

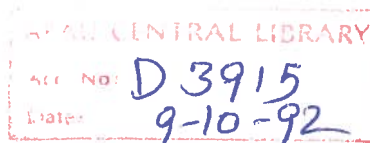
CHARACTERISATION OF BETELVINE (Piper betel L.)
GERMPLASM"

THESES SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE

By
D.SRIDEVI, B.Sc. (Ag)

DEPARTMENT OF HORTICULTURE
AGRICULTURAL COLLEGE
BAPATLA

OCTOBER, 1991



ANGRAU
Central Library
Hyderabad



C E R T I F I C A T E

Mrs. D. Sridevi has satisfactorily prosecuted the course of research and that the thesis entitled "CHARACTERISATION OF BETELVINE (Piper betel L.) GERMPLASM" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any University.

Date 14-10-1991


14.10.91
(Dr.C. RAVI SANKAR)
MAJOR ADVISOR
ASSOCIATE PROFESSOR
DEPT. OF HORTICULTURE
AGRICULTURAL COLLEGE
BAPATLA

C E R T I F I C A T E

This is to certify that the thesis entitled
"CHARACTERISATION OF BETELVINE GERMPLASM" submitted in
partial fulfilment of the requirements for the degree of
MASTER OF SCIENCE IN AGRICULTURE of the Andhra Pradesh
Agricultural University, Hyderabad, is a record of the
bonafide research work carried out by Mrs D SRIDEVI under
my guidance and supervision. The subject of the thesis
has been approved by the Student's Advisory Committee.

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

(Dr C RAVI SANKAR)
CHAIRMAN OF THE ADVISORY COMMITTEE

Thesis approved by the Student Advisory Committee

Chairman (Dr C Ravi Sankar)

Ravi Sankar
14.10.91

Member (Dr M Karunakara Babu)

M Karunakara Babu

Member (Dr A Narayanan)

A Narayanan

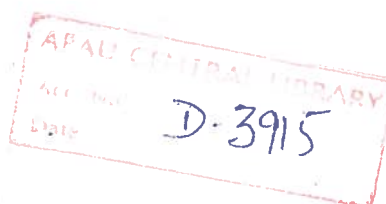
Member (Dr D K Sarkar)

D K Sarkar
14.10.91

APAU CENTRAL LIBRARY
24 2 2 1971

C O N T E N T S

Chapter	Title	Page
I	INTRODUCTION	.. 1 - 4
II	REVIEW OF LITERATURE	.. 5 - 22
III	MATERIALS AND METHODS	.. 23 - 44
IV	RESULTS	.. 45 - 82
V	DISCUSSION	.. 83 - 112
VI	SUMMARY	.. 113 - 115
	LITERATURE CITED	..



LIST OF FIGURES

Figure	Title	Page
1	Lay out of experimental field	.. 35
2	Leaf area of betelvine cultivars	.. 51
3	Per cent essential oil of betelvine cultivars	.. 67
4	Per cent essential oil constituents of betelvine cultivars	.. 68
5	Total chlorophyll of betelvine cultivars	.. 72
6	Number of leaves per vine of betelvine cultivars	75
7	Weight of leaves per vine of betelvine cultivars	77
8	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Karapaku	.. 94
9	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Bangla	.. 95
10	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Gachipan	.. 96
11	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Godi Bangla	.. 97
12	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Kakair	.. 98
13	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Maghai	.. 99
14	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Meetha cum Bangla	.. 100
15	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Meetha Calcutta	.. 101
16	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Pachai Kodi	.. 102
17	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Karielle	.. 103
18	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Tellaku of Chennur	.. 105
19	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Tellaku of Ponnur	.. 106
20	Gas liquid chromatogram of essential oil of <u>Piper betel</u> L. Cv. Tellaku of Utukur	.. 107

LIST OF PLATES

Plate	Title	Page
1	Karapaku	.. 27
2	Bangla	.. 27
3	Gachipan	.. 28
4	Godi Bangla	.. 28
5	Kakair	.. 29
6	Meetha Calcutta	.. 29
7	Pachai Kodi	.. 30
8	Maghai	.. 30
9	Tellaku of Chennur	.. 31
10	Kariele	.. 31
11	Meetha cum Bangla	.. 32
12	Tellaku of Ponnur	.. 32
13	Tellaku of Utukur	.. 33
14	Leaf of karapaku, Bangla, Gachipan, Godi Bangla, Kakair and Meetha Calcutta	.. 48
15	Leaf of Pachai Kodi, Maghai, Tellaku of Chennur, Kariele, Meetha cum Bangla, Tellaku of Ponnur and Tellaku of Utukur	.. 48

LIST OF TABLES

Table	Title	Page
1 a	Leaf area prediction equations and coefficient of regression (R_2)	.. 11
1 b	Weekly meteorological data during the crop period	.. 24
2	Chemical analysis of the soil	.. 25
3	Betelvine cultivars, regions of their cultivation and source of collection	.. 26
4	Morphological characters of thirteen betelvine cultivars	.. 46-47
5	Cataloguing of betelvine cultivars based on leaf colour, leaf shape, leaf area and number of branches per plant	.. 50
6	Means of leaf area, petiole length, internodal length and number of branches per plant among thirteen cultivars of betelvine	.. 53
7	Means of R-value and specific leaf weight among thirteen cultivars of betelvine	.. 55
8	Means of stomatal size, stomatal frequency, stomatal index, palisade ratio and veinlet termination number among thirteen cultivars of betelvine	.. 57
9	Cataloguing of betelvine cultivars based on stomatal frequency, stomatal index, palisade ratio and veinlet termination number	.. 59
10	Organoleptic evaluation of betelvine cultivars based on pungency, flavour and fibre	.. 62
11	Cataloguing of betelvine cultivars based on pungency, flavour and fibre	.. 64
12	Essential oil and its constituents and means of total chlorophyll among thirteen cultivars of betelvine	.. 66
13	Cataloguing of betelvine cultivars based on essential oil, eugenol, terpenyl acetate and total chlorophyll content	.. 70
14	Means of number of leaves per vine and weight of leaves per vine among thirteen cultivars of betelvine	.. 74

LIST OF TABLES (CONTD.)

Table	Title	Page
15	Cataloguing of betelvine cultivars based on number of leaves per vine and weight of leaves per vine	.. 78
16	Estimates of genetic components of variation for different characters in betelvine cultivars	.. 80
17	General morphology of four distinct groups of betelvine	.. 88
18	Organoleptic evaluation and chemical characteristics of four distinct groups of betelvine	.. 92



ACKNOWLEDGEMENTS

I wish to place my deep sense of gratitude and reverence to my major advisor and the Chairman of the Advisory Committee Dr.C.Ravi Sankar, Associate Professor and Head, Department of Horticulture, Agricultural College, Bapatla for his valuable guidance, benevolent criticism, constant inspiration and encouragement during the course of investigation and in preparation of the manuscript of the thesis.

I am equally grateful to the former Chairman of the Advisory Committee and Head, Department of Horticulture, Agricultural College, Bapatla Late Dr.K.Nagaraja Sharma for his initiation in selecting the problem and providing the facilities.

I extend my heartfelt indescribable gratitude and respect to Dr.M.Karunakara Babu, Horticulturist, Agricultural Research Station, Chintalapudi and member of Advisory Committee for his guidance, unstinted attention, transcendent suggestions and help throughout the investigation and in preparation of this dissertation.

I am also grateful to Dr.A.Narayanan, Professor and Head, Department of Plant Physiology and Dr.D.K.Sarkar, Assistant Professor, Dept. of Soil Science and Agril. Chemistry, members of Advisory Committee for their valuable suggestions and guidance in preparation of manuscript of the thesis.

I am extremely thankful to Dr.V.R.Balasubrahmanyam, Principal Investigator, Betelvine Research Project (Mahoba)

N B R I., Lucknow for his keen interest, valuable suggestions, untiring help and facilities provided for carrying out the chemical analysis part at NBRI Laboratory. Thanks are also due to Sri S.Gurunath, Research Assistant, Dr.A.~~KS~~ Rawat, Scientist, NBRI, Lucknow who deserve special mention for their active help and co-operation while carrying out the analysis work.

I take this opportunity to express my thanks to Sri R. Srinivasulu, Assistant Professor in Statistics and Mathematics, Agricultural College, Bapatla for his guidance in carrying out the statistical analysis. I am also thankful to Smt.Y.Ashoka Rani, Assistant Professor, Department of Plant Physiology for her help in analysis part.

My sincere thanks goes to Sri Ch.V.V.Satyanarayana, Asst. Professor, College of Agricultural Engineering for his help in processing the data through computer. I am also thankful to the Principal, College of Agricultural Engineering for providing me the computer facility.

I wish to express my heartfelt appreciation to my friends Rangavalli, Padmasri, Chandra Rao, Vijaya Nirmala and Chinnabbai without whose help at various stages, it would have been difficult to complete the investigation.

I owe much to my beloved parents Dr.D.Appa Rao and Satyavathi, sisters Latha and Madhu and my brothers Prasada Rao and Sridhar for their matchless encouragement bestowed to me.

I am also thankful to Dr.T.V.Satyanarayana, Assistant Professor, College of Agricultural Engineering and my brother-in-law B.V.Madhusudhana Rao for their encouragement during the study.

I am also thankful to Andhra Pradesh Agricultural University for providing me financial assistance in form of stipend.

Assistance rendered by Sri S.Md.Sharief, Typist is very much appreciated.

I never forget the encouragement, constant help and association of my husband Sri M.Lakshmi Prasad rendered in this venture.

D.Sridevi
(D.SRIDEVI)

DECLARATION

I, Mrs. D. SRIDEVI hereby declare that the Thesis entitled "CHARACTERISATION OF BETELVINE (Piper betel L.) GERMPLASM" is a result of the original research work done by me. It is further declare that the thesis or any part thereof has not been published earlier in any manner.

Date: 14-10-1991

D. sridevi
(D. SRIDEVI)

Author : D. SRIDEVI
Title of thesis : "CHARACTERISATION OF BETELVINE
(Piper betel L.) GERMPLASM"
Degree : M.Sc. (Ag)
Subject : Horticulture
Faculty : Agriculture
Major Advisor : Dr.C.Ravi Sankar
University : Andhra Pradesh Agricultural
University
Year of submission : 1991

ABSTRACT

The present study relates to the characterisation of betelvine germplasm and cataloguing them into appropriate groups based on morphological, physiological and chemical parameters. Thirteen cultivars grown at Agricultural Research Station, Chintalapudi, Ponnur mandal, Guntur district have been selected for detailed study.

The thirteen cultivars were categorised into four distinct groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori' on the basis of morphological characters of the leaves. The cultivars included under each group have similar morphological characters.

Studies on physiological parameters were carried out and the results thus obtained were found to be overlapping and could not be used as parameters for the categorisation of cultivars. Growth analysis parameters were also studied.

Based on organoleptic evaluation and the essential oil and its constituents such as eugenol, anethol, terpenyl acetate, methyl eugenol and α -terpineol of thirteen cultivars confirmed the categorisation into four similar groups.

Observations on yield parameters showed some heterogeny in growth behaviour of four distinct groups and differ in their vigour as represented by number of leaves per vine and weight of leaves per vine.

Genetic variability studies on various morphological, physiological, growth analysis, total chlorophyll and yield parameters showed high GCV and high estimates of heritability for the characters number of branches per plant, number of leaves per vine, weight of leaves per vine, leaf area, total chlorophyll content and veinlet termination number. The traits, number of leaves per vine and weight of leaves per vine recorded high estimates of heritability with high genetic advance.

LIST OF ABBREVIATIONS USED

Km	Kilometer
m	meter
°C	Degrees centigrade
cm	centimeter
kg ha ⁻¹	Kilogram per hectare
t ha ⁻¹	tonnes per hectare
cm ²	square centimeter
cm ⁻²	per square centimeter
mm ⁻²	per square millimeter
mg cm ⁻²	milligram per square centimeter
ml	milli liter
mm	millimeter
DMSO	Dimethyl sulphoxide
mg	milligram
g	gram
mm/min	millimeter per minute
ml/min	millileter per minute
CD	critical difference
SEm	Standard error of mean
SEd	standard error of difference
d.f.	degrees of freedom
RBD	Randomised Block Design
NS	Non-significant
Fig	Figure
%	Per cent
um	micrometer
GCV	Genotypic coefficient of variation
PCV	Phenotypic coefficient of variation
GA	Genetic Advance
h ² (b)	Heritability in broad sense
GLC	Gas Liquid Chromatography
TLC	Thin layer chromatography
FID	Flame ionising detector
Cv	Cultivar

INTRODUCTION

Betelvine (Piper betel L.) is a perennial, dioecious, evergreen creeper belonging to family Piperaceae (Order : Piperales). It is believed to be native of Malayan Peninsula. The leaves of betelvine have been traditionally used for mastication along with arecanut (Areca catechu L.) and lime throughout the South East Asian region. It is also intimately linked with the history, religion and cultural life of people of the sub-continent. It is also considered digestive, carminative, aromatic and stimulant and used in curing catarrhal pulmonary diseases (Burkill, 1935).

The composition of a leaf is dependent on several factors, i.e. variety, position of leaf on the vine, plucking time and nature (bleached or unbleached, fresh or dry). They are reported to contain essential amino acids (glutamic acid, methionine, leucine, aspartic acid etc.), several vitamins (ascorbic acid, thiamine, nicotinic acid, riboflavin and carotene (as Vitamin A), sugars (glucose, fructose, sucrose and maltose), organic acids (malic acid and oxalic acid), enzymes (catalase and diastase), proteins, fats, mineral matters, essential oil etc. The flavour of the leaf is mainly due to essential oil while the mild stimulation during chewing is due to alkaloid, arecoline present in arecanut (Singh and Joshi, 1973).

2

Betelvine^{is} grown for its leaves since ages. It is cultivated on commercial scale in many states of India. At present it is one of the most distinctive plant based industries involving an approximate annual turn over of Rs. 700 crores and occupying nearly 40,000 hectares of land in India (Maiti, 1989). It occupies about 2626 hectares in Andhra Pradesh. The betelvine leaves are exported every year to the tune of Rs.110 to 150 lakh. The importance of the betelvine crop in agricultural economy of the country may be judged by the hectareage under its cultivation, the value of production as also by the preponderance of 'Pan' chewing habit amongst our countrymen and its place in our social, cultural and religious life.

Cultivation of betelvine is however, have many taboos and beliefs which have kept it away from the modern agricultural practices and made it tradition bound. The conservative outlook of betelvine cultivators was perhaps responsible for the meagre attention by the scientists. Very little research efforts have been put up so far towards the improvement of betelvine germplasm and its cultivation. Whatever little work has been carried out so far is mainly related to the identification of pathogens infecting betelvine and management of diseases. Perhaps, it was not realised by the research workers that the success in improving the crop lies in thorough study of all the various aspects of betelvine and its culture. The growth of betelvine industry by private endeavour without the

support of an organised research effort led to the failure of many plantations and caused disillusionment amongst growers. As a consequence, a gradual but perceptible decline in betelvine cultivation is noticeable in the country.

Detailed studies have also shown that lot of confusion exist in the nomenclature of different cultivars of P. betel L. grown in India. The same cultivar has often designated by different names in different locations, for example, 'Bangla' cultivar is known as 'Navakalapatha' in Tamil Nadu, Ramtek in Maharashtra and Desi in West Bengal and conversely different cultivars sometimes found to go under the same name, for example 'Desi' refers to 'Bangla' in Bengal, 'Kapoori' in Maharashtra and 'Desawari' in Madhya Pradesh. Further, the local names of few cultivars indicate some typical characters of the cultivar ('Meetha' cultivar due to its sweet taste) or it may indicate the place of origin (Bangla from West Bengal). This is how such names have come ⁱⁿ to existence over years resulting in a plethora of synonyms and adding to the confusion, already existing regarding the true identity of betelvine cultivars. However, several varieties distinctly differing in their morphology, taste and aroma are cultivated in different parts of India. The differences in their morphological aspects such as leaf colour, leaf shape, leaf texture, taste etc. are very important in determining their market value.

Keeping the above facts in view, thirteen cultivars which are commercially important have been selected for detailed study with the following objectives:

- 1) To categorize the cultivars into various groups based on morphological, physiological and chemical characteristics.
- ii) To estimate the genetic variability both phenotypically and genotypically, genetic advance and heritability for various morphological, physiological and yield parameters.

REVIEW OF LITERATURE

Betelvine crop is cultivated in India since time immemorial and perhaps dates back to the vedic age. It finds mention in various old Sanskrit literature, viz. Charak Samhita and Sushruta Samhita as 'Nagaballi' and 'Bhujaballi' respectively where its medicinal uses were described.

Betelvine has been recently recognized as an important agricultural crop as is evident by the attention being received from the leading institutes and the universities of our country.

As the present work is related only to morphological characteristics of betelvine crop and essential oil extraction and therefore the important ones directly related to present work have been reviewed below.

The work carried out so far on classification does not relate to all the commercial cultivars grown throughout the country but is restricted to some regions like parts of West Bengal, Andhra Pradesh, Uttar Pradesh and Madhya Pradesh. The characteristics investigated for the classification are mainly morphological and in some cases a few physiological and chemical aspects have also been included. There are about 35 types existing in India with information on gross morphology, colour of leaves, pungency etc. (Anon, 1969).

2.1 CATALOGUING THE CULTIVARS

For any planned crop improvement programme, selection of cultivars with desirable characters such as high yield of acceptable quality and better keeping quality is a prerequisite.

Though there are several cultivars grown in different regions of the country there is a confusion in the nomenclature of the existing cultivars with distinct characteristics. This necessitates the characterization and cataloguing of betelvine cultivars basing on morphological, physiological and chemical characteristics and therefore, reviewed the literature accordingly.

2.1.1 Morphological characters

Chibber (1912) observed that the petiole of the betelvine leaf is plano-convex in transverse section with a central groove along the plane of upper surface. He further, observed that the groove is distinct in the upper one third of the petiole length and extended towards the apex.

Murthy (1959 a, b) studied extensively the vegetative anatomy of P. betel L. and observed that the petiole is plano-convex in cross section with a central groove on the adaxial side which varies in depth in different regions of petiole.

Ganguly and Gupta (1974a) and Ganguly (1984) carried out the extensive survey of betelvine cultivars in West Bengal and observed that betelvine types grown commercially in West Bengal can broadly be grouped into three cultivars viz. 'Bangla', 'Meetha' and 'Sanchi'. The authors further distinguished two groups among twelve types of 'Bangla' and studied their gross morphological, micrometrical and R-value of the leaves. The

7

group consisting of 'Bhagirhat Jhal Amtala', 'Bhavana Amtala' and 'Murshidabad Beldangro' has roundish type of leaves while the rest of the types have elongated leaves. Further, they observed that among the nine elongated forms, only four types namely, 'Desi Bira', 'Bhagirhat Jhal Bira', 'Bangla Midnapur' and 'Bangla Baruipur' are distinguishable by the arrangement and number of major veins.

Ganguly and Gupta (1974 b) further recognized two types in 'Sanchi' cultivar viz. 'Sanchi Midnapur' a roundish and brittle type and 'Karui Sanchi' an elongated and membraneous. Besides, they pointed out that these two types can be distinguished on the basis of nature and position of the upper two lateral vein pairs which originate from the main nerve axis and also due to difference in shape of basal part of the lamina. The authors also observed that the arrangement of upper lateral vein pairs are opposite to sub-opposite and situated more towards the base in case of 'Sanchi Midnapur' while in 'Karui Sanchi' the upper lateral pairs of veins are alternately situated and originated from other vein pairs.

Rawat (1985) selected nineteen representative cultivars of betelvine from all parts of India with a view to classify these types on the basis of their leaf morphology. He classified nineteen cultivars into five distinct groups viz. 'Bangla', 'Desawari', 'Kapoori', 'Meetha' and 'Sanchi' on the basis of their morphological characters of the leaves.

'Bangla' Group

The cultivars studied under this group were 'Bangla Banaras', 'Calcutta Bangla', 'Garhi Malhara Bangla', 'Bangla Madhya Pradesh', 'Navakalapatha', and 'Ramtek Bangla'. The leaves of all the six types have cordate to roundish shape, base auriculate, apices acuminate. Lamina has 4-6 prominent secondary veins spreading in a curved manner. Petiolar size is medium (6.5 to 10 cm) to long (12 cm to 17 cm). Leaf colour is light to dark green.

'Desawari' Group

The cultivars studied under this group were 'Desi Desawari' and 'Desawari Mahoba'. The leaves of these two types are large, cordate to ovate in shape with curved apex in either directions and an asymmetrical leaf base. The petioles of these types are observed to be long. Leaf colour was green and often pinkish in colour. Lamina has 4-6 prominent secondary veins.

'Kapoori' Group

The cultivars studied under this group were 'Doma', 'Gangeri', 'Kapoori Salem' and 'Satyavaram'. Rawat (1985) reported that all the six types have narrow, ovate leaves (length/width ratio ranging from 1.6:1 to 1.8:1). The lamina was glabrous, entire, some times the basal portion of marginal lamina was undulate. The leaf apices were acuminate and the leaf bases were not lobed as in case of 'Bangla' and 'Sanchi'

cultivars. Leaves have prominent midrib with 4-6 secondary veins which run nearly parallel to the midrib and not curved as in other groups. The petiole was comparatively short. The leaf colour is light yellowish green to light green.

'Meetha' Group

This group was represented by a lone cultivar namely 'Meetha' cultivar. The cultivar was mainly restricted to Howrah and Midnapur districts of West Bengal. The leaves were large, cordate to roundish (length/width ratio being 1.4:1 to 1.6:1), acute leaf tip, basal lobes were less conspicuous than that of 'Bangla' and 'Sanchi' cultivars. The leaf lamina was entire usually but sometimes lower portion was undulate. The leaf was thick, waxy and dark green in colour with characteristic yellowish spots. Prominent 4-6 secondary veins are present. Petiole is long.

'Sanchi' Group

The cultivars under this group were 'Sanchi Banaras', Green 'Kaker', 'Kare', 'Kuljedu' and Nadan. The leaves were medium to large and broadly ovate (length/width ratio was 1.6:1 to 1.7:1) with long tapering attenuate leaf tips. The base was lobed but the lobes were less prominent than that of 'Bangla' cultivar. Leaf margin was entire. The venation being reticulate, multicostate with 6-8 prominent divergent secondary veins. Petiole was shortest in this group and was channelled (6.1 to 9.5 cm). Unlike other cultivars it runs quite close

to the stem and forms an angle of less than 40° approximately. The leaves were dark green in colour.

Sharma et al. (1987) selected two types of cultivars viz. 'Desi Desawari', and 'Mahoba Desawari' for studies on their morphological characters. They stated that the leaves of 'Desi Desawari' type cultivars were comparatively less crisp and smaller in size than 'Mahoba Desawari'. The shape of the leaves in both the cases was cordate with curved pointed apex.

Rawat et al. (1989) evolved a procedure to find out leaf area which is required in physiological and agronomic investigations and stated that direct estimation of leaf area is cumbersome and tedious. The authors have selected five commercial betelvine cultivars viz. 'Bangla', 'Desawari', 'Kapoori', 'Meetha and Sanchi' and from each of the five cultivars, eighty leaves were selected to include wide range of sizes for determining the leaf area. They developed prediction equations in respect of each cultivar involving the length (L) and maximum breadth (B). (Table 1 a).

It was further stated by the authors that there was a high degree of association between leaf area and leaf breadth in these five cultivars.

2.1.2 Physiological characters

Chibber (1912) observed that the upper epidermis of the betel leaf is many layered usually three. The hypodermis was characterised by the presence of secretory cells which were

Table 1 a Leaf area prediction equations and coefficient of regression (R_2)

Cultivar	Equation	R^2
Bangla	$A = -58.785 + 11.634 L$	0.905
	$A = -50.354 + 15.505 B$	0.940
	$A = -52.496 + 1.775 L + 13.245 B$	0.941
Desawari	$A = -97.768 + 13.574 L$	0.946
	$A = -63.864 + 16.696 B$	0.979
	$A = -73.759 + 3.236 L + 12.911 B$	0.983
Kapoori	$A = -65.316 + 9.961 L$	0.931
	$A = -65.110 + 17.933 B$	0.952
	$A = -68.544 + 3.924 L + 11.271 B$	0.965
Meetha	$A = -84.463 + 13.218 L$	0.903
	$A = -50.753 + 14.530 B$	0.947
	$A = -69.124 + 5.122 L + 9.497 B$	0.969
Sanchi	$A = -77.647 + 11.277 L$	0.922
	$A = -73.110 + 17.747 B$	0.943
	$A = -80.677 + 4.923 L + 10.592 B$	0.965

spherical in outline and measure about 27 μm across and contain essential oil. He also observed that the cells were oblong and stomata more or less uniformly distributed ranging from 5000 to 6000 per cm^2 when peeled off the lower epidermis together with hypodermis. The xylem was pointing towards the centre and phloem towards the periphery which is characterized by the presence of secretory cells within its limit.

Murthy (1959 a, b) studied extensively the vegetative anatomy of P. betel L. and observed that the petiole has single layer of epidermis and the epidermal cells are papillose. Collenchyma cells below the upper epidermis were observed to be typically tubular resembling cork cells in their arrangement. Secretory cells and calcium oxalate crystals are found scattered in the parenchyma region.

Pant and Benerjee (1965) had made an attempt to study stomatal characters of 3 cultivars of P. betel L., viz. 'Desi Kapoori', 'Desi Kaker' and 'Calcutta Bangla' and found that most of the stomata were ~~tetracytic~~. They also observed that anisocytic and paracytic stomata occur in small proportions.

Ganguly and Gupta (1974 b) recognized 2 types in 'Sanchi' cultivar viz. 'Sanchi Midnapur' and 'Karui Sanchi' and studied in detail the palisade ratio and vein termination number and found that they are different in both types. In 'Sanchi Midnapur' the palisade ratio varied from 6.70 to 7.60 while in 'Karui Sanchi' it varied from 11.25 to 19.25. Similarly,

veinlet termination number was minimum in 'Sanchi Midnapur' ranging from 0.25 to 0.75 as against 0.75 to 1.25 in 'Karui Sanchi'. The authors finally concluded that both have probably originated from 'Sanchi' cultivar and their qualitative and quantitative differences are probably due to cultivation under different cultural and ecological conditions.

Mohandas and Shaw (1980) emphasized the structure of epidermis as a tool in the classification of varieties of P. betel L. They observed that it was possible to distinguish the cultivars 'Bombay' and 'Maghai' from 'Banaras', 'Chaveli' and 'Kaker' by the presence of much larger epidermal cells on the adaxial surface. Similarly 'Bombay' and 'Chaveli' can be separated from other types by the presence of smaller guard cells. The authors further observed that 'Chaveli' cultivar have 2 to 4 glandular hairs on leaves which make it distinct from other cultivars and concluded that the cultivars of betelvine were characterized by the most frequent occurrence of tetracytic type of stomata and presence of non-glandular, peltate trichomes on both the surfaces. They recommended that their micrometrical characters may also aid in identification of betelvine cultivars besides the important features such as colour, size and the taste of the leaves of betelvine.

Das and Chattopadhyay (1984) carried work on seventeen betelvine cultivars of Midnapur district of West Bengal and grouped them into 'Bangla', 'Kapoori', 'Meetha', 'Meetha cum Bangla' and 'Sanchi' on basis of micrometrical characteristics.

They observed that use of micrometrical studies like vein-islet number, veinlet termination number, palisade ratio and leaf data pertaining to stomatal frequency, stomatal index and stomatal size to identify the cultivars did not prove to be of any help.

Rawat (1985) selected nineteen representative cultivars of P. betel L. from the germplasm collection of 85 cultivars collected from all parts of India and divided into five groups viz. 'Bangla', 'Desawari', 'Kapoori', 'Meetha' and 'Sanchi' and conducted scanning electron microscopic studies. He observed that the adaxial surface of the leaf was found to be smooth, surface of the epidermal cells convex, cell walls mostly straight, depressed and clear, cells longer than broad in all the cultivars. He also carried out work on quantitative microscopic studies of leaves viz. Stomatal index, palisade ratio, vein islet number, vein termination number, size and density of stomata and trichome density. It was revealed from the data in respect of all the above parameters the cultivars differ widely. The ranges of stomatal index (8.40 to 10.40), Palisade ratio (5.14 to 9.82), vein islet number (1.11 to 2.54), vein termination number (3.90 to 11.14), stomatal density (107.50 to 187.50), trichome density (31.75 to 65.00) and gland cells density (212.50 to 380.00) indicated wide divergence of cultivars. The sizes of stomata and trichomes were also varied and ranged from (23.41 x 22.37 to 30.21 x 21.20 μ m) and (33.41 x 13.22 to 51.75 x 19.5 μ m) respectively. He stated that the study

proved of little help for the identification of different cultivars of betelvine.

2.1.3 Growth Analysis Characters

Ganguly and Gupta (1974 a) and Ganguly (1984) carried out the extensive survey of betelvine cultivars in West Bengal and broadly grouped them into 3 cultivars, viz. 'Bangla', 'Meetha' and 'Sanchi'. The authors further distinguished two groups among twelve types of 'Bangla' and studied the R-value of leaves. The first group consists of 'Bhagirhat Jhal Amtala', 'Bhavana Amtala' and 'Murshidabad Beldangro' has roundish type of leaves whose R-value was observed to be below 1.5 while the rest of the types have elongated leaves with R-value above or near 1.5.

Rawat (1985) selected nineteen representative cultivars of P. betel L. from the germplasm collection of 85 cultivars collected from all parts of India and divided into five groups viz. 'Bangla', 'Desawari', 'Kapoori', 'Meetha' and 'Sanchi' and studied their R-values. 'Bangla' group have cordate to roundish leaves with R-value ranges from 1.44 to 1.46. 'Desawari' group have cordate to ovate shape leaves with R-value ranges from 1.48 to 1.50. 'Kapoori' group have narrow ovate leaves with R-value ranges from 1.5 - 1.59. 'Meetha' group have large, cordate to roundish leaves with R-value of 1.49. 'Sanchi' group have medium to large, broadly ovate with long tapering attenuate leaf tips with R-value ranges from 1.55 to 1.59.

2.1.4 Organoleptic studies

Sharma et al. (1982) studied organoleptic characters of the leaves of the Kapoori cultivar and reported that the leaves bear spicy, pungent and aromatic flavour which was due to the presence of essential oil.

Sharma et al. (1983) studied organoleptic characters of fresh leaves of the three types of P. betel L., viz. 'Desi Bangla', 'Calcutta Bangla' and 'Ramtek Bangla' and reported that the leaves of all these types were having clove like spicy odour and sharp pungent taste.

Narayana Reddy (1984) collected 55 cultivars from different parts of country and grouped them into two based on their taste as pungent and non-pungent types.

Rawat (1985) selected 19 representative cultivars from the germplasm collection of 85 cultivars from all parts of India and divided into 5 groups viz. 'Bangla', 'Desawari', 'Kapoori', 'Meetha' and 'Sanchi' and studied their organoleptic characters viz. fibre content, flavour and pungency. He reported that 'Bangla' group leaves were less pungent than Sanchi. 'Desawari' group leaves were less pungent than those of Bangla and Sanchi. Kapoori group leaves were less fibrous, aromatic and least pungent than 'Bangla' and 'Sanchi'. It was also reported that 'Meetha' group leaf has characteristic 'Saunf' (fennel) like aroma and sweet palatable taste due to which it is also known as 'Sauffia' or 'Meetha pan'. The characteristic taste and

and yellowish spots on the leaf differentiate this type from the rest of the cultivars. 'Sanchi' group leaves were highly pungent in taste.

2.1.5 Chemical characteristics

Ueda et al. (1951) and Guenther (1952) worked on the leaves of betelvine and isolated the substances chavicol, allyl pyrocatechol, chevibetol, methyl chavicol, carvacrol, eugenol, estrogol, eugenol methyl ether, 1-8 cineol, caryophyllene and cardinens from its essential oil.

Atal et al. (1975) worked out the essential oil composition of betel leaves and confirmed that the results of Ueda et al. (1951) and Guenther (1952) were related to the substances isolated from the essential oil of the leaves of P. betel L.

Sharma et al. (1982) examined the chemical composition of essential oil of leaves of the 'Kapoori' cultivar extracted by the process of hydro-distillation which gave 0.1% of essential oil at fresh weight basis and observed to be lighter than water. The chemical composition of the essential oil was examined by gas liquid and thin layer chromatography and the different constituents of this oil were 0.05 per cent (by weight), α -pinene, 0.06 per cent β -pinene, 1.26 per cent camphene, 1.76 per cent 'P-cymene, traces of 3 unidentified hydrocarbons and caryophyllene, 5.75 per cent 1,8 cineole, 21.98 per cent, terpenyl acetate, 0.66 per cent α -terpineol, 0.86 per cent methyl chavicol, 15.82 per cent eugenol and 1.65 per cent methyl eugenol.

Sharma et al. (1983) studied 3 types of cultivars viz. 'Desi Bangla', 'Calcutta Bangla' and 'Ramtek Bangla' for their essential oil content which gave 0.17 per cent, 0.20 per cent and 0.18 per cent of essential oils respectively. It was noticed that the oils were heavier than water. The oil of 'Desi Bangla' and 'Ramtek Bangla' contained 0.02 and 0.11 per cent P-cymene, 0.02 and 0.05 per cent α -terpeneol, 0.06 and 0.91 per cent terpenyl acetate 82.2 and 90.5 per cent eugenol, 6.9 and 4.1 per cent methyl eugenol, 0.63 and 0.75 per cent caryophyllenes respectively. The oils of 'Calcutta Bangla' was not examined by GLC, but on TLC it gave chromatogram similar to the above two types showing similar composition of its oil.

Chattopadhyay et al. (1984) conducted experiments and determined chlorophyll, sugar and ash percentages of P. betel L. and also estimated the nitrogen, potassium and phosphorus contents.

Rawat (1985) selected 19 representative cultivars from the germplasm collection of 85 cultivars from all parts of India and divided into 5 groups namely, 'Bangla', 'Desawari', 'Kapoori', 'Meetha' and 'Sanchi'. He conducted experiments from extraction of their oil content by hydro-distillation process and observed that the percentage of essential oils obtained for all these 5 groups varied from 0.10 to 0.85 on fresh weight basis. It was also observed that the 'Meetha' group has yielded the highest percentage of essential oil (0.85) followed by 'Sanchi'

(0.165 - 0.200), 'Bangla' (0.145 - 0.170), Desawari (0.12 - 0.14) and Kapoori (0.1 to 0.115). He reported that the oils of 'Bangla', 'Sanchi' and 'Meetha' groups had higher specific gravity and were heavier than water while the oils of 'Kapoori' and 'Desawari' groups had lower specific gravity and lighter than water. The oils of these groups were examined by Gas Liquid Chromatography (GLC) for their constituents as detailed below.

'Bangla' Group

The major constituent identified was the eugenol whose percentage varied from 80 - 90 and other constituents identified were methyl eugenol, terpenyl acetate and terpineol.

'Desawari' Group

The major constituent identified was the terpenyl acetate ranged from 44.93 to 45.90 per cent followed by eugenol^{with} ranged from 26.65 to 28.29 per cent. The other constituents identified were anethole, P-cymene, methyl chavicol and methyl eugenol.

'Kapoori' Group

The terpenyl acetate (22%) was identified as the major constituent in this group. Due to the higher terpenic content the oil was lighter than water and less pungent. The other constituents identified were eugenol, methyl eugenol and terpineol. Methyl chavicol, α -pinene, β -pinene and caryophyllene were also present in traces.

'Meetha' Group

The essential oil was observed to be yellowish in colour and had the anethole (32.3%) as the major constituent. The other constituents identified were eugenol, methyl eugenol, terpenyl acetate and terpineol.

'Sanchi' Group

The essential oil largely contains phenolic constituents and eugenol being its chief component. However, its percentage was found to be less as compared to 'Bangla' group. The other constituents identified were methyl eugenol, α -terpineol, terpenyl acetate, caryophyllene and traces of unidentified constituents.

Rawat et al. (1987) studied the essential oil of Cv. 'Meetha' (P. betel L.), a highly preferred cultivar among the people of West Bengal. They observed that fresh leaves of the cultivar yielded 0.25 per cent of essential oil on hydro-distillation and the oil was observed to be yellowish brown colour with fennel like odour and sweet taste. Further, it was observed that the oil contains about 32 per cent anethole which is the chief constituent responsible for fennel like odour and sweet taste. Anethole in combination with other constituents present in the oil makes its flavour very pleasant and palatable and hence, it can find application in food, drug and beverage industries for flavouring purposes.

Sharma et al. (1987) selected two types of betelvine cultivars viz. 'Desi Desawari' and 'Mahoba Desawari' for studies on essential oil. These two cultivars yielded 0.12 and 0.14 per cent of essential oil respectively on fresh weight basis. The authors have discussed the physico-chemical properties and chemical composition of the oils. Similarities in the composition of the oils showed that both the types belong to the same cultivar and the minor differences between the two types were attributed to different ecological conditions in which they were grown.

Rawat et al. (1989) analysed the essential oil from two important cultivars of Piper betel L. viz. 'Bangla' and 'Meetha' by Gas liquid chromatography and thin layer chromatography. The results showed that these cultivars could be identified on the basis of chemical composition of essential oil. Anethole (32.2%) was present in 'Meetha' as major constituent while it was absent in 'Bangla' cultivar. In 'Bangla' eugenol was a major constituent (82%) in the essential oil.

Rawat et al. (1989) studied the composition of the essential oil of Piper betel L. which served as determinates to distinguish betelvine cultivars. From their experiments, it was observed that eugenol was found to be the major and common constituent amongst the cultivars. Eugenol was dominant in 'Bangla' (64%) and 45 per cent in 'Desawari'. 'Meetha' can be distinguished from others due to the presence of Anethole (19.31%) and cis-caryophyllene. Amongst the five cultivars studied, 'Kapoori' appears to be distinct genotype as marked by

large number of specific molecules such as α -thujene, trans β -ocimene, terpinolene, allo ocimene, Δ -cadinene, terpinen-1-ol, α -costol, Δ -cardinol, methyl-2-hexadecan, geraniol, hexadeconic acid, methyl benzoate etc. 'Sanchi' was marked by the presence of steonaldehyde which was absent in other cultivars.

2.2 YIELD POTENTIAL

Rawat (1985) showed the differential yield potential of the cultivars under sub-tropical conditions. He reported that 'Kapoori' group recorded maximum stem elongation and number of leaves followed by 'Bangla', 'Sanchi' and 'Desawari' in that order. 'Meetha' group recorded poorest growth in terms of vine elongation and number of leaves. In terms of leaf area and leaf weight per vine 'Bangla' and 'Sanchi' were observed to produce maximum yield.

MATERIALS AND METHODS

The experiment entitled 'Characterisation of Betelvine Germplasm' was carried out under the following steps.

3.1 SCHEME OF STUDY

The study relates to the characterisation of betelvine germplasm and cataloguing them into appropriate groups based on morphological, physiological and chemical parameters. Since the betelvine crop is grown mainly for its leaf, only the vegetative characters particularly of leaf have been taken up for detailed studies.

3.2 EXPERIMENTAL SITE

The experimental site is located at Agricultural Research Station, Chintalapudi, Guntur district. It is located 15 km away from Bapatla at an altitude of 5 m above mean sea level, 15° 54' north latitude and 80° 31' east longitude.

3.3 WEATHER CONDITIONS

The meteorological data during the crop growth period at Agricultural Research Station, Chintalapudi was recorded (Table 1b).

The weekly mean maximum temperature ranged from 28.5°C to 40.7°C with an average of 34.25°C while the mean minimum temperature varied from 17.2°C to 29.4°C with an average of 23.45°C. The mean relative humidity values during the crop growth period varied from 58.1 to 91.7 per cent with an average of 74.95 per cent. The total rainfall of 745.6 mm was received during the entire period of the crop growth.

Table 1b Weekly Meteorological data during the Crop Period (17.9.1990 to 7.5.1991)

Standard week	Date and Month	Mean Temperature °C		Relative Humidity(%)			Rain fall (mm)	No. of rainy days
		Maximum	Minimum	At 8.30 hr	At 17.30 hr	Mean		
38	17 to 23 Sep 90	34.0	25.7	80.3	67.0	73.7	17.9	3
39	24 to 30 Sep 90	31.6	24.4	86.0	78.9	82.4	60.9	6
40	01 to 07 Oct 90	29.5	23.9	83.4	81.4	82.4	24.5	4
41	08 to 14 Oct 90	32.1	25.2	83.1	75.4	79.3	2.8	3
42	15 to 21 Oct 90	31.3	23.4	84.9	73.6	79.2	17.4	2
43	22 to 28 Oct 90	28.9	23.4	92.4	91.0	91.7	87.6	6
44	29 to 04 Nov 90	29.2	22.2	83.3	84.1	83.7	30.3	2
45	05 to 11 Nov 90	31.9	22.1	82.6	67.7	75.1	4.0	1
46	12 to 18 Nov 90	30.0	21.6	87.0	79.6	83.3	91.4	4
47	19 to 25 Nov 90	29.1	22.0	90.0	81.0	85.5	60.8	4
48	26 to 2 Dec 90	30.1	21.2	88.6	72.1	80.4	5.0	1
49	3 to 9 Dec 90	30.2	19.5	88.3	71.0	79.6	-	-
50	10 to 16 Dec 90	29.3	18.5	75.1	63.6	69.4	-	-
51	17 to 23 Dec 90	29.85	19.5	84.0	66.7	75.4	-	-
52	24 to 31 Dec 90	28.7	19.5	87.4	65.4	76.4	-	-
1	01 to 07 Jan 91	28.5	20.4	80.1	76.0	78.05	11.2	1
2	08 to 14 Jan 91	28.6	18.5	87.0	67.1	77.1	-	-
3	15 to 21 Jan 91	29.2	18.1	93.3	68.1	80.7	-	-
4	22 to 28 Jan 91	30.0	18.2	91.6	62.6	77.1	-	-
5	29 to 04 Feb 91	31.0	17.2	90.6	61.7	76.1	-	-
6	05 to 11 Feb 91	30.7	18.4	89.9	60.3	75.1	-	-
7	12 to 18 Feb 91	31.8	18.0	91.7	57.9	74.8	-	-
8	19 to 25 Feb 91	31.9	18.4	89.9	60.9	75.0	-	-
9	26 to 04 Mar 91	31.2	20.3	84.9	63.9	74.4	-	-
10	05 to 11 Mar 91	31.7	23.3	78.1	70.6	74.4	-	-
11	12 to 18 Mar 91	31.8	22.2	75.4	64.1	69.8	-	-
12	19 to 25 Mar 91	34.0	21.8	82.0	60.4	71.2	-	-
13	26 to 01 Apr 91	33.1	23.0	79.7	67.4	73.6	-	-
14	02 to 08 Apr 91	33.1	25.1	76.0	67.0	71.5	-	-
15	09 to 15 Apr 91	34.2	26.5	70.6	66.3	68.5	-	-
16	16 to 22 Apr 91	34.7	26.0	70.3	65.7	68.0	-	-
17	23 to 29 Apr 91	35.2	26.0	70.1	61.4	65.8	-	-
18	30 to 6 May 91	40.7	28.8	60.3	55.9	58.1	-	-
19	7 May 91	36.2	29.4	73.0	70.0	71.5	-	-

3.4 SOIL CHARACTERS

The soils at experimental site were clay loams. Before applying the manures, soil samples were collected randomly at selected spots from a depth of 20 cm and were analysed for their physical and chemical properties. The results are tabulated (Table 2).

Table 2: Chemical analysis of the soil

S.No.	Particulars	Quantities
1	pH	8.1
2	Electrical conductivity	0.528mmhos cm^{-1}
3	Available nitrogen	238 kg ha^{-1} (low)
4	Available P_2O_5	38.4 kg ha^{-1} (medium)
5	Available K_2O	286 kg ha^{-1} (high)

The data in the above table indicated the suitability of the land for the betelvine cultivation.

3.5 EXPERIMENTAL DETAILS

The details about the cultivars selected for the experimental purpose, their layout, cultivation practices and design are furnished below.

3.5.1 Treatments

Thirteen cultivars were used for the experimental work and the source of their collection is furnished in Table 3 (Plates 1 to 13).

Table 3 Betelvine cultivars regions of their cultivation and source of collection

Cultivars	Locality	Source
1. Karapaku	Andhra Pradesh	A. R. S., Utukur
2. Bangla	Madhya Pradesh	A. R. S., Utukur
3. Gachipan	Assam	A. R. S., Utukur
4. Godi Bangla	Orissa	O.U.A.T., Bhubaneswar
5. Kakair	Bihar	A. R. S., Utukur
6. Meetha Calcutta	West Bengal	Calcutta
7. Pachai Kodi	Tamil Nadu	Sirugamani Betelvine Research Project, Tamil Nadu
8. Maghai	Bihar	N.B.R.I., Lucknow
9. Tellaku of Chennur	Andhra Pradesh	Cuddapah
10. Karielle	Karnataka	I.I.H.R., Hassarghatta, Bangalore
11. Meetha cum Bangla	Uttar Pradesh	N.B.R.I., Lucknow
12. Tellaku of Ponnur	Andhra Pradesh	Ponnur
13. Tellaku of Utukur	Andhra Pradesh	A.R.S., Utukur



PLATE 1
KARAPAKU



PLATE 2
BANGLA



PLATE 3
GACHIPAN

PLATE 4
GODI BANGLA

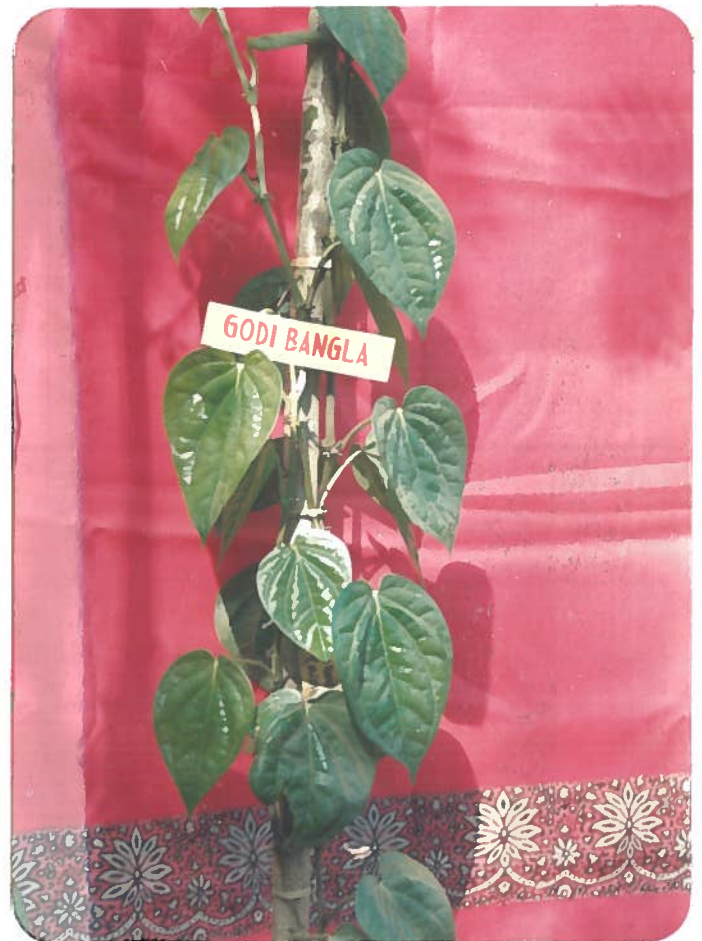




PLATE 5
KAKAIR



PLATE 6
MEETHA CALCUTTA



PLATE 7
PACHAI KODI



PLATE 8
MAGHAI



PLATE 9
TELLAKU OF CHENNUR



PLATE 10
KARIELE



PLATE 11
MEETHA CUM BANGLA



PLATE 12
TELLAKU OF PONNUR



PLATE 13
TELLAKU OF UTUKUR

3.5.2 Layout

An experimental plot size of 15 m x 8 m was taken to grow thirteen cultivars at a spacing of 1 m x 20 cm with 3 replications in a randomized block design (Fig. 1).

3.6 CULTIVATION DETAILS

3.6.1 Preparatory cultivation

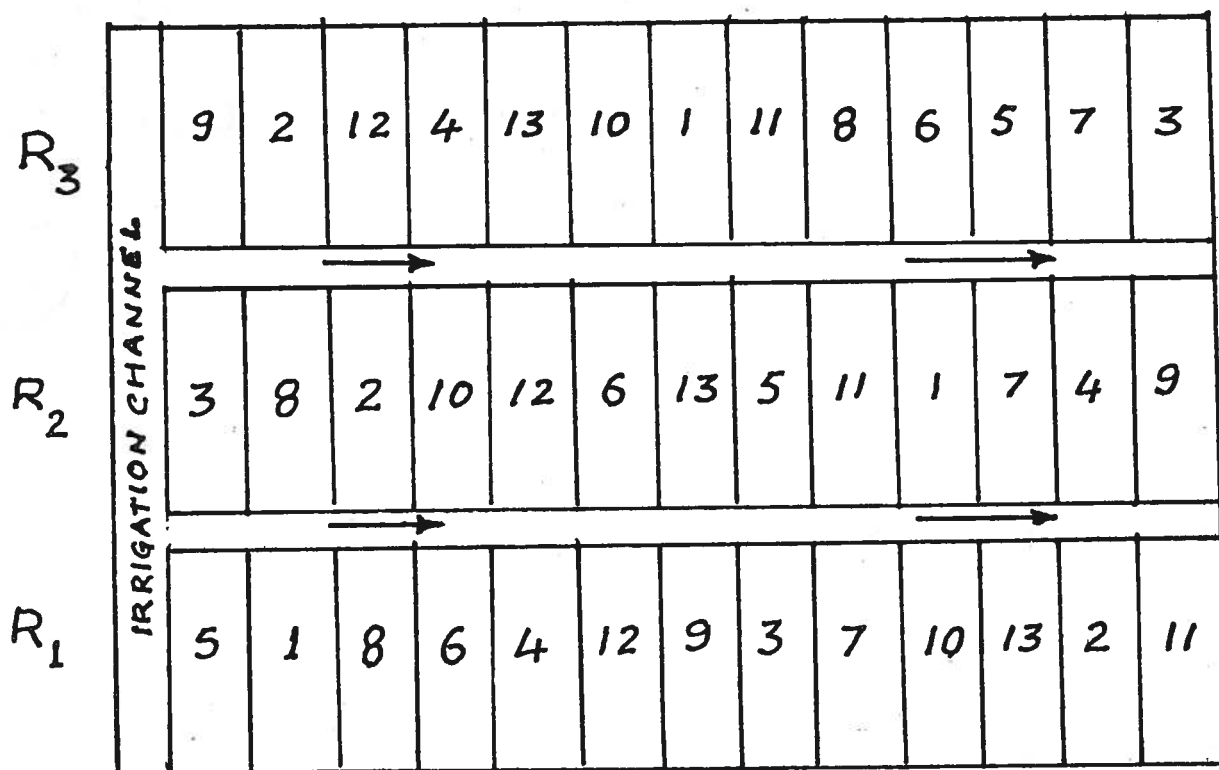
The experimental area was ploughed three times with the help of a tractor drawn cultivator. In the last ploughing, farm yard manure was incorporated into the soil at the rate of 15 t/ha⁻¹. To bring the soil to fine tilth, the land was worked with spade and finally ridges and furrows were formed at 45 cm apart and irrigation channels were formed at convenient places.

3.6.2 Sowing of prop crop and planting of betelvine

As the crop required cool shade, diffused sunlight and considerable humidity a live support plant 'Avisi' (Sesbania grandiflora L.) was raised. Seeds of prop crop were sown at the rate of 40 kg per ha on 20th July 1990 at a distance of 1 m apart from row to row.

Healthy, disease free vine cuttings of betelvine consisting 6 to 8 nodes were collected and planted on slope of the ridges at a distance of 20 cm on 17th September 1990 when the supporting plants are two months old. The vines after establishment within a month after planting were allowed to creep on the live standards.

Fig 1 LAY-OUT OF EXPERIMENTAL FIELD



Cultivars 13

- | | |
|--------------------|------------------------|
| 1. Karapaku | 8. Maghai |
| 2. Bangla | 9. Tellaku of Chennur |
| 3. Gachipan | 10. Karielle |
| 4. Godi Bangla | 11. Meetha cum Bangla |
| 5. Kakair | 12. Tellaku of Ponnur |
| 6. Meetha Calcutta | 13. Tellaku of Utukuru |
| 7. Pachai Kodi | |

3.6.3 After care

Periodic intercultural operations such as weeding, propping, pruning of Sesbania plants and irrigation were carried out as and when required uniformly. Basal manuring was done at 100 cart loads of farm yard manure, 100 kg P_2O_5 per hectare through superphosphate and 50 kg K_2O per hectare through sulphate of potash. 75 kg N through castor kernel cake and 25 kg N per hectare through ammonium sulphate were applied as top dressing in four splits starting from second month onwards after planting at bimonthly intervals. Malathion was sprayed at 0.25% against leaf eating caterpillars during early stages of Sesbania plants.

3.6.4 Harvesting

Harvesting of leaves was done with the help of an artificial thumb nail made up of iron. The leaves were cut along with the petiole about 1 cm length. It was carried out from November 1990 to May 1991 at monthly intervals in case of 'Kapoori' group and once in two months in case of 'Bangla', 'Sanchi' and 'Meetha' group cultivars.

3.7 DATA RECORDED

Data relating to morphological, physiological and chemical characteristics of betel leaf were recorded.

Leaf sampling technique as suggested by Singh et al. (1988) was adopted while collecting the leaf samples from the

13 cultivars. The leaves from 6th to 8th position from the apex of the vine representing 6 to 8 weeks old were taken for conducting the studies. From each cultivar in each replication, six leaves were collected to arrive at the average values.

3.7.1 Morphological characters

3.7.1.1 Leaf size: Leaves were grouped on the basis of leaf area as big (above 70 cm^2), medium ($50-70 \text{ cm}^2$) and small (50 cm^2 and less) depending on the data collected on leaf area.

3.7.1.2

Morphological characters such as leaf shape, tip, margin of lamina, colour, texture, venation, colour of internodes and branching habit were described as per standard terminology.

3.7.1.3 Size of internodes and petiole length: Length of internodes and petiole was measured using the scale.

3.7.1.4 Leaf area: The leaf area was measured using the leaf area meter 'Delta-T Area meter' manufactured by Delta-T Devices Limited, Area meter, UK.

3.7.2 Growth Analysis Parameters

3.7.2.1 R-value: The ratio of the area of the rectangle of the leaf to actual area of the leaf. This term used to denote leaf shape quantitatively.

$$\text{R-value} = \frac{\text{Length} \times \text{breadth (at maximum width of the leaf)}}{\text{Actual leaf area}}$$

3.7.2.2 Specific Leaf Weight

Specific leaf weight was estimated using the given formula and expressed in mg cm^{-2} .

$$\text{Specific leaf weight} = \frac{\text{Dry weight of leaf}}{\text{Leaf Area}}$$

3.7.3 Physiological characters

3.7.3.1 Clearing off leaves: It is the first step to clear the leaves before determining veinlet termination number and palisade ratio. Clearing off leaves was accomplished by dipping the recently matured leaves in pure lactic acid and leaves was cleared after 10 to 12 days of treatment as described by Sprone (1948). Leaf pieces of 2 cm^2 were taken from the treated leaves at apical, middle and basal regions of lamina for determining the said characters.

3.7.3.2 Veinlet Termination Number: "Ultimate free termination of vein or branch of a veinlet is termed as veinlet termination and its number per mm^2 of leaf surface was calculated", which denote veinlet termination number. The cleared sample leaf was examined under microscope and counted veinlet terminations per mm^2 using camera lucida and stage micrometer.

3.7.3.3 Palisade Ratio: The average number of palisade cells beneath each upper epidermal cell is termed as the palisade ratio (Trease and Evans, 1972). Outerlines of epidermal cells were sketched with the help of camera lucida under magnification

of 10 x 40. The palisade mesophyll cells were superimposed by further adjusting the focus. Total number of palisade mesophyll cells were counted beneath the epidermal cells. The palisade ratio was calculated using the formula

$$\text{Palisade Ratio} = \frac{\text{Total palisade cells under four epidermal cells}}{4}$$

3.7.3.4 Stomatal number and size: The number of stomata in an unit area of one mm² gives the stomatal density and the size of the stomata was measured with the help of ocular micrometer whose value was calibrated with the help of a stage micrometer. For recording the stomatal number, quick fix in thin layer was applied on the lower surface of the leaf. Quick fix layer was peeled off from the leaf after drying and the sample was examined under microscope for counting the number of stomata in a unit area of mm² which gave the stomatal density.

3.7.3.5 Stomatal Index: The number of stomata out of the total number of epidermal cells of a leaf is called stomatal index and is expressed in percentage. It was calculated using the formula as suggested by Salisbury (1927).

$$\text{Stomatal Index} = \frac{S}{S + E} \times 100$$

Where, S = Number of stomata per unit area

E = Number of epidermal cells per unit area

3.7.4 Chemical Characteristics

3.7.4.1 Estimation of total chlorophyll: The chlorophyll content in the leaf was estimated colorimetrically by Dimethyl

sulfoxide method of Hiscox and Israel Stan (1979).

40

The leaf samples were collected, cleaned and sliced into small pieces. About 300 mg of sample was immersed in 10 ml of pure dimethyl sulphoxide (DMSO) for 3 hours in a hot air oven maintained at 60°C - 65°C and the optical densities were taken at 645 and 663 nm in Spectronic-20 Colorimeter. Chlorophyll content was calculated according to the following formula (Arnon, 1949).

$$\text{Chl. a} = (12.7 \times D \ 663) - (2.69 \times D \ 645) \times \frac{V}{1000 \times W}$$

$$\text{Chl. b} = (22.9 \times D \ 645) - (4.68 \times D \ 663) \times \frac{V}{1000 \times W}$$

$$\text{Total chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

Where, V = Volume of DMSO

W = Fresh weight of sample taken

If the optical density values proved to be greater than 0.7, the extract was diluted to 50 per cent with DMSO and the equation was adjusted accordingly. Initially the leaf tissue fractions were placed in a vial containing 7 ml of DMSO and finally adjusted to 10 ml.

3.7.4.2 Estimation of essential oil: Mature leaves of all thirteen cultivars were collected and weighed. The leaves were hydrodistilled in clevenger's apparatus. The essential oil was collected after 6 hours of distillation and yield of oil in terms of percentage fresh weight of leaves was calculated.

3.7.4.2.1 Gas liquid chromatographic studies of essential oil

The essential oil was examined by gas liquid chromatographic technique over 'Amil Nucan gas liquid chromatograph (Cat. No.5500)' at National Botanical Research Institute, Lucknow. It is having stainless steel column of 10 cm length and 0.3 cm diameter. SE = 30 on chromosorb W of 100 mesh was used as stationary phase. Nitrogen was used as carrier gas. The other conditions were maintained as below.

Injector temperature	250°C
Column temperature range (at the rising rate of 4°C/min)	80°C to 200°C
FID temperature	270°C
Gas flow rate	35 ml/min
Chart speed	10 mm/min

The identification of the chemical constituents such as eugenol, anethol and terpenyl acetate in essential oil was accomplished by comparing their retention data and R_f values with those obtained with reference samples run under similar conditions.

3.7.5 Organoleptic studies

Organoleptic evaluation of matured leaves of betelvine for assessing fibre content, pungency and flavour was done by a panel of 10 members at Agricultural Research Station, Chintalapudi. The results presented were based on the scoring technique on characters like pungency, flavour and fibre.

3.7.6 Yield characters

Yield characters, like number of leaves per vine and weight of leaves per vine were recorded at harvesting time from eight months stage crop.

3.8 STATISTICAL ANALYSIS

The data were subjected to statistical analysis and the statistical significance was tested by 'F' value at 5 per cent level of probability and the critical differences were worked out for the effects which were significant.

3.8.1 Analysis of variance

The analysis of variance for each character was done as per the standard statistical procedure for RBD given by Cochran and Cox (1950). Analysis of variance (model) furnished in the following Table.

ANOVA					
Sl. No.	Source of variation	d.f.	S.S.	M.S.S.	'f' cal 'f' tab
1	Replications	2 (r - 1)	r'	Mr	Mr/E
2	Treatments	12 (c - 1)	c'	Mc	Mc/E
3	Error	24 (r-1) (c-1)	E'	E	
4	Total	38 (rc - 1)			

d.f = Degrees of freedom

c = Cultivars

r = Replications

S.S = Sum of squares

M.S.S = Mean sum of squares

$$\text{Genotypic variance } (\sigma_G^2) = \frac{\text{TMSS} - \text{EMSS}}{r}$$

EMSS = Error mean sum of squares

TMSS = Treatment mean sum of squares

r = Number of replications

$$\text{Phenotypic variance } (\sigma_P^2) = \sigma_G^2 + \sigma_E^2$$

Where σ_G^2 = Genotypic variance

σ_E^2 = Environmental variance = EMSS

3.8.2 Coefficients of variation

The coefficients of variation were calculated using the formulae adopted by Burton and Deurane (1953).

Genotypic coefficient of variation (GCV)

$$\text{GCV (\%)} = \frac{\sqrt{\sigma_G^2}}{\bar{X}} \times 100$$

Where $\sqrt{\sigma_G^2}$ = Genotypic standard deviation

$\bar{X}$ = General mean of the character

Phenotypic coefficient of variation (PCV)

$$\text{PCV (\%)} = \frac{\sqrt{\sigma_P^2}}{\bar{X}} \times 100$$

Where $\sqrt{\sigma_P^2}$ = Phenotypic standard deviation

$\bar{X}$ = General mean of the character

3.8.3 Heritability in broad sense

Heritability in broad sense was estimated according to the formula given by Allard (1960).

$$h^2 (b) = \frac{\sigma_G^2}{\sigma_P^2}$$

Where, $h^2 (b)$ = Heritability in broad sense
 σ_G^2 = Genotypic variance
 σ_P^2 = Phenotypic variance

3.8.4 Genetic Advance

Genetic advance refers to the expected gain or improvement in the next generation by selecting the superior individual under certain amount of selection intensity. From the heritability estimates, the genetic advance was estimated by the formula given by Allard (1960).

$$GA = K \sqrt{\sigma_P^2} \times h^2 (b)$$

Where, GA = Expected genetic gain

σ_P^2 = Phenotypic variance

$h^2 (b)$ = Heritability in broad sense

K = Selection differential and it is defined as the difference between the mean of selected population and mean of original population expressed in standard units. Thus $K = 2.06$ where top 5 per cent population is advanced.

RESULTS

Studies on the categorisation of betelvine cultivars into various groups based on leaf morphology, physiology, growth analysis, organoleptic tests, essential oil content and its chemical constituents in essential oil were conducted besides the genetic variability and the results so obtained are presented below.

4.1 MORPHOLOGICAL CHARACTERS

The morphological characters such as leaf size (big, medium and small), leaf shape (cordate to roundish, broadly ovate and narrowly ovate), leaf tip (acuminate, acute and attenuate), margin of lamina (entire and undulate), leaf colour (light green, light to dark green and dark green), leaf texture (coriaceous and membranous), venation (palmately reticulate) and colour of internodes (green, pink and pinkish green) were observed visually for all the thirteen cultivars and details are presented in Table 4. (plates 14 and 15)

4.1.1 Leaf Colour

Basing on the colour of the leaf, the thirteen cultivars were grouped into four categories, viz. light green, light to dark green, dark green and dark green with characteristic yellowish spots. The cultivars viz. "Tellaku of Chennur", "Tellaku of Ponnur" and "Tellaku of Utukur" were having light green colour. Cultivars "Karapaku", "Bangla", "Gachipan", "Godibangla", "Kakair", "Maghai" and "Meetha cum Bangla" were having the colour of light

TABLE 4 MORPHOLOGICAL CHARACTERS OF THIRTEEN BETELVINE CULTIVARS

CHARACTER	KARAPAKU	BANGLA	GACHIPAN	GODIBANGLA	KAKAIR	MEETHA CALCUTTA	PACHAI
Leaf size	Big	Medium	Big	Big	Small	Small	Small
Leaf shape	Cordate to roundish, basal lobes most prominent	Cordate to roundish, basal lobes most prominent	Cordate to roundish, basal lobes most prominent	Cordate to roundish, basal lobes most prominent	Cordate to roundish, basal lobes most prominent	Cordate to roundish	Broadly ov basal lobe less conspicuous than B cv.
Leaf tip	Acuminate	Acuminate	Acuminate	Acuminate	Acuminate	Acute	Attenuate
Margin of lamina	Entire	Entire	Entire	Entire	Entire	Entire, sometimes lower portion is undulate	Entire
Leaf colour	Light to dark green	Light to dark green	Light to dark green	Light to dark green	Light to dark green	Dark green with characteristic yellowish spots	Dark green
Leaf texture	Coriaceous	Coriaceous	Coriaceous	Coriaceous	Coriaceous	Coriaceous	Coriaceous
Venation	Palmately reticulate with 4-6 secondary veins, curved	Palmately reticulate with 4-6 secondary veins curved	Palmately reticulate with 4-6 secondary veins curved	Palmately reticulate with 4-6 secondary veins curved	Palmately reticulate with 4-6 secondary veins curved	Palmately reticulate with 4-6 secondary veins, prominent and curved	Palmately reticulate with secondary veins prominent and curved
Colour of internodes	Green	Green	Green	Green	Pinkish green	Green	Pinkish green

TABLE 4 (CONTD.)

CHARACTER	MAGHAI	TELLAKU OF CHENNUR	KARIELE	MEETHA CUM BANGLA	TELLAKU CF PONNUR	TELLAKU CF UTUKUR
Leaf size	Small	Medium	Small	Small	Medium	Medium
Leaf shape	Cordate to roundish, basal lobes most prominent	Narrowly ovate, basal lobes not well developed	Broadly ovate, basal lobes less conspicuous than Bangla Cv.	Cordate to roundish, basal lobes most prominent	Narrowly ovate, basal lobes not well developed	Narrowly ovate, basal lobes not well developed
Leaf tip	Acuminate	Acuminate	Attenuate	Acuminate	Acuminate	Acuminate
Margin of lamina	Entire	Basal portion undulate	Entire	Entire	Basal portion undulate	Basal portion undulate
Leaf colour	Light to dark green	Yellowish green to light green	Dark green	Light to dark green	Yellowish green to light green	Yellowish green to light green
Leaf texture	Coriaceous	Membranous	Coriaceous	Coriaceous	Membranous	Membranous
Venation	Palmately reticulate venation with 4-6 secondary veins, curved	Palmately reticulate, 4-6 secondary veins parallel to mid rib	Palmately reticulate, 6-8 secondary veins, curved	Palmately reticulate, 4-6 secondary veins, curved	Palmately reticulate, 4-6 secondary veins parallel to mid rib	Palmately reticulate, 4-6 secondary veins parallel to mid rib
Colour of internodes	Pinkish green	Green	Pinkish green	Pinkish green	Green	Green



PLATE 14

Leaf of: 1. Karapaku 2. Bangla 3. Gachiban 4. Godi Bangla
5. Kakair 6. Meetha Calcutta

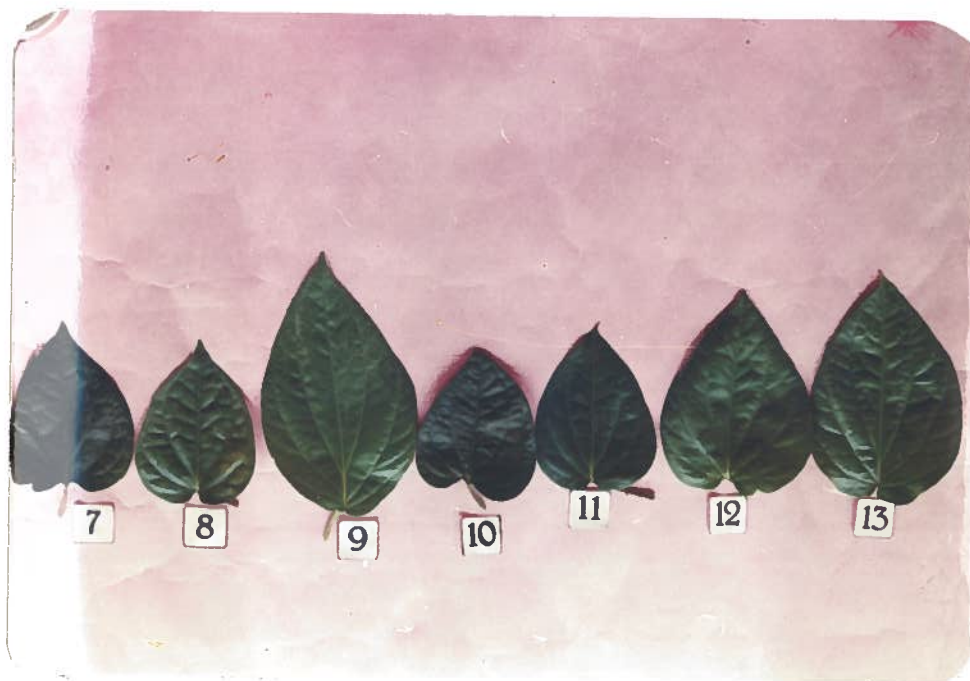


PLATE 15

Leaf of: 7. Pachai Kodi 8. Maghai 9. Tellaku of Chennur
10. Karielle 11. Meetha cum Bangla
12. Tellaku of Ponnur 13. Tellaku of Utukur

to dark green. 'Pachai Kodi' and 'Kariele' cultivars were having dark green colour. Among all the cultivars 'Meetha Calcutta' alone was having dark green colour with characteristic yellowish spots (Table 5).

4.1.2 Leaf Shape

The thirteen cultivars were categorized into three groups based on their leaf shape. The cultivars viz. 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Meetha Calcutta', 'Maghai' and 'Meetha cum Bangla' have come under the leaf shape of cordate to roundish. 'Pachai Kodi' and 'Kariele' cultivars were having broadly ovate leaf shape and the cultivars 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' were having narrowly ovate leaf shape (Table 5).

4.1.3 Leaf Area (Cm²)

Data pertaining to leaf area of all the thirteen cultivars are presented in Table 6 and Fig. 2.

Statistically it was observed that there were significant differences among the thirteen cultivars for this character. Maximum leaf area was recorded in the cultivar 'Karapaku' (83.78) followed by 'Gachipan' (81.56). Minimum leaf area was recorded by 'Meetha Calcutta' (34.67) followed by 'Maghai' (36.89). The leaf area of the remaining cultivars ranged in between 83.78 and 34.67.

The leaf area was divided into three groups based on their range as small (30-50), medium (50-70) and big (70-90).

TABLE 5 CATALOGUING OF BETELVINE CULTIVARS BASED ON LEAF COLOR, LEAF SHAPE, LEAF AREA (Cm²) AND NUMBER OF BRANCHES PER PLANT

LEAF COLOR				LEAF SHAPE			LEAF AREA (Cm ²)			NO. OF BRANCHES PER PLANT		
Light green	Light to dark green	Dark green	Dark green with characteristic yellow spots	Cordate to roundish	Broadly ovate	Narrowly ovate	Small (30-50)	Medium (50-70)	Big (70-90)	Low (0-3.3)	Medium (3.3 - 6.7)	High (6.7-10)
Tellaku of Chennur	Karapaku Bangla	Pachai Kodi Kariela	Meetha Calcutta	Karapaku Bangla	Pachai Kodi Kariela	Tellaku of Chennur	Meetha Calcutta	Bangla	Karapaku	Karapaku	---	Tellaku of Chennur
Tellaku of Ponnur	Gachipan			Gachipan		Tellaku of Ponnur	Maghai Kariela	Tellaku of Utukur	Gachipan	Gachipan		Tellaku of Ponnur
Tellaku of Utukur	Godi Bangla			Godi Bangla		Tellaku of Utukur	Pachai Kodi	Tellaku of Ponnur	Godi Bangla	Godi Bangla		Tellaku of Utukur
	Kakair			Kakair			Kakair	Tellaku of Chennur		Meetha Calcutta		
	Maghai			Maghai						Bangla		
	Meetha cum Bangla			Meetha cum Bangla			Meetha cum Bangla			Kakair		
				Meetha Calcutta						Maghai		
										Meetha cum Bangla		
										Pachai Kodi		
										Kariela		

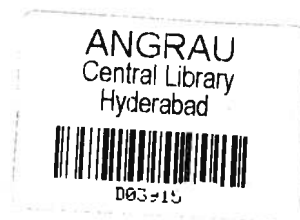
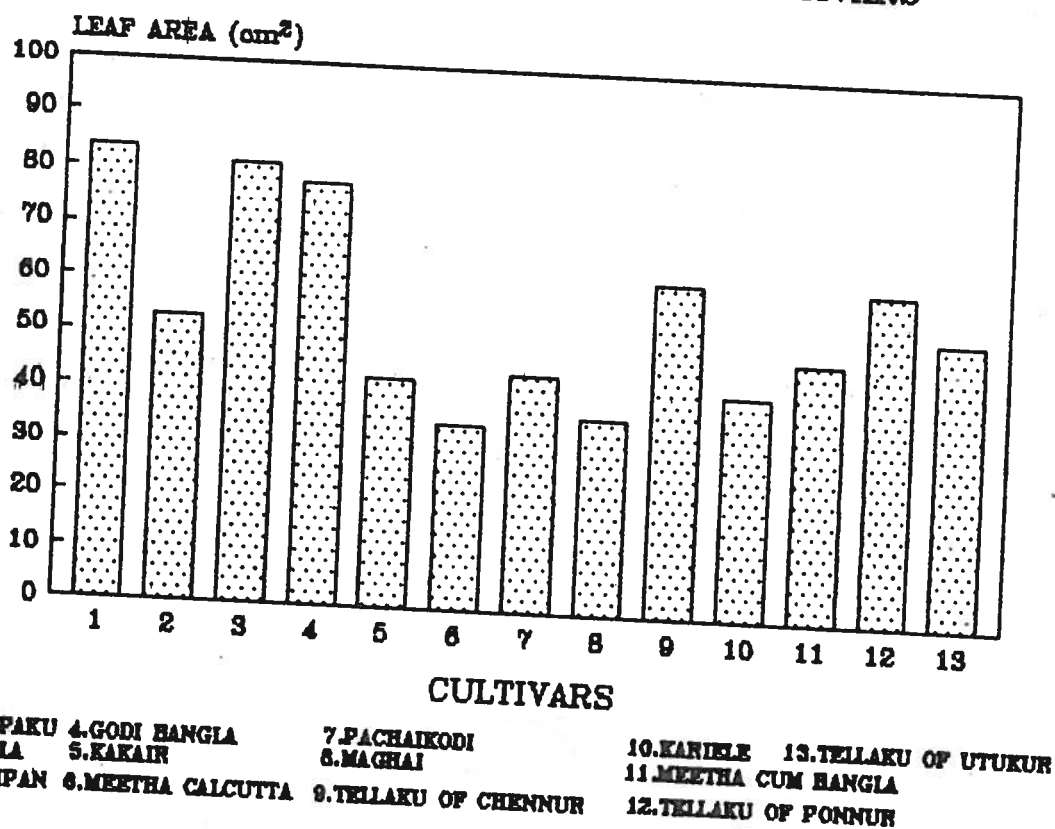


FIG 2: LEAF AREA OF BETELVINE CULTIVARS



The cultivars viz. 'Meetha Calcutta', 'Maghai', 'Kakair', 'Kariele', 'Pachai Kodi' and 'Meetha cum Bangla' were grouped under small while medium group was having 'Bangla', 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' cultivars. 'Karapaku', 'Gachipan' and 'Godi Bangla' cultivars were grouped under big (Table 5).

4.1.4 Petiole length

Data pertaining to petiole length of all the thirteen cultivars are presented in Table 6.

Statistical analysis indicated that there were significant differences among the thirteen cultivars. The cultivar 'Gachipan' recorded maximum (6.95 cm) petiole length followed by Tellaku of Ponnur (5.91 cm). The cultivar 'Maghai' recorded minimum (5.06 cm) petiole length followed by Bangla (5.12 cm). The petiole length for other cultivars ranged in between the cultivars 'Gachipan' and 'Maghai'.

4.1.5 Internodal length

Statistically significant differences were observed among the thirteen cultivars.

Highest internodal length was observed in 'Gachipan' (6.95 cm) followed by 'Tellaku of Ponnur' (6.88 cm) while the lowest was recorded in 'Bangla' (4.81 cm) followed by Maghai (5.24 cm). For the remaining cultivars the length of internodes ranged between 5.35 to 6.83 cm. The data are presented in Table 6.

Table 6 Means of leaf area, petiole length, internodal length and number of branches per plant among thirteen cultivars of Betelvine

Cultivars	Leaf Area (cm ²)	Petiole length (cm)	Internodal length (cm)	Number of branches/ plant
1. Karapaku	83.78	5.83	5.35	1.33
2. Bangla	52.89	5.12	4.81	3.00
3. Gachipan	81.56	6.95	6.95	1.67
4. Godi Bangla	78.11	5.78	5.59	1.67
5. Kakair	42.66	5.96	5.56	0
6. Meetha Calcutta	34.67	5.72	5.53	1.33
7. Pachai Kodi	44.22	5.46	6.39	0
8. Maghai	36.89	5.06	5.24	0
9. Tellaku of Chennur	61.78	5.49	6.83	8.33
10. Karielle	41.56	5.71	6.06	0
11. Meetha cum Bangla	47.67	5.72	5.83	0
12. Tellaku of Ponnur	61.55	5.91	6.88	8.67
13. Tellaku of Utukur	53.00	5.44	5.81	9.00
SEm	3.92	0.31	0.22	0.627
SEd	5.55	0.44	0.31	0.887
CD at 5%	11.45	0.91	0.64	1.83

4.1.6 Number of branches per plant

Data pertaining to number of branches per plant of all the thirteen cultivars are presented in Table 6.

Statistically significant differences were observed among all the thirteen cultivars. Maximum (9.0) number of branches per plant was recorded in the cultivar 'Tellaku of Utukur' followed by 'Tellaku of Ponnur' (8.67). Minimum (1.33) was recorded in the cultivars 'Karapaku' and 'Meetha Calcutta' followed by 'Gachipan' and 'Godi Bangla' (1.67). There was no branching in the cultivars viz. 'Kakair', 'Maghai', 'Meetha cum Bangla', 'Pachai Kodi' and 'Kariele'.

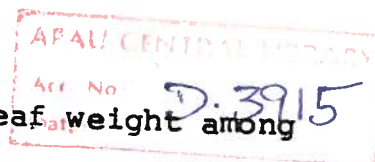
Based on the branching habit the cultivars were grouped as low (0 - 3.3), moderate (3.3 - 6.7) and heavy (6.7 - 10.0). Low branching habit was observed in the cultivars viz. 'Karapaku', 'Gachipan', 'Godi Bangla', 'Meetha Calcutta', 'Bangla', 'Kakair', 'Maghai', 'Meetha cum Bangla', 'Pachai Kodi' and 'Kariele'. No cultivar has come under moderate branching habit. The cultivars, 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' were having heavy branching habit (Table 5).

4.2 GROWTH ANALYSIS PARAMETERS

4.2.1 R-value

The data pertaining to R-value of all the thirteen cultivars are given in Table 7.

Table 7 Means of R-value and specific leaf weight among thirteen cultivars of Betelvine



Cultivars	R-value	Specific Leaf Weight (mg cm ⁻²)
1. Karapaku	1.42	5.5
2. Bangla	1.43	4.7
3. Gachipan	1.41	5.3
4. Godi Bangla	1.41	4.0
5. Kakair	1.41	5.1
6. Meetha Calcutta	1.46	5.0
7. Pachai Kodi	1.56	3.6
8. Maghai	1.41	5.4
9. Tellaku of Chennur	1.50	3.7
10. Kariela	1.54	5.1
11. Meetha cum Bangla	1.43	4.7
12. Tellaku of Ponnur	1.51	3.6
13. Tellaku of Utukur	1.54	3.9
SEm	0.01	5.5
SEd	0.02	7.81
CD at 5%	0.05	NS



From the statistical data, it was inferred that the cultivars were significantly differed among themselves in respect of the parameter R-value. Maximum R-value (1.56) was recorded in the cultivar 'Pachai Kodi' followed by Karielle (1.54) and Tellaku of Utukur (1.54). Minimum (1.41) was recorded in 'Gachipan', 'Godi Bangla', 'Kakair' and 'Maghai'.

4.2.2 Specific Leaf Weight (mg cm^{-2})

Statistically it was observed that there was no significant differences among the thirteen cultivars. Maximum value was observed in the cultivar 'Karapaku' (5.5) while minimum value (3.6) in 'Pachai Kodi' and 'Tellaku of Ponnur'. The data pertaining to this character are given in Table 7.

4.3 PHYSIOLOGICAL CHARACTERS

4.3.1 Stomatal Size (μm)

Data pertaining to the stomatal size of all the thirteen cultivars are given in Table 8.

Statistically significant differences were observed among the thirteen cultivars. Maximum stomatal size (31.08×23.68) was observed in the cultivar 'Meetha cum Bangla' followed by 'Meetha Calcutta' (31.08×22.20) and 'Karapaku' (31.08×19.24) while minimum (22.20×13.32) in 'Tellaku of Chennur'. The stomatal size of the remaining cultivars were in between 31.08×23.68 and 22.20×13.82 .

Table 8 Means of stomatal size, stomatal frequency, stomatal index, palisade ratio and veinlet termination number among thirteen cultivars of betelvine

Cultivars	Stomatal Size (mu)		Stomatal frequency (mm ⁻²)	Stomatal Index	Palisade ratio	Veinlet termination number (mm ⁻²)
	Length	Width				
1. Karapaku	31.08	19.24	165.90	14.79	6.64	8.51
2. Bangla	28.12	22.20	150.62	13.29	7.46	10.57
3. Gachipan	26.64	22.20	128.79	13.50	4.97	6.17
4. Godi Bangla	22.20	17.76	149.53	14.18	7.85	8.15
5. Kakair	31.08	20.72	161.00	16.90	6.22	10.85
6. Meetha Calcutta	31.08	22.20	164.81	15.02	6.70	12.13
7. Pachai Kodi	26.64	20.72	175.72	14.44	6.94	10.87
8. Maghai	26.64	17.76	132.06	12.44	6.73	11.58
9. Tellaku of Chennur	22.20	13.32	197.55	13.52	7.00	7.54
10. Karielle	26.64	22.20	180.09	13.31	6.89	13.27
11. Meetha cum Bangla	31.08	22.20	147.34	12.73	5.52	9.14
12. Tellaku of Ponnur	22.20	14.80	179.10	13.42	7.31	5.70
13. Tellaku of Utukur	25.16	17.76	188.82	13.83	6.40	6.78
SEm	0.51	1.40	9.10	0.44	0.21	0.47
SEd	0.80	1.98	12.86	0.63	0.29	0.67
CD at 5%	1.66	4.08	26.55	1.29	0.60	1.38

4.3.2 Stomatal frequency (mm^{-2})

Data pertaining to stomatal frequency of all the thirteen cultivars are presented in Table 8.

Statistically it was observed that, significant differences among the thirteen cultivars were found in respect of this character. Stomatal frequency was recorded maximum (197.55) in the cultivar 'Tellaku of Chennur' and minimum (132.06) in the cultivar 'Maghai'.

Based on the stomatal frequency, all the thirteen cultivars were categorized into three groups as low (120-146), medium (146-174) and high (174-200). The cultivars viz. 'Gachipan' and 'Maghai' were grouped under low stomatal frequency while the cultivars 'Meetha cum Bangla', 'Godi Bangla', 'Bangla', 'Kakair', 'Meetha Calcutta' and Karapaku were under medium stomatal frequency. The remaining cultivars viz. 'Pachai Kodi', 'Kariele', 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' were grouped under high stomatal frequency (Table 9).

4.3.3 Stomatal Index

Data pertaining to stomatal indices of all the thirteen cultivars are given in the Table 8.

Statistically significant differences were found among the thirteen cultivars. The cultivar 'Kakair' recorded maximum (16.90) stomatal index whereas the cultivar 'Maghai' recorded minimum (12.44) stomatal index.

9 CATALOGUING OF BETELVINE CULTIVARS BASED ON STOMATAL FREQUENCY, STOMATAL INDEX, PALISADE RATIO AND VEINLET TERMINATION NUMBER

STOMATAL FREQUENCY (mm^{-2})			STOMATAL INDEX			PALISADE RATIO			VEINLET TERMINATION NUMBER (mm^{-2})		
Low (146)	Medium (146 - 174)	High (174 - 200)	Low (12.0-14.0)	Medium (14.0-16.0)	High (16.0-18.0)	Low (4.5-5.2)	Medium (5.2-6.3)	High (6.3-8.0)	Low (5.0-8.0)	Medium (8.0-11.0)	High (11.0-14.0)
Gachipan	Meetha cum Bangla	Pachai Kodi	Maghai	Pachai Kodi	Kakair	Gachipan	Meetha cum Bangla	Tellaku of Utukur	Tellaku of Ponnur	Karapaku	Maghai
	Godi Bangla	Kariele	Meetha cum Bangla	Godi Bangla			Kakair	Karapaku	Gachipan	Godi Bangla	Meetha Calcutta
	Bangla	Tellaku of Chennur	Kariele	Karapaku				Meetha Calcutta	Tellaku of Utukur	Meetha cum Bangla	Kariele
	Kakair	Tellaku of Ponnur	Tellaku of Chennur	Meetha Calcutta				Maghai	Tellaku of Chennur	Bangla	
	Meetha Calcutta	Tellaku of Utukur	Tellaku of Ponnur					Kariele		Kakair	
	Karapaku		Bangla					Pachai Kodi		Pachai Kodi	
			Gachipan					Tellaku of Chennur			
			Tellaku of Utukur					Tellaku of Ponnur			
								Bangla			
								Godi Bangla			

All the thirteen cultivars were categorized into three groups namely low, medium and high. The cultivars 'Maghai', 'Meetha cum Bangla', 'Kariele', 'Tellaku of Chennur', 'Tellaku of Ponnur', 'Bangla', 'Gachipan' and 'Tellaku of Utukur' have come under low (12.0 - 14.0) category. The cultivars 'Pachai Kodi', 'Godi Bangla', 'Karapaku', 'Meetha Calcutta' were grouped under medium (14.0 - 16.0) category and the only cultivar 'Kakair' placed under high (16.0 - 18.0) stomatal index (Table 9).

4.3.4 Palisade ratio

Data pertaining to the Palisade ratio of all the thirteen cultivars are given in the Table 8.

From the statistical analysis, it was observed that significant differences were found among the thirteen cultivars. Maximum Palisade ratio (7.85) was recorded in the cultivar 'Godi Bangla' followed by 'Bangla' (7.46). Minimum (4.97) was recorded in the cultivar 'Gachipan'.

Based on the palisade ratio, the cultivars were categorized into three groups. The cultivar 'Gachipan' was having low (4.5 - 5.2) palisade ratio. The cultivars viz. 'Meetha cum Bangla' and 'Kakair' were having medium (5.2 - 6.3) palisade ratio while the other cultivars namely, 'Tellaku of Utukur', 'Karapaku', 'Meetha Calcutta', 'Maghai', 'Kariele', 'Pachai Kodi', 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Godi Bangla' come under high (6.3 - 8.0) category of palisade ratio (Table 9).

4.3.5 Veinlet Termination Number

The data on veinlet termination number of different cultivars of betelvine are given in Table 8.

The differences among the cultivars was found significant for this character. Maximum veinlet termination number (11.58) was recorded in the cultivar 'Maghai' followed by 'Kakair' (10.85) while minimum was recorded in 'Tellaku of Ponnur' (5.70).

All the thirteen cultivars were categorized into three groups based on the parameter veinlet termination number. The cultivars viz. 'Tellaku of Ponnur', 'Tellaku of Chennur', 'Tellaku of Utukur' and 'Gachipan' were grouped under low (5.0 - 8.0) category. The cultivars viz. 'Karapaku', 'Godi Bangla', 'Meetha cum Bangla', 'Bangla', 'Kakair' and 'Pachai Kodi' were grouped under medium (8.0 - 11.0) category while the cultivars 'Maghai', 'Meetha Calcutta' and 'Kariele' under high (11.0 - 14.0) category of veinlet termination number (Table 9).

4.4 ORGANOLEPTIC STUDIES

The details pertaining to organoleptic aspects such as pungency, flavour and fibre of the thirteen cultivars of betelvine are presented in Table 10.

4.4.1 Pungency

Based on the pungency all the thirteen cultivars were categorized into three groups. The cultivars namely 'Meetha

Table 10 Organoleptic evaluation of Betelvine cultivars based on Pungency, Flavour and Fibre

Cultivars	Pungency	Flavour	Fibre
1. Karapaku	Pungent	Aromatic	Fibrous
2. Bangla	Pungent	Aromatic	Fibrous
3. Gachipan	Pungent	Aromatic	Fibrous
4. Godi Bangla	Pungent	Aromatic	Fibrous
5. Kakair	Pungent	Aromatic	Fibrous
6. Meetha Calcutta	Least pungent	Fennel like flavour	Less fibrous
7. Pachai Kodi	Highly pungent	Aromatic	Fibrous
8. Maghai	Pungent	Aromatic	Fibrous
9. Tellaku of Chennur	Least pungent	Mildly flavoured	Less fibrous
10. Karielle	Highly pungent	Aromatic	Fibrous
11. Meetha cum Bangla	Pungent	Aromatic	Fibrous
12. Tellaku of Ponnur	Least pungent	Mildly flavoured	Less fibrous
13. Tellaku of Utukur	Least pungent	Mildly flavoured	Less fibrous

Calcutta', 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' were grouped under least pungent group. The cultivars viz. 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Maghai' and 'Meetha cum Bangla' were grouped under pungent group while the cultivars 'Pachai Kodi' and 'Kariele' under highly pungent group (Table 11).

4.4.2 Flavour

Based on flavour, the cultivars were grouped as mild flavour, flavour and fennel-like flavour. Mild flavour group included the cultivars 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur'. Flavour group included 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Maghai', 'Meetha cum Bangla', 'Pachai Kodi' and 'Kariele'. The cultivar 'Meetha Calcutta' was the only cultivar grouped under fennel-like flavour (Table 11).

4.4.3 Fibre

All the thirteen cultivars were grouped into less fibrous, fibrous and highly fibrous. The cultivars 'Meetha Calcutta', 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' comes under less fibrous group. The group fibrous include 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Maghai', 'Pachai Kodi', 'Kariele', 'Meetha cum Bangla'. No cultivar was grouped under highly fibrous group (Table 11).

TABLE 11 CATALOGUING OF BETELVINE CULTIVARS BASED ON PUNGENCY, FLAVOUR AND FIBRE

PUNGENCY			FLAVOUR			FIBRE		
Least pungent	Pungent	Highly pungent	Mild flavour	Aromatic	Fennel like flavour	Less fibrous	Fibrous	Highly fibrous
Meetha Calcutta	Karapaku	Pachai Kodi	Tellaku of Chennur	Karapaku	Meetha Calcutta	Meetha Calcutta	Karapaku	--
Tellaku of Chennur	Bangla	Kariele	Tellaku of Ponnur	Bangla		Tellaku of Chennur	Bangla	
Tellaku of Ponnur	Gachipan		Tellaku of Utukur	Gachipan		Tellaku of Ponnur	Gachipan	
Tellaku of Utukur	Godi Bangla			Godi Bangla		Tellaku of Utukur	Godi Bangla	
	Kakair			Kakair			Kakair	
	Maghai			Maghai			Pachai Kodi	
	Meetha cum Bangla			Meetha cum Bangla			Maghai	
				Pachai Kodi			Kariele	
				Kariele			Meetha cum Bangla	

4.5 CHEMICAL CHARACTERISTICS

The data on per cent content of essential oil and its chemical constituents such as eugenol, anethol, terpenyl acetate, methyl eugenol and α -terpineol obtained from the chromatograms through gas liquid chromatography are presented in Table 12 and Figures 3 & 4.

4.5.1 Essential Oil

Maximum per cent content of essential oil (0.512) was recorded in the cultivar 'Meetha Calcutta' over all other cultivars. It was followed by 'Godi Bangla' (0.465) while the cultivars 'Tellaku of Utukur', 'Tellaku of Chennur' and 'Tellaku of Ponnur' recorded minimum values of 0.086, 0.110 and 0.126 respectively.

Based on the per cent content of oil all the thirteen cultivars were categorized into three groups as low (0.5 - 0.23), medium (0.23 - 0.42) and high (0.42 - 0.60). The cultivars viz. 'Tellaku of Utukur', 'Tellaku of Chennur', 'Tellaku of Ponnur', 'Bangla', 'Karapaku', 'Pachai Kodi' and 'Kariele' were grouped under low category while the cultivars 'Gachipan', 'Kakair', 'Meetha cum Bangla' and 'Maghai' under medium category. The cultivars namely 'Godi Bangla' and 'Meetha Calcutta' were grouped under high essential oil content (Table 13).

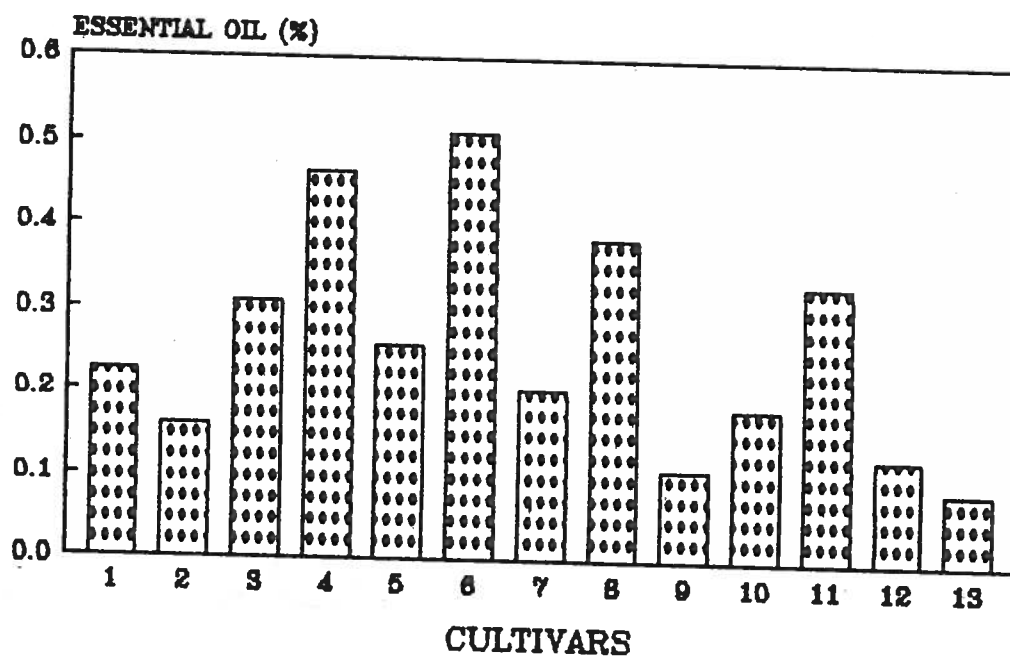
4.5.2 Chemical Constituents in the Essential Oil

4.5.2.1 Eugenol: The chemical constituent eugenol per cent was recorded maximum (57.39) in the cultivar 'Karapaku' followed by

Table 12 Essential oil (%) & its constituents (%) and means of total Chlorophyll (mg g^{-1}) amo
thirteen cultivars of Betelvine

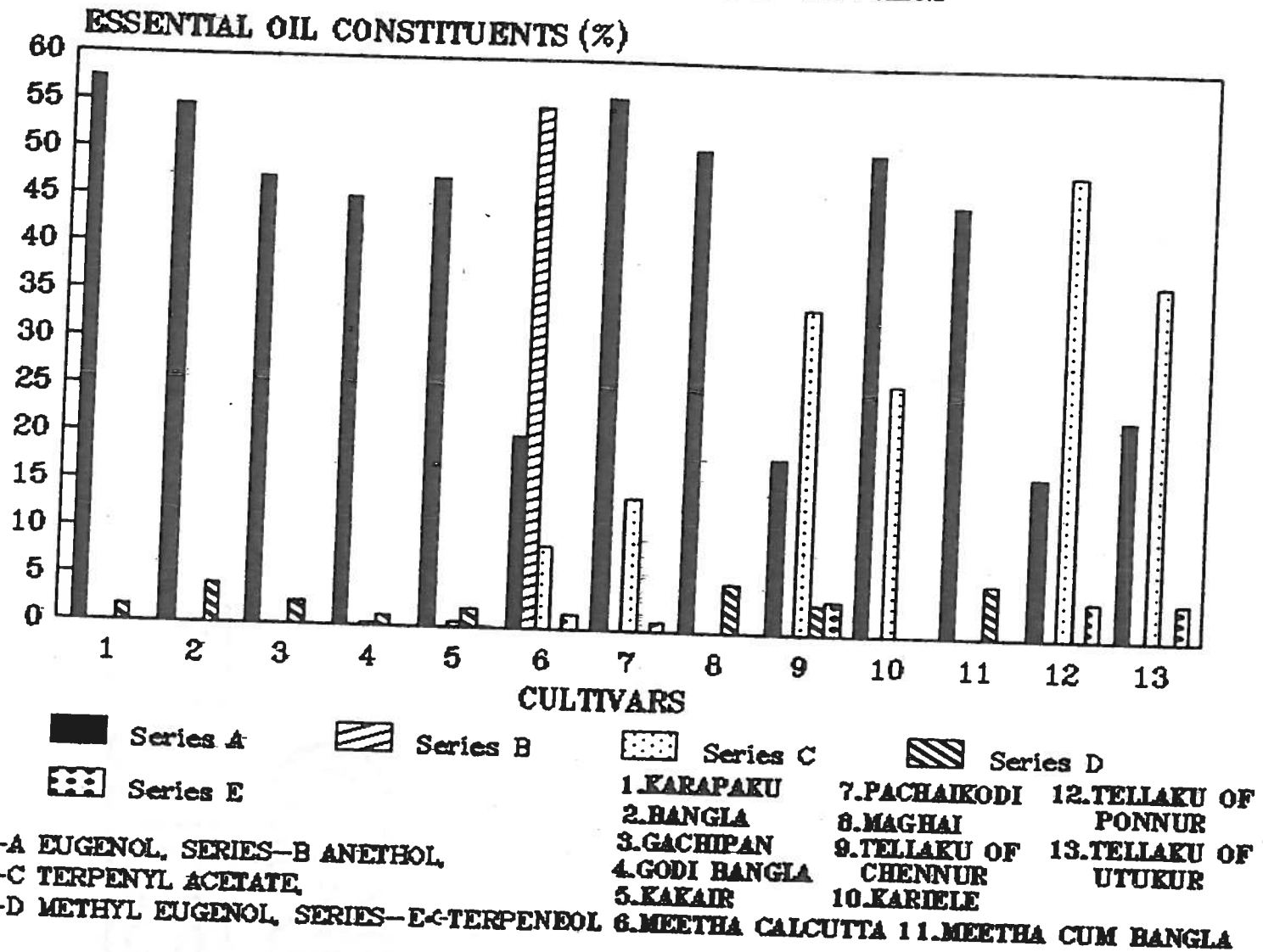
Cultivars	Essential oil (%)	ESSENTIAL OIL CONSTITUENTS (%)					Total chlorophy (mg g^{-1})
		Eugenol	Anethol	Terpenyl acetate	Methyl eugenol	α -terpineol	
1. Karapaku	0.228	57.39	-	-	1.75	-	2.31
2. Bangla	0.16	54.66	-	-	4.13	-	2.30
3. Gachipan	0.308	47.13	-	-	2.39	-	1.95
4. Godi Bangla	0.465	45.18	-	0.23 (traces)	1.20	0.074 (Traces)	1.96
5. Kakair	0.260	47.20	-	0.54 (traces)	2.01	0.11 (traces)	1.68
6. Meetha Cal- cutta	0.512	20.27	54.93	8.73	-	1.63	1.80
7. Pachai Kodi	0.205	56.09	-	14.02	-	1.04	3.02
8. Maghai	0.386	50.77	-	-	5.11	-	2.35
9. Tellaku of Chennur	0.11	18.42	-	34.21	3.1	3.61	1.32
10. Kariela	0.183	50.89	-	26.39	-	-	2.83
11. Meetha cum Bangla	0.333	45.33	-	-	5.53	-	2.20
12. Tellaku of Ponnur	0.126	17.00	-	48.76	-	4.08	1.20
13. Tellaku of Utukur	0.086	23.16	-	37.43	-	3.99	1.03
SEm							
SEd							0.07
CD at 5%							0.10
							0.21

FIG 3: PER CENT ESSENTIAL OIL OF
BETELVINE CULTIVARS



1. KARAPAKU	4. GODI HANGLA	7. PACHANKODI	10. KANDELE	13. TELLAKU OF UTUKUR
2. HANGLA	5. KAKAIR	8. MAGHAI	11. MEETHA CUM HANGLA	
3. GACHIPAN	6. MEETHA CALCUTTA	9. TELLAKU OF CHENNU	12. TELLAKU OF PORNUR	

FIG4: PER CENT ESSENTIAL OIL CONSTITUENTS
OF BETELVINE CULTIVARS



the cultivar 'Pachai Kodi' (56.09) and 'Bangla' (54.66) while minimum (17.0) was recorded in the cultivar 'Tellaku of Ponnur'.

Based on the eugenol content, the thirteen cultivars were categorized into three groups as low (15-30), medium (30-45) and high (45-60). The cultivars viz. 'Tellaku of Ponnur', 'Tellaku of Chennur', 'Tellaku of Utukur' and 'Meetha Calcutta' were grouped under low category while no cultivar was grouped in medium category. The cultivars viz. 'Meetha cum Bangla', 'Godi Bangla', 'Gachipan', 'Kakair', 'Maghai', 'Kariele', 'Bangla', 'Pachai Kodi' and 'Karapaku' were grouped under high eugenol content (Table 13).

4.5.2.2 Anethol: The cultivar 'Meetha Calcutta' alone recorded 54.93 per cent anethol while the remaining cultivars did not show anethol content.

4.5.2.3 Terpenyl Acetate: The other essential oil constituent, terpenyl acetate per cent was found to be maximum (48.76) in 'Tellaku of Ponnur' followed by the cultivars 'Tellaku of Utukur' (37.43) and 'Tellaku of Chennur' (34.21) while minimum was recorded in 'Meetha Calcutta' (8.73). Traces of terpenyl acetate was observed in 'Godi Bangla' (0.23) and Kakair (0.54). Terpenyl acetate was not recorded in the rest of the cultivars namely 'Karapaku', 'Bangla', 'Gachipan', 'Maghai' and 'Meetha cum Bangla'.

Based on the per cent content of terpenyl acetate, the thirteen cultivars were grouped into three categories. Low category (0.0 - 16.55) included the cultivars 'Meetha Calcutta',

TABLE 13 CATALOGUING OF BETELVINE CULTIVARS BASED ON ESSENTIAL OIL, EUGENOL, TERPENYL ACETATE AND CHLOROPHYLL CONTENT

ESSENTIAL OIL (%)			TOTAL CHLOROPHYLL (mg g ⁻¹)			EUGENOL (%)			TERPENYL ACETATE (%)		
Low (0.05-0.23)	Medium (0.23-0.42)	High (0.42-0.6)	Low (0.0 - 1.32)	Medium (1.32-2.68)	High (2.68-4.0)	Low (15.0-30.0)	Medium (30.0-45.0)	High (45.0-60.0)	Low (0.0-16.5)	Medium (16.5-33.50)	High (33.50-)
Tellaku of Utukur	Gachipan	Godi Bangla	Tellaku of Chennur	Karapaku	Pachai Kodi	Tellaku of Ponnur	-	Meetha cum Bangla	Meetha	Kariele	Tellaku Chennu
Tellaku of Chennur	Kakair	Meetha	Tellaku of Ponnur	Bangla	Kariele	Tellaku of Chennur		Godi Bangla	Calcutta		Tellaku Ponnur
Tellaku of Ponnur	Meetha cum Bangla	Calcutta	Tellaku of Utukur	Gachipan		Tellaku of Utukur		Pachai Kodi	Karapaku		Tellaku Utukur
Bangla	Maghai			Godi Bangla		Meetha		Gachipan	Bangla		
Karapaku				Kakair		Calcutta		Kakair	Gachipan		
Pachai Kodi				Meetha				Maghai	Godi Bangla		
Kariele				Calcutta				Kariele	Kakair		
				Maghai				Bangla	Maghai		
				Meetha cum Bangla				Pachai Kodi	Meetha cum Bangla		
								Karapaku			

'Pachai Kodi', 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Maghai' and 'Meetha cum Bangla'. While the medium category (16.55 - 33.50) included the cultivar 'Kariele', the high category (33.5 - 50.0) contains the remaining cultivars namely 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' (Table 13).

4.5.2.4 Methyl eugenol: The per cent content of methyl eugenol was the highest in 'Meetha cum Bangla' (5.53) followed by 'Maghai' (5.11) and lowest in 'Godi Bangla' (1.20). The cultivars that did not show methyl eugenol were 'Meetha Calcutta', 'Pachai Kodi', 'Kariele', 'Tellaku of Ponnur' and 'Tellaku of Utukur'.

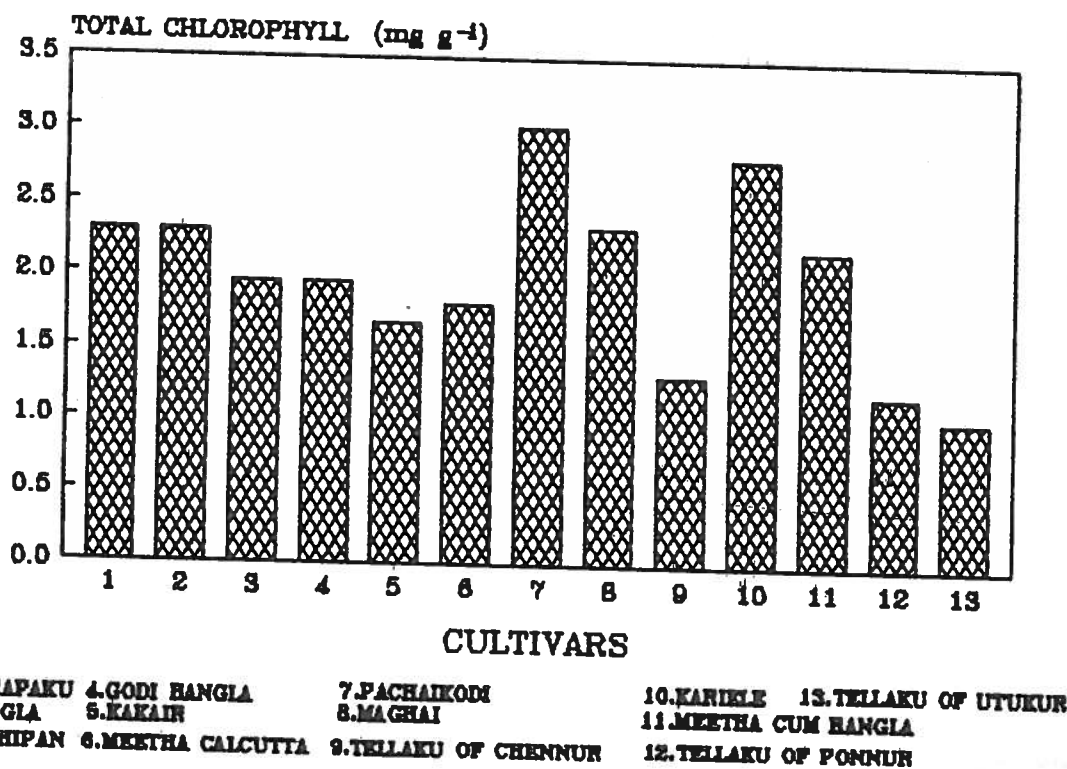
4.5.2.5 α -Terpineol: α -Terpineol was not found in 'Karapaku', 'Bangla', 'Gachipan', 'Maghai', 'Meetha cum Bangla' and 'Kariele' while it was maximum (4.08) in Tellaku of Ponnur, minimum (1.04) in 'Pachai Kodi' and traces were recorded in 'Godi Bangla' and 'Kakair'.

4.5.3 Total Chlorophyll (mg g^{-1})

The data on total chlorophyll content of all the thirteen cultivars are given in Table 12 and Figure 5.

From the statistical analysis, it was observed that highly significant differences were observed among the cultivars. The cultivar 'Pachai Kodi' recorded maximum total chlorophyll content (3.02) followed by 'Kariele' (2.83). Minimum total chlorophyll content (1.03) was found in 'Tellaku of Utukur' followed by 'Tellaku of Ponnur' (1.20) and Tellaku of Chennur (1.32).

FIG 5: TOTAL CHLOROPHYLL OF BETELVINE CULTIVARS.



Based on the total chlorophyll content, all the thirteen cultivars were grouped as low (0.0 - 1.32), medium (1.32 - 2.68) and high (2.68 - 4.0). The cultivars viz. 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' were grouped under low group while the cultivars viz. 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Meetha Calcutta', 'Maghai' and 'Meetha cum Bangla' under medium group and the cultivars 'Pachai Kodi' and 'Kariele' under high total chlorophyll content group (Table 13).

4.6 YIELD PARAMETERS

4.6.1 Number of leaves per vine

Data pertaining to number of leaves per vine of all the thirteen cultivars are given in Table 14 and Figure 6.

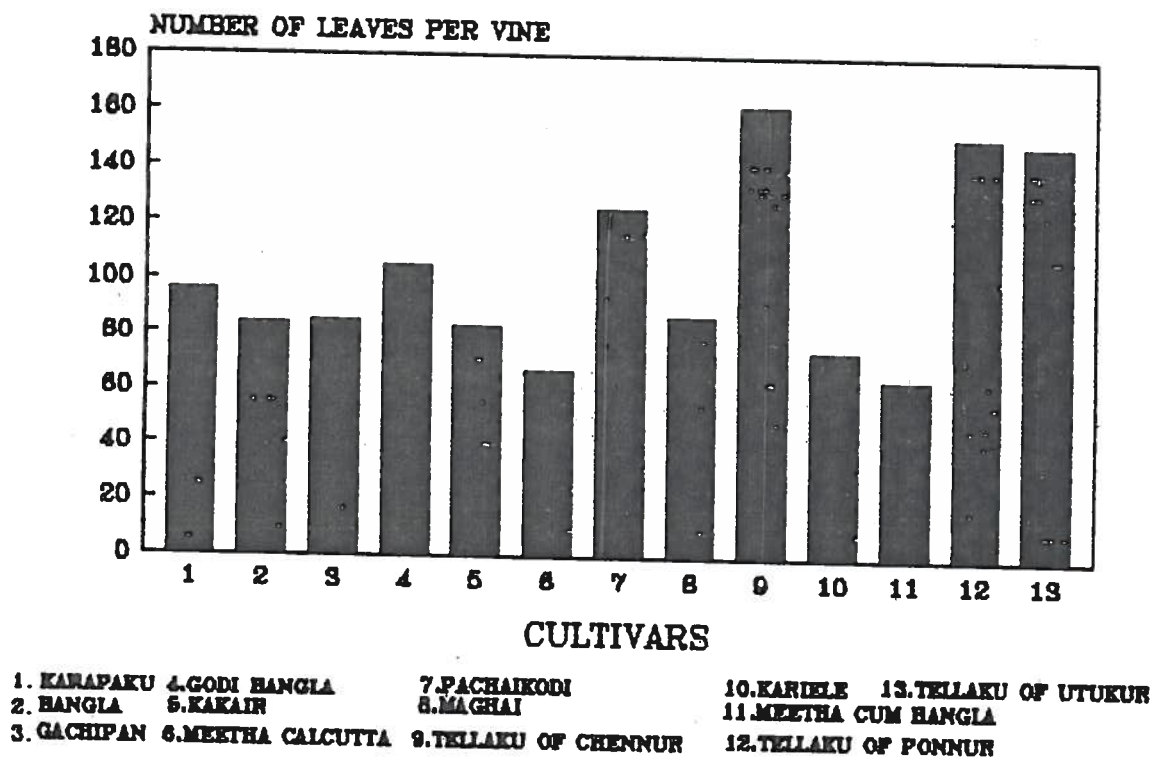
Statistically significant differences were recorded among the thirteen cultivars. Maximum number of leaves per vine (162.0) was recorded by cultivar 'Tellaku of Chennur' followed by 'Tellaku of Ponnur' (152.0) and 'Tellaku of Utukur' (149.0). Minimum (64.00) number of leaves per vine was recorded by the cultivar 'Meetha cum Bangla'.

Based on number of leaves per vine, all the thirteen cultivars were categorized into three groups as low (60-96), medium (96-134) and high (134-170). The cultivars observed under low category were 'Meetha Calcutta', 'Kariele', 'Meetha cum Bangla', 'Kakair', 'Gachipan', 'Bangla' and 'Maghai'.

Table 14 Means of number of leaves per vine and weight of leaves per vine among thirteen cultivars of Betelvine

Cultivars	Number of leaves/vine	Weight of leaves/vine (g)
1. Karapaku	96.67	173.05
2. Bangla	84.00	124.65
3. Gachipan	85.67	202.51
4. Gadi Bangla	105.00	198.97
5. Kakair	83.00	95.74
6. Meetha Calcutta	67.33	71.10
7. Pachai Kodi	125.33	135.26
8. Maghai	86.67	67.80
9. Tellaku of Chennur	162.00	240.72
10. Karielle	74.33	135.71
11. Meetha cum Bangla	64.00	65.69
12. Tellaku of Ponnur	152.00	250.56
13. Tellaku of Utukur	149.00	200.88
SEm	6.52	28.84
SEd	9.21	40.78
CD at 5%	19.02	84.18

**FIG 6: NUMBER OF LEAVES PER VINE OF
BETELVINE CULTIVARS**



Medium category included 'Karapaku', 'Godi Bangla' and 'Pachai Kodi' cultivars while high category included 'Tellaku of Utukur', 'Tellaku of Ponnur' and 'Tellaku of Chennur' cultivars (Table 15).

4.6.2 Weight of leaves per vine

The data on weight of leaves per vine of all the thirteen cultivars are given in Table 14 and Figure 7.

Statistically it was observed that there were significant differences among the thirteen cultivars. The cultivar 'Tellaku of Ponnur' has recorded maximum (250.56 g) in respect of weight of leaves per vine followed by Tellaku of Chennur (240.72 g) and 'Tellaku of Utukur' (200.88 g). 'Meetha cum Bangla' recorded the minimum value (65.69 g) followed by 'Maghai' (67.80 g).

Based on the weight of leaves per vine, all the thirteen cultivars were categorized into three groups. The group low weight of leaves per vine (50-125 g) included 'Meetha cum Bangla', 'Meetha Calcutta', 'Maghai', 'Bangla' and 'Kakair'. The cultivars 'Pachai Kodi', 'Kariele', 'Godi Bangla' and 'Karapaku' were grouped under medium (125-200 g) group. The cultivars 'Gachipan', 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' were grouped under high (200-275 g) weight of leaves per vine (Table 15).

4.7 GENETIC VARIABILITY

The estimation of coefficient of variation for both genotype and phenotype, heritability and genetic advance for the characters of morphological, physiological, growth analysis,

**FIG 7: WEIGHT OF LEAVES PER VINE OF
BETELVINE CULTIVARS.**

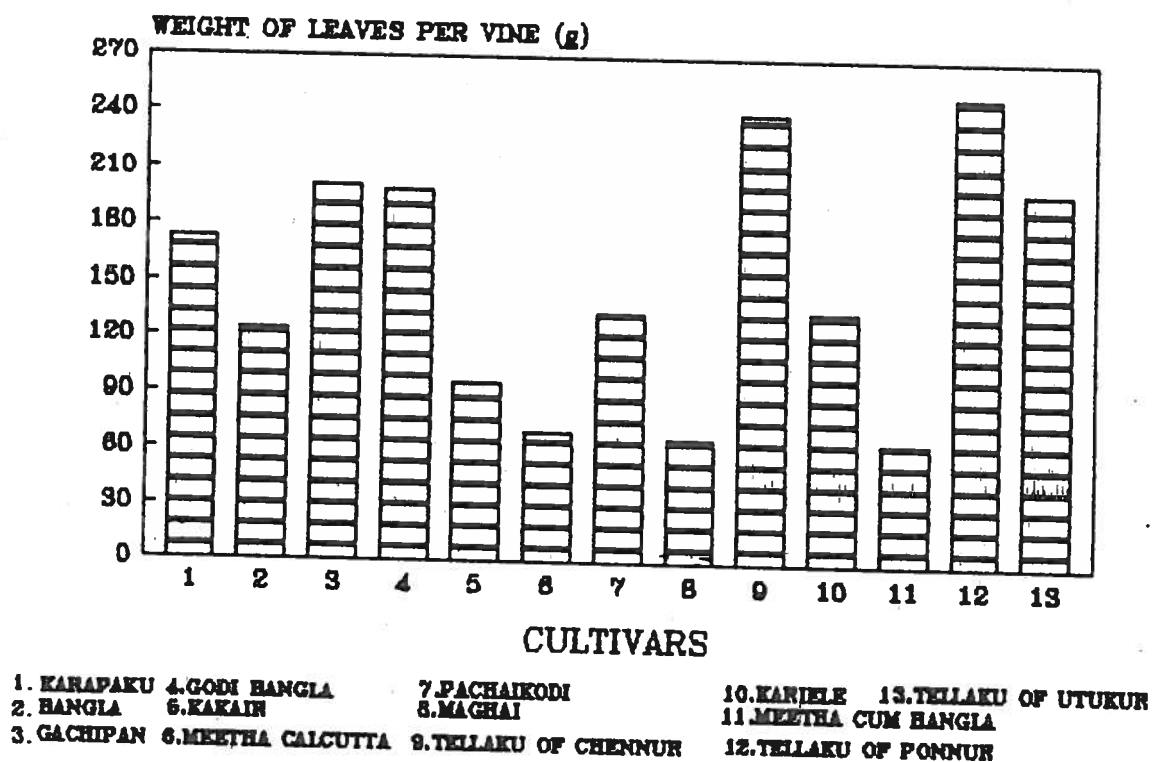


TABLE 15 CATALOGUING OF BETELVINE CULTIVARS BASED ON NUMBER OF LEAVES PER VINE AND WEIGHT OF LEAVES PER VINE

NUMBER OF LEAVES PER VINE			WEIGHT OF LEAVES PER VINE (g)		
Low (60 - 90)	Medium (96-134)	High (134 - 170)	Low (50 - 125)	Medium (125 - 200)	High (200 - 275)
Meetha Calcutta	Karapaku	Tellaku of Utukur	Meetha cum Bangla	Pachai Kodi	Gachipan
Kariele	Godi Bangla	Tellaku of Ponnur	Meetha Calcutta	Kariele	Tellaku of Utukur
Meetha cum Bangla	Pachai Kodi	Tellaku of Chennur	Maghai	Godi Bangla	Tellaku of Ponnur
Kakair			Bangla	Karapaku	Tellaku of Chennur
Gachipan			Kakair		
Bangla					
Maghai					

total chlorophyll and yield parameters for different cultivars of betelvine are presented in Table 16.

4.7.1 Morphological characters

4.7.1 Leaf Area: This trait recorded high heritability estimate of 0.853 coupled with moderate genetic advance of 31.24. The coefficient of variation for genotype and phenotype were 29.57 and 32.01 respectively.

4.7.1.2 Petiole length: This trait recorded low heritability estimate (0.290) with low genetic advance (0.38). The phenotypic coefficient of variation and genotypic coefficient of variation recorded were 11.26 and 6.06 respectively.

4.7.1.3 Internodal Length: In this trait, the length of the internodes recorded high heritability estimate of 0.738 with low genetic advance of 1.13. The coefficient of variation for phenotype and genotype were 12.59 and 10.87 respectively.

4.7.1.4 Number of branches per plant: The phenotypic and genotypic coefficients of variation recorded for this trait were 134.38 and 129.39 respectively. High heritability estimate (0.927) and low genetic advance (6.92) were recorded for this character.

4.7.2 Growth Analysis Characters

4.7.2.1 R-value: The coefficient of variation for phenotype and genotype were 4.25 and 3.72 respectively. This trait recorded high heritability estimate of 0.764 with low genetic advance of 0.10.

Table 16 Estimates of Genetic components of variation for different characters in Betelvine Cultivars

Character	GCV (%)	PCV (%)	h^2 (b)	GA
I. MORPHOLOGICAL CHARACTERS				
1. Leaf area	29.57	32.01	0.85	31.24
2. Petiole length	6.06	11.26	0.29	0.38
3. Internodal length	10.87	12.59	0.738	1.13
4. Number of branches per plant	129.00	134.00	0.927	6.92
II. GROWTH ANALYSIS PARAMETERS				
1. R-value	3.72	4.25	0.764	0.10
2. Specific leaf weight	10.54	23.39	0.203	0.0005
III. PHYSIOLOGICAL CHARACTERS				
1. Stomatal size : Length	12.52	13.04	0.922	6.70
Width	14.40	18.98	0.576	4.42
2. Stomatal frequency	11.60	15.09	0.591	30.03
3. Stomatal Index	7.68	9.44	0.662	1.79
4. Palisade Ratio	11.17	12.39	0.872	1.38
5. Veinlet termination number	25.00	26.48	0.891	4.57
IV. Total Chlorophyll Content	29.67	30.30	0.959	1.19
V. YIELD PARAMETERS				
1. Number of leaves per vine	32.02	33.85	0.895	64.19
2. Weight of leaves per vine	38.53	50.78	0.576	91.13

4.7.2.2 Specific Leaf Weight: The phenotypic and genotypic coefficient of variation were 23.39 and 10.54 respectively. Low heritability estimate (0.203) was observed in this trait with very low genetic advance (0.0005).

4.7.3 Physiological characters

4.7.3.1 Stomatal Size (μm): The length of the stomata recorded high heritability estimate (0.922) with low genetic advance (6.70). The coefficient of variation for phenotype and genotype were 13.04 and 12.52 respectively.

The width of the stomata recorded moderate heritability estimate (0.576) with low genetic advance (4.42). The phenotypic and genotypic coefficient of variation were 18.98 and 14.40 respectively.

4.7.3.2 Stomatal frequency: The coefficient of variation was 15.09 for phenotype and 11.60 for genotype. This trait recorded moderate heritability estimate of 0.591 coupled with moderate genetic advance (30.03).

4.7.3.3 Stomatal Index: This trait recorded 9.44 as phenotypic coefficient of variation and 7.68 as genotypic coefficient of variation. Moderate heritability estimate of 0.662 with low genetic advance of 1.80 were recorded for this trait.

4.7.3.4 Palisade Ratio: The coefficient of variation for phenotype and genotype were 12.39 and 11.17 respectively. This trait recorded high heritability estimate of 0.872 coupled with low genetic advance (1.38).

4.7.3.5 Veinlet Termination Number: The genotypic and phenotypic coefficient of variation were 25.00 and 26.48 respectively. It recorded high heritability estimate of 0.891 coupled with low genetic advance (4.57).

4.7.4 Total chlorophyll content

This trait recorded high heritability estimate of 0.959 with low genetic advance of 1.20. The phenotypic and genotypic coefficients of variation recorded for this trait were 30.30 and 29.67 respectively.

4.7.5 Yield Parameters

4.7.5.1 Number of leaves per vine: This trait recorded high heritability estimate of 0.895 coupled with high genetic advance (64.19). The coefficient of variation for phenotype and genotype were 33.85 and 32.02 respectively.

4.7.5.2 Weight of leaves per vine: This trait recorded moderate heritability estimate of 0.576 coupled with very high genetic advance (91.13). The phenotypic and genotypic coefficient of variation were 50.78 and 38.53 respectively.

DISCUSSION

The main objective of the present study is to categorize the existing cultivars of Piper betel L. and to describe the different cultivars which are commercially important. So that these cultivars could be used as foundation material for the improvement programme of betelvine. The first step in the improvement of betelvine is necessarily the study and identification of different cultivars based on morphological, physiological and chemical characteristics. Such a study will remove a great deal of confusion in the nomenclature of betelvine cultivars existing in the State. Further the improvement of any crop depends upon the presence of variation in the germplasm and its utilization in the breeding programme. Larger genetic variability in the initial breeding material ensures better chances of producing new desired forms of a crop plant. Therefore, estimates of genotypic and phenotypic coefficient of variation together with the heritability estimates would give the best picture of the amount of advance to be expected from selection.

In this context, about twenty eight cultivars from different commercial betelvine growing regions of the country were introduced in the experimental conservatory of Agricultural Research Station, Chintalapudi and grown under uniform cultural conditions. Of these thirteen cultivars representing different groups from varied ecological zones were selected for detailed study.

5.1 MORPHOLOGICAL CHARACTERS

Morphological characters of leaf are important for the identification of different cultivars. It is more relevant in case of betelvine as the leaf is the only part used for the commercial purpose.

Observations on morphological characters viz. leaf size, leaf shape, leaf tip, margin of lamina, leaf colour, leaf texture, size and colour of internodes, petiole length, leaf area, venation and branching habit have been used as a basis for categorization of the thirteen cultivars under study into four distinguishable groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori'. The cultivars under each group having some diagnostic features in common, were described.

'Bangla' Group

The cultivars studied under this group are 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Maghai' and 'Meetha cum Bangla'. The leaves of all the seven cultivars have cordate to roundish shape with acuminate leaf tip and margin of lamina is entire with prominent basal lobes. Lamina has palmately reticulate venation with 4 to 6 prominent secondary veins spreading in a curved manner. Petiole length ranges between 5.06 to 6.95 cm. The length of internodes ranged between 4.81 to 6.95 cm with green to pinkish green colour. Leaf colour was light to dark green with coriaceous texture. Branching habit was moderate.

Although these seven cultivars were grouped in 'Bangla' category, some heterogeny was observed amongst these cultivars especially in size of the leaf and branching habit. The cultivars 'Karapaku', 'Godