury one and injury two

4.3 Time of treatment application

The entire experiment was conducted in tree season viz. rainy, winter and summer. The application of different doses of ethephon was applied on the first (1st) day of each and every month of entire season. The treatment was given after 10 o'clock in between 10-12 am.

4.4 Time of gum exudation

The gum exudation was noticed by regular daily observations after the application of treatment in almost all experimental trees. The collection of gum was done at the interval of ten days.

4.5 Effect of temperature and relative humidity on gum exudation

Beside girth class, number of injury and ethephon concentration, temperature and relative humidity are important factors which influenced the gum exudation.

4.5.1 Rate of gum exudation (mg/tree/day)

Temperature and relative humidity were decreased proportionally from September to November. That might be due to uncertain and heavy rainfall in September followed by October and November. Therefore, rate of gum exudation was increased with decreasing temperature and relative humidity from September to November. Beyond November, temperature and relative humidity showed inversely proportional relation upto May. Moreover, temperature increased gradually from January to May with decreased relative humidity. Therefore, the rate of gum exudation was maximum (160.7 mg/tree/day) in May followed by April (129.2 mg/tree/day), March (121.4 mg/tree/day), February (82.1 mg/tree/day) and January (64.1 mg/tree/day), respectively. Although, the month of January has shown the lowest rate of gum production due to less temperature with high relative humidity which is depicted in Table 4.22. Overall rate of gum exudation (mg/tree/day) was observed in order of summer (137.1) > rainy (77.40) > winter (77.35) which is depicted in Table 4.23.

Table 4.22: Effect of temperature and relative humidity on rate of gum exudation (mg/tree/day)

Month	Temperature (°C)	Relative humidity (%)	Gum yield (mg/tree/day)
September	27.6	83.2	71.0
October	26.4	73.7	83.8
November	22.9	61.1	97.5
December	19.3	61.6	65.7
January	18.8	63.6	64.1
February	22.7	58.7	82.1
March	26.2	54.5	121.4
April	30.2	54.0	129.2
May	34.5	43.1	160.7

Table 4.23: Effect of temperature and relative humidity on seasonal rate of gum exudation

Month	Temperature (°C)	Relative humidity (%)	Gum yield (mg/tree/day)
Rainy	27.0	78.4	77.40
Winter	20.9	61.2	77.35
Summer	30.3	50.5	137.1

4.5.1.1 Effect of ethephon concentration, girth class and seasons on rate of gum exudation:

The rate of gum exudation was significantly higher in summer season (1.465 mg/tree/day) compared to rainy and winter (0.000 mg/tree/day) seasons, but rate of gum exudation in rainy season (0.000 mg/tree/day) was at par with winter season (0.000 mg/tree/day) on the application of 0 ml ethephon in ≥ 30.1 to ≤ 50.0 cm girth class of babool at 1% level of significance (Table. 4.24). A similar trend was observed on the application of 0 ml and 2 ml ethephon in ≥ 50.1 cm and \geq

30.1 to \leq 50.0 cm girth classes of babool. The rate of gum exudation differed significantly at 1% level of significant due to different season on the treatment of 2 ml of ethephon in \geq 50.1 cm girth class. A similar trend was noticed on the treatment of 4 ml ethephon in \geq 30.1 to \leq 50.0 cm and \geq 50.1 cm girth class of babool.

Table 4.24: Rate of gum exudation as per interaction between ethephon concentration, girth class and seasons

	Ethephon concentration X Girth class X Season		
	Rainy	Winter	Summer
Ethephon (0 ml), Girth (\geq 30.1 to \leq 50.0 cm)	0.000 ^{a*} _A	0.000 ^a _A	1.465 ^b _A
Ethephon (0 ml), Girth (\geq 50.1 cm)	0.000 ^a _A	0.000 ^a _A	1.952 ^b _A
Ethephon (2 ml), Girth (\geq 30.1 to \leq 50.0 cm)	5.923 ^a _B	5.683 ^a _B	11.413 ^b _B
Ethephon (2 ml), Girth (\geq 50.1 cm)	12.508 ^b _D	9.703 ^a _D	15.162 ^c _C
Ethephon (4 ml), Girth (\geq 30.1 to \leq 50.0 cm)	10.543 ^b _C	8.858 ^a _C	16.195 ^c _D
Ethephon (4 ml), Girth (\geq 50.1 cm)	16.333 ^b _E	13.297 ^a _E	22.502 ^c _E
	SE(d)	CD-1%	
	0.2476	0.6552	

***Note:** CD comparisons have been indicated for rows by small alphabetical letters in the superscripts of mean data, while for comparison of columns, capital alphabets are used in subscripts of mean data.

In rainy season, rate of gum exudation was significantly higher (16.333 mg/tree/day) for the treatment of 4 ml of ethephon in \geq 50.1 cm girth class followed by rate of 12.508 mg/tree/day on the treatment of 2 ml of ethephon in \geq 50.1 cm girth class, rate of 10.543 mg/tree/day on the treatment of 4 ml of ethephon in \geq 30.1 to \leq 50.0 cm girth class and the rate of 5.923 mg/tree/day on the

treatment of 2 ml of ethephon in ≥ 30.1 to ≤ 50.0 cm of girth class of babool. The rate of gum exudation due to treatment of 0 ml in ≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm girth classes were at par to each other at 1% level of significant. On increasing the level of ethephon (2 ml to 4 ml) with decreasing girth class (≥ 50.1 cm to ≥ 30.1 to ≤ 50.0 cm), the rate of gum production was significantly decreased from 12.508 to 10.503 mg/tree/day in rainy season and 9.703 to 8.858 mg/tree/day in winter season but in summer season rate of gum production was significantly increased from 15.162 to 16.195 mg/tree/day. Significantly highest gum exudation rate (22.502 mg/tree/day) was observed in summer season on 4 ml of ethephon in ≥ 50.1 cm of girth class.

4.5.1.2 Effect of ethephon concentration, injury and seasons on rate of gum exudation:

The rate of gum exudation was significantly higher in summer season (1.572 mg/tree/day) compared to rainy and winter (0.000 mg/tree/day) seasons, but rate of gum exudation in rainy season (0.000 mg/tree/day) was at par with winter season (0.000 mg/tree/day) on the treatment of 0 ml ethephon in single injury of babool at 1% level of significance (Table. 4.25). A similar trend was observed on the treatment of 0 ml ethephon in double injury of babool. The rate of gum exudation differed significantly at 1% level of significance due to different season on the treatment of 2 ml of ethephon in single and double injury of babool. A similar trend was noticed on the treatment of 4 ml ethephon in single and double injury of babool.

In rainy season, rate of gum exudation was significantly higher (14.803 mg/tree/day) in the treatment of 4 ml of ethephon in double injury followed by rate of 12.073 mg/tree/day on the treatment of 4 ml of ethephon in single injury and rate of 9.885 mg/tree/day and 8.547 mg/tree/day on the treatment of 2 ml of ethephon in double and single injury of babool. But the rate of gum exudation due to treatment of 0 ml in single and double injury was at par to each other at 1% level of significance. A similar trend was observed in both winter and summer season. Significantly highest rate (20.382 mg/tree/day) of gum exudation was observed in summer season on 4 ml of ethephon due to double injury.

Table 4.25: Rate of gum exudation as per interaction between ethephon concentration, injury and seasons

	Ethephon concentration X Injury X Season		
	Rainy D1	Winter D2	Summer D3
Ethephon (0 ml), Injury (1)	0.000 ^{a *} A	0.000 ^a A	1.572 ^b A
Ethephon (0 ml), Injury (2)	0.000 ^a A	0.000 ^a A	1.845 ^b A
Ethephon (2 ml), Injury (1)	8.547 ^b B	6.935 ^a B	12.227 ^c B
Ethephon (2 ml), Injury (2)	9.885 ^b C	8.452 ^a C	14.348 ^c C
Ethephon (4 ml), Injury (1)	12.073 ^b D	10.458 ^a D	18.315 ^c D
Ethephon (4 ml), Injury (2)	14.803 ^b E	11.697 ^a E	20.382 ^c E
	SE(d) 0.2476	CD-1% 0.6552	

*Note: CD comparisons have been indicated for rows by small alphabetical letters in the superscripts of mean data, while for comparison of columns, capital alphabets are used in subscripts of mean data.

4.5.2 Quantity of gum exudation (g/tree/month)

The gum exudation per tree was 2.9 g/tree/month in November followed by 2.6 g/tree/month in October and 2.1 g/tree/month in September. Relative humidity was highest in September later it decreases and lowest in November. Therefore, gum yield was significantly higher when tapping was carried out during the sharp decrease of the relative humidity (Harmand *et al.*, 2012). Ballal *et al.* (2005a) have also reported that highest yield per tree in all types of stands is obtained in early (1 October to 1 November) tapping.

The temperature was increased gradually from the month of January to May and relative humidity decreased in concomitantly. The maximum (5.0 g/tree/month) quantity of gum per tree was observed in May when temperature was maximum (34.5°C) with lowest relative humidity (43.1%). Whereby, the lowest

(1.99 g/tree/month) quantity of gum per tree was observed in January, which is depicted in Table 4.26 and Fig. 4.1. Overall quantity of gum per tree (g/tree) was observed in order of summer (4.21) > rainy (2.36) > winter (2.31), which is depicted in Table 4.27.

Table 4.26: Effect of temperature and relative humidity on gum exudation per tree (g/tree/month)

Month	Temperature (°C)	Relative humidity (%)	Gum yield (g/tree/month)
September	27.6	83.2	2.13
October	26.4	73.7	2.60
November	22.9	61.1	2.93
December	19.3	61.6	2.05
January	18.8	63.6	1.99
February	22.7	58.7	2.30
March	26.2	54.5	3.77
April	30.2	54.0	3.88
May	34.5	43.1	5.0

Table 4.27: Effect of temperature and relative humidity on seasonal gum exudation per tree

Month	Temperature (°C)	Relative humidity (%)	Gum yield (g/tree)
Rainy	27.0	78.4	2.36
Winter	20.9	61.2	2.31
Summer	30.3	50.5	4.21

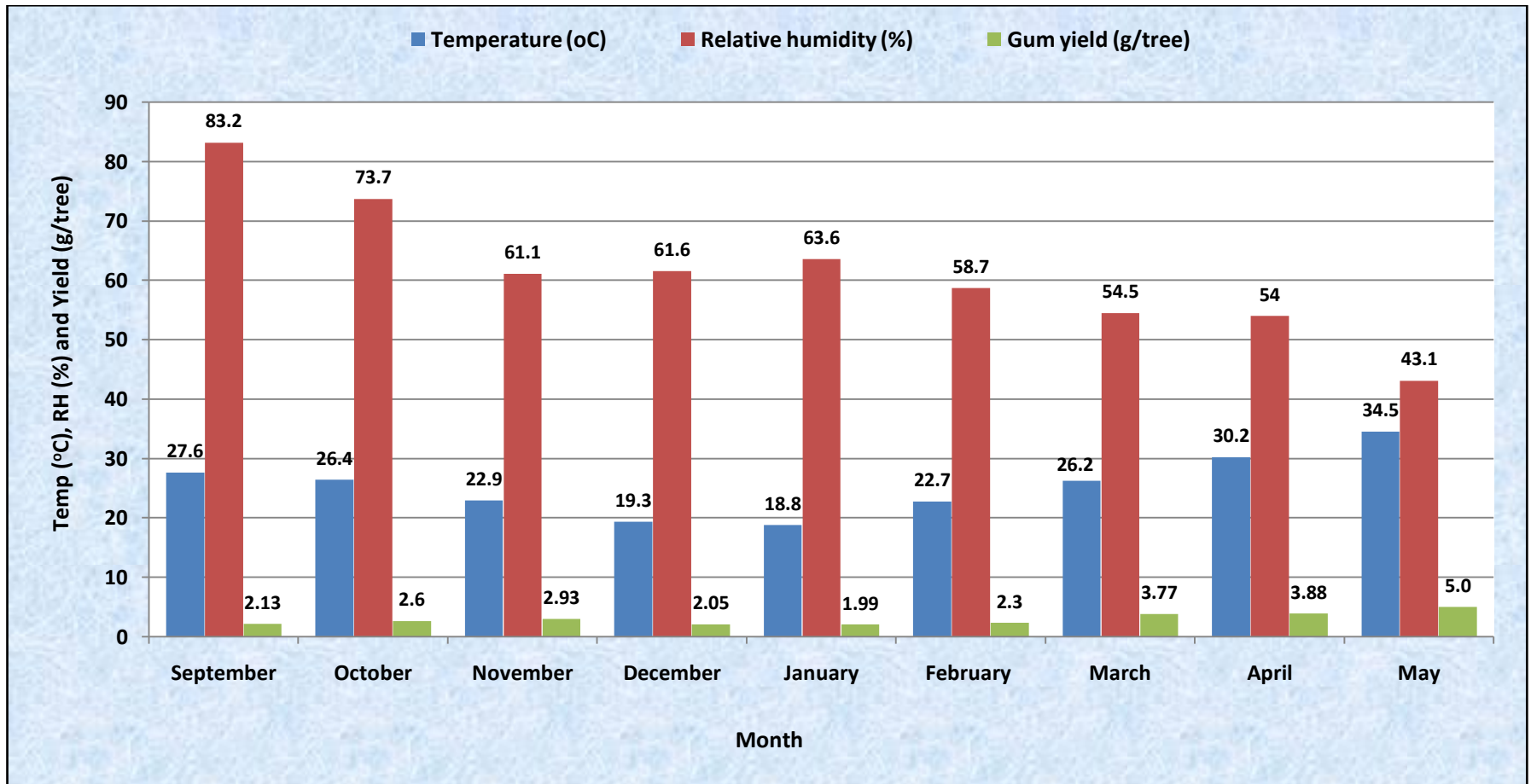


Fig 4.1: Effect of Temperature and Relative humidity on gum exudation per tree in different months (g/tree)

4.5.2.1 Effect of ethephon concentration, girth class and seasons on quantity of gum exudation (g/tree/month):

The quantity of gum exudation per tree was significantly higher in summer season (0.045 g/tree/month) compared to rainy and winter (0.000 g/tree/month) seasons, but quantity of gum exudation in rainy season (0.000 g/tree/month) was at par with winter season (0.000 g/tree/month) on the application of 0 ml ethephon in ≥ 30.1 to ≤ 50.0 cm girth class of babool at 1% level of significance (Table. 4.28 and Fig. 4.2). A similar trend was observed on the application of 0 ml and 2 ml ethephon in ≥ 50.1 cm and ≥ 30.1 to ≤ 50.0 cm girth classes of babool. The quantity of gum exudation differed significantly at 1% significance level due to different season on the treatment of 2 ml of ethephon in ≥ 50.1 cm girth class. A similar trend was observed on the treatment of 4 ml ethephon in ≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm girth classes of babool.

In rainy season, quantity of gum exudation was significantly higher (0.498 g/tree/month) in the treatment of 4 ml of ethephon in ≥ 50.1 cm girth class followed by 0.382 g gum/tree/month on the treatment of 2 ml of ethephon in ≥ 50.1 cm girth class, 0.322 g gum/tree/month on the treatment of 4 ml of ethephon in ≥ 30.1 to ≤ 50.0 cm girth class and 0.181 g gum/tree/month on the treatment of 2 ml of ethephon in ≥ 30.1 to ≤ 50.0 cm of girth class of babool. The quantity of gum exudation due to treatment of 0 ml in ≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm girth classes were at par to each other at 1% level of significance. On increasing the dose of ethephon (2 ml to 4 ml) with decreasing girth class (≥ 50.1 cm to ≥ 30.1 to ≤ 50.0 cm), the quantity of gum production was significantly decreased from 0.382 to 0.322 g/tree/month in rainy season and from 0.291 to 0.266 g/tree/month in winter season but in summer season quantity of gum production was significantly increased from 0.465 to 0.497 g/tree/month. Significantly highest quantity (0.690 g/tree/month) of gum exudation was observed in summer season on 4 ml of ethephon in ≥ 50.1 cm of girth class.

Table 4.28: Quantity of gum exudation as per interaction between ethephon concentration, girth class and seasons

	Ethephon concentration X Girth class X Season		
	Rainy	Winter	Summer
Ethephon (0 ml), Girth (≥ 30.1 to ≤ 50.0 cm)	0.000 ^{a *} _A	0.000 ^a _A	0.045 ^b _A
Ethephon (0 ml), Girth (≥ 50.1 cm)	0.000 ^a _A	0.000 ^a _A	0.06 ^b _A
Ethephon (2 ml), Girth (≥ 30.1 to ≤ 50.0 cm)	0.181 ^a _B	0.171 ^a _B	0.350 ^b _B
Ethephon (2 ml), Girth (≥ 50.1 cm)	0.382 ^b _D	0.291 ^a _D	0.465 ^c _C
Ethephon (4 ml), Girth (≥ 30.1 to ≤ 50.0 cm)	0.322 ^b _C	0.266 ^a _C	0.497 ^c _D
Ethephon (4 ml), Girth (≥ 50.1 cm)	0.498 ^b _E	0.399 ^a _E	0.690 ^c _E
	SE(d)	CD-1%	
	0.0075	0.0198	

***Note:** CD comparisons have been indicated for rows by small alphabetical letters in the superscripts of mean data, while for comparison of columns, capital alphabets are used in subscripts of mean data.

4.5.2.2 Effect of ethephon concentration, injury and seasons on quantity of gum exudation (g/tree/month):

The quantity of gum exudation per tree was significantly higher in summer season (0.048 g/tree/month) compared to rainy and winter (0.000 g/tree/month) seasons, but quantity of gum exudation in rainy season (0.000 g/tree/month) was at par with winter season (0.000 g/tree/month) on the application of 0 ml ethephon in single injury of babool at 1% level of significance (Table. 4.29 and Fig. 4.3). A similar trend was observed on the application of 0 ml ethephon in double injury of babool. The quantity of gum exudation differed significantly at 1% significance level due to different season on the treatment of 2 ml of ethephon in single and

double injury of babool. A similar trend was noticed on the treatment of 4 ml ethephon in the single and double injury of babool.

Table 4.29: Quantity of gum exudation as per interaction between ethephon concentration, injury and seasons:

	Ethephon concentration X Injury X Season		
	Rainy	Winter	Summer
Ethephon (0 ml), Injury (1)	0.000 ^{a *} A	0.000 ^a A	0.048 ^b A
Ethephon (0 ml), Injury (2)	0.000 ^a A	0.000 ^a A	0.057 ^b A
Ethephon (2 ml), Injury (1)	0.261 ^b B	0.208 ^a B	0.375 ^c B
Ethephon (2 ml), Injury (2)	0.302 ^b C	0.254 ^a C	0.440 ^c C
Ethephon (4 ml), Injury (1)	0.368 ^b D	0.314 ^a D	0.562 ^c D
Ethephon (4 ml), Injury (2)	0.452 ^b E	0.351 ^a E	0.625 ^c E
	SE(d) 0.0075	CD-1% 0.0198	

***Note:** CD comparisons have been indicated for rows by small alphabetical letters in the superscripts of mean data, while for comparison of columns, capital alphabets are used in subscripts of mean data.

In rainy season, quantity of gum exudation was significantly higher (0.452 g/tree/month) in the treatment of 4 ml of ethephon in double injury followed by 0.368 g gum/tree/month on the treatment of 4 ml of ethephon in single injury and 0.302 g gum/tree/month and 0.261 g gum/tree/month on the treatment of 2 ml of ethephon in double and single injury of babool. But the quantity of gum exudation due to treatment of 0 ml in single and double injury was at par to each other at 1% level of significance. Similar trend was observed in winter and summer season. Significantly highest quantity (0.625 g/tree/month) of gum exudation was observed in summer season on the treatment 4 ml of ethephon in double injury.

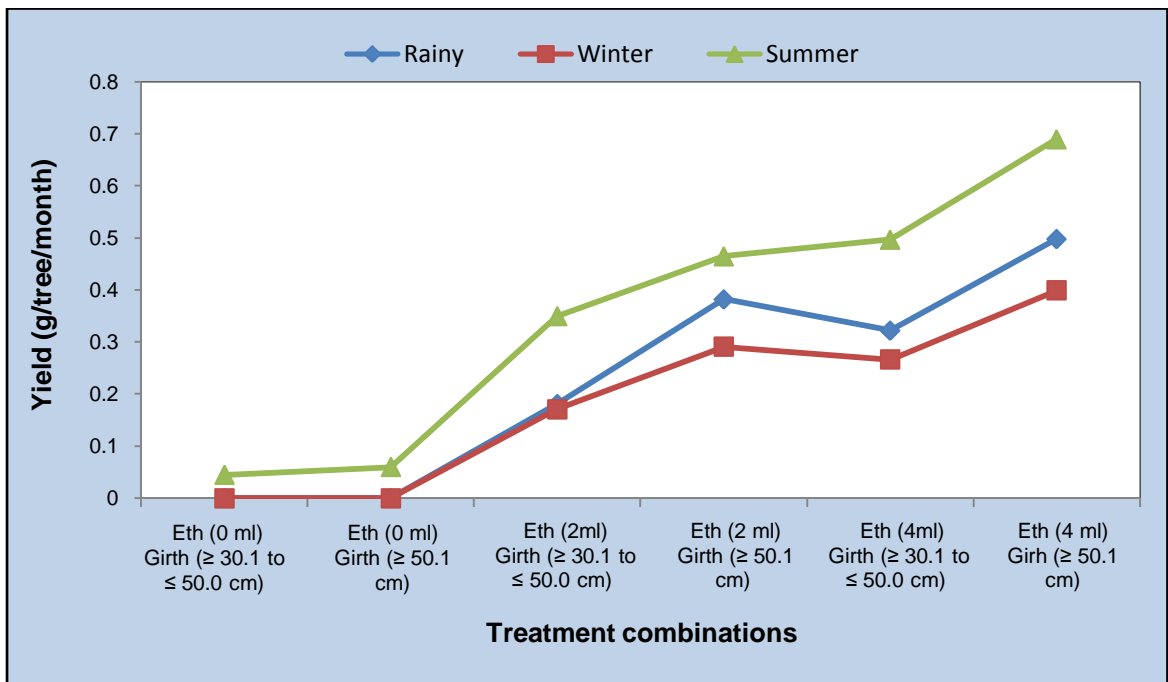


Fig 4.2: Quantity of gum exudation as per interaction between ethephon concentration, girth class and seasons

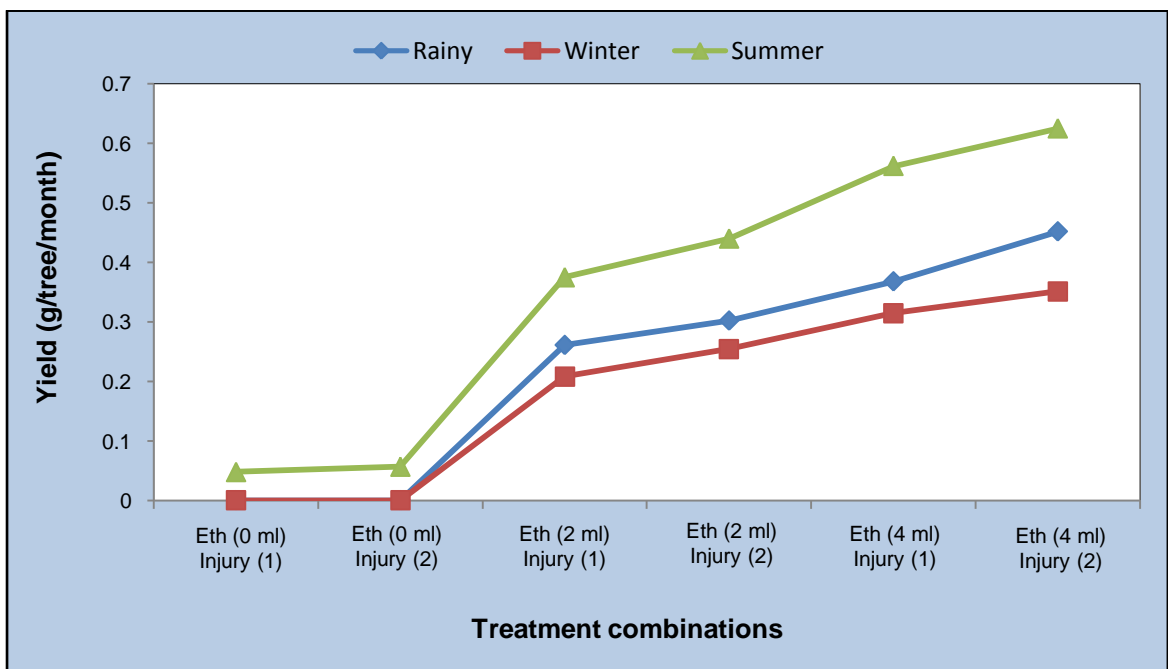


Fig 4.3: Quantity of gum exudation as per interaction between ethephon concentration, injury and seasons

CHAPTER-V

SUMMARY AND CONCLUSIONS

An investigation entitled “**Evaluation of Gummosis Potential in *Acacia nilotica* L. Using Various Concentration of Ethephon**” was carried out in plantation area of babul trees at New Rajdhani area in Raipur district (Chhattisgarh) during rainy, winter and summer season of 2014-2015. After the complete survey of the plot 36 trees of each replication were selected on the basis of 36 different treatment combinations and each treatment combination repeated three times (36X3=108 trees). Each replicate were grouped into two girth classes i.e. ≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm. Drill machine was used to make hole in the trunk of tree. For the purpose of gum tapping, two different concentrated solutions viz. 2 ml of 0.78% ethephon (containing 15.6 mg active ingredient) and 4 ml of 1.56% ethephon (containing 62.4 mg active ingredient) were used into single and double injury (hole), respectively. During the study period observations i.e. rate of gum exudation, time of gum exudation, time of treatment applications, effect of temperature and relative humidity on gum exudation, quality parameter, quantity of gum/ plant (yield) were taken. Four factor factorial experiments in completely randomized design was used for statistical analysis. The salient findings of the experiment are summarized below:-

Quality parameter comprises pH, moisture content and ash content were 4.5, 15.2% and 2.63 %, respectively.

The concentration used for treatment is critical for babool, which was modified by two different girth classes and number of hole. The rate of gum exudation was increased to double (0.0116 to 0.0248 g/tree/day) on increasing the concentration (0.78 to 1.56%), doses of ethephon (2 to 4 ml), injury (single to double) and girth class (≥ 30.1 - ≤ 50.0 cm to ≥ 50.1 cm) of babool in the month of May. Similar pattern of exudation rate was observed in rainy, winter and summer season. Overall rate of gum exudation (mg/tree/day) was observed in the order: May (160.7) > April (129.2) > March (121.4) > Nov (97.5) > Oct (83.8) > Feb (82.1) > Sep (71.0) > Dec (65.7) > Jan (64.1).

On increasing the level of ethephon (2 ml to 4 ml) with decreasing girth class (≥ 50.1 to ≥ 30.1 to ≤ 50.0 cm), the rate of gum production was significantly decreased from 12.508 to 10.503 mg/tree/day in rainy season and 9.703 to 8.858 mg/tree/day in winter season but in summer season rate of gum production increased significantly from 15.162 to 16.195 mg/tree/day. Therefore, interaction between girth class and doses of ethephon have played significant role in rate of gum exudation in rainy, winter and summer season. Significantly highest rate (22.502 and 20.382 mg/tree/day) of gum exudation was observed in summer season under the treatment of 4 ml of ethephon in ≥ 50.1 cm of girth class and same 4 ml treatment of ethephon in double injury of babool at 1% level of significance.

Under controlled condition gum was produced only in the month of May. The rate of gum production under ethephon treatment was observed 0.140 g/tree/day, which is 7 times more than in control having 0.0207 g/tree/day in the month of May. Overall, rate of gum production under ethephon treatment was 42 times more than controlled in entire three season viz., rainy, winter and season.

The maximum (5.0 g/tree/month) gum exudation per plant was observed in the month of May when average temperature and relative humidity were 34.5°C and 43.1%, whereas minimum (1.99 g/tree/month) gum exudation per plant was observed in month of January when average temperature and relative humidity were 18.8°C and 63.6%. Overall gum exudation per plant (g/tree/month) was observed in order: May (5.0) > April (3.88) > March (3.77) > November (2.93) > October (2.60) > February (2.30) > September (2.13) > December (2.05) > January (1.99). Therefore, gum yield was higher when tapping was carried out during the increasing temperature with sharp decrease of the relative humidity.

On increasing the level of ethephon (2 ml to 4 ml) with decreasing girth class (≥ 50.1 to ≥ 30.1 to ≤ 50.0 cm), the quantity of gum production was significantly decreased from 0.382 to 0.322 g/tree/month in rainy season and from 0.291 to 0.266 g/tree/month in winter season but in summer season quantity of gum production increased significantly from 0.465 to 0.497 g/tree/month.

Therefore, interaction between girth class and ethephon has played significant role on quantity of gum exudation in rainy, winter and summer season. Significantly highest quantity (0.690 and 0.625 g/tree/month) of gum exudation was observed in summer season under the treatment of 4 ml of ethephon in ≥ 50.1 cm of girth class and same 4 ml treatment of ethephon in double injury of babool at 1% level of significance.

The rate (mg/tree/day) and quantity (g/tree/month) of gum exudation differed significantly at 1% level of significant due to different season on the treatment of 2 ml of ethephon in ≥ 50.1 cm girth class and 4 ml ethephon in ≥ 30.1 to ≤ 50.0 cm and ≥ 50.1 cm girth class of babool. Similarly, the rate of gum exudation differed significantly at 1% level of significance due to different season on the treatment of 2 ml and 4 ml of ethephon in single and double injury of babool.

Overall rate of gum exudation (mg/tree/day) and quantity of gum per plant (g/tree/month) were observed in order: summer (137.1, 4.21) > rainy (77.40, 2.36) > winter (77.35, 2.31). This was due to climatic factors *viz.*, temperature with relative humidity, ethephon with different concentration (from 0.78 to 1.56%) along with different doses (0, 2, 4 ml), number of hole and girth of tree.

CONCLUSIONS

The commercial tapping of babul is done by blazing, peeling or by making deep cuts at the base of the bole using an axe or sickle. This method often leads to the death of the tapped trees. Hence, there is a need to develop a scientific and sustainable tapping method to increase the gum yield and ensure the survival of the tapped trees. Therefore, it was observed that chemical method using ethephon was safe and scientific techniques for gum production in sustainable way.

During the study period it was observed that 4 ml dose of 1.56% ethephon (containing 62.4 mg active ingredient) in double hole of ≥ 50.1 cm girth class was superior to gum production than 2 ml dose of 0.78% ethephon (containing 15.6 mg active ingredient) in single hole of ≥ 30.1 to ≤ 50.0 cm girth class. Also, girth class ≥ 50.1 cm was superior to ≥ 30.1 to ≤ 50.0 cm for gum production. The best time

of gum tapping in trees was at the beginning of the dry season, when the relative humidity was low. That is why, maximum rate of gum exudation and quantity of gum per plant was observed in month of May, whereas minimum exudation was observed in January. Seasonally, significantly highest rate (22.502 and 20.382 mg/tree/day) of gum exudation was observed in summer season under the treatment of 4 ml of ethephon in ≥ 50.1 cm of girth class and same 4 ml treatment of ethephon in double injury of babool. Similarly, the significantly highest quantity (0.690 and 0.625 g/tree/month) of gum exudation was observed in summer season under the treatment of 4 ml of ethephon in ≥ 50.1 cm of girth class and same 4 ml treatment of ethephon in double injury of babool.

However, summer season showed quite effective for high production of gum in all the experimental trees as compared to other season. Under controlled condition gum was produced only in the month of May. The rate of gum production under ethephon treatment was observed 0.140 g/tree/day, which is 7 times more than in controlled having 0.0207 g/tree/day in the month of May. Moreover, rate of gum production under ethephon treatment was 42 times more than controlled in three season viz., rainy, winter and season.

SUGGESTIONS FOR FUTURE RESEARCH WORK

- 1) The chemical treatments should be applied at more levels, injury (hole), girth class and applied in big sample size of experimental trees.
- 2) To avoid unscientific method of gum tapping there is a need to standardize scientific tapping techniques in all valuable gum and resin producing trees species.
- 3) Technology, for gum tapping also need information regarding the impact of use of gum enhancer (*i.e.*, ethephon) on gum formation without injuring inner tissue containing vessels which transport the nutrient to the trees. Thus, the process of gum formation and production is very important in this direction.

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APPENDIX - A

Table: ANOVA of rate of gum exudation (mg/tree/day)

Source	df	SS	MSS	F cal	F tab 5%	F tab 1%	CV
Factor A	2	3700.667	1850.333	10054.1846**	3.124	4.913	5.10%
Factor B	1	328.130	328.130	1782.9662**	3.974	7.001	
AB	2	151.531	75.766	411.6883**	3.124	4.913	
Factor C	1	42.450	42.450	230.6634**	3.974	7.001	
AC	2	18.813	9.406	51.1115**	3.124	4.913	
BC	1	0.034	0.034	0.1835	3.974	7.001	
ABC	2	0.225	0.112	0.6107	3.124	4.913	
Factor D	2	525.687	262.843	1428.2162**	3.124	4.913	
AD	4	134.058	33.515	182.1088**	2.499	3.591	
BD	2	7.681	3.840	20.867**	3.124	4.913	
ABD	4	13.077	3.269	17.7648**	2.499	3.591	
CD	2	1.597	0.799	4.34*	3.124	4.913	
ACD	4	2.915	0.729	3.9594**	2.499	3.591	
BCD	2	0.854	0.427	2.3214	3.124	4.913	
ABCD	4	1.068	0.267	1.4511	2.499	3.591	
Error	72	13.251	0.184				
Total	107	4.62					

Factor A (Ethephon concentration), Factor B (Girth class), Factor C (Injury) and Factor D (Season)

* Significant at 5%, ** Significant at 1%

APPENDIX - B

Table: ANOVA of quantity of gum exudation per tree (g/tree/month)

Source	df	SS	MSS	F cal	F tab 5%	F tab 1%	CV
Factor A	2	3.429	1.714500	10077.9364**	3.124	4.913	5.09%
Factor B	1	0.304	0.304000	1785.0507**	3.974	7.001	
AB	2	0.140	0.070000	411.74**	3.124	4.913	
Factor C	1	0.039	0.039000	231.181**	3.974	7.001	
AC	2	0.017	0.008500	51.2408**	3.124	4.913	
BC	1	0.000	0.000000	0.1646	3.974	7.001	
ABC	2	0.000	0.000000	0.5865	3.124	4.913	
Factor D	2	0.517	0.258500	1518.7122**	3.124	4.913	
AD	4	0.135	0.033750	197.9988**	2.499	3.591	
BD	2	0.008	0.004000	22.6515**	3.124	4.913	
ABD	4	0.012	0.003000	18.1975**	2.499	3.591	
CD	2	0.002	0.001000	4.6969*	3.124	4.913	
ACD	4	0.003	0.000750	4.0305**	2.499	3.591	
BCD	2	0.001	0.000500	2.3443	3.124	4.913	
ABCD	4	0.001	0.000250	1.4278	2.499	3.591	
Error	72	0.012	0.000167				
Total	107	4.62					

Factor A (Ethephon concentration), Factor B (Girth class), Factor C (Injury) and Factor D (Season)

* Significant at 5%, ** Significant at 1%

APPENDIX- C

Table: Weekly meteorological data during crop growing period (September 2014-May 2015) at Labhandi, Raipur

Week No.	Date	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)		Evaporation (mm)	Sun Shine (hours)	
		Max.	Min.		I	II			
36	Sep	03-09	25.1	28.3	79.5	94	83	1.7	0.5
37		10-16	30.5	24.3	41.0	95	79	3.3	3.4
38		17-23	32.1	24.6	57.6	94	68	3.7	4.4
39		24-30	33.4	24.0	0.0	93	57	4.1	8.3
40	Oct	01-07	33.2	24.0	0.0	91	57	3.9	8.3
41		08-14	30.4	23.6	52.2	89	66	3.6	4.9
42		15-21	31.5	22.5	1.2	91	56	3.4	8.4
43		22-28	29.1	19.4	5.4	92	52	2.8	5.9
44		29-04	30.1	16.9	0.0	94	37	3.0	8.0
45	Nov	05-11	30.7	17.6	0.0	88	44	3.4	7.8
46		12-18	31.4	19.3	0.0	84	35	3.6	6.8
47		19-25	29.3	11.9	0.0	91	28	2.9	8.5
48		26-02	30.2	12.5	0.0	90	26	3.2	8.6
49	Dec	03-09	28.9	10.8	0.0	90	28	3.4	9.0
50		10-16	28.6	15.8	0.0	89	49	2.2	3.0
51		17-23	25.0	8.3	0.0	89	31	2.8	7.8
52		24-31	26.0	9.9	0.0	86	34	2.9	8.3
1	Jan	01-07	25.0	14.8	9.4	95	52	2.6	4.5
2		08-14	25.8	8.0	0.0	90	29	2.8	9.2
3		15-21	26.0	8.3	0.0	90	29	2.7	8.3
4		22-28	28.9	13.5	0.0	88	37	2.9	7.4
5		29-04	28.3	11.7	0.0	88	29	3.5	7.6
6	Feb	05-11	29.9	14.0	0.0	83	36	3.5	5.7
7		12-18	29.3	13.6	2.2	88	39	3.6	8.2
8		19-25	33.5	15.7	0.0	84	28	4.6	9.8
9		26-04	30.8	18.5	19.2	83	49	3.8	6.7
10	Mar	05-11	31.3	16.6	0.0	81	34	4.5	8.1
11		12-18	34.1	19.9	0.1	76	33	5.8	7.6
12		19-25	35.1	18.7	0.0	66	22	6.7	9.0
13		26-01	37.3	21.5	0.0	66	31	7.5	7.2
14	Apr	02-08	39.1	22.8	0.0	65	26	10.0	8.2
15		09-15	33.7	20.8	21.6	83	49	6.0	5.4
16		16-22	38.0	24.6	14.2	71	33	8.9	9.4
17		23-29	38.1	24.1	15.6	74	34	10.2	9.0
18		30-06	39.6	25.4	12.4	73	36	8.7	7.7
19	May	07-13	40.2	26.2	0.0	65	36	10.2	7.3
20		14-20	39.8	27.2	0.1	63	31	9.5	7.8
21		21-27	41.4	29.5	0.0	40	14	13.6	9.3
22		28-03	42.9	27.7	5.8	57	25	11.2	7.7
Total/ Average			32.1	18.8	8.6	82	40	5.0	7.2

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Awards / Recognitions (If any) : Yes

Publications (If any) : 1


 Signature 21/7/15



Lalji Singh <lalji.singh2@gmail.com>

Submission of manuscript entitled "Effects of girth class, injury and seasons on ethephon induced gum exudation in *Acacia nilotica* in Chhattisgarh"

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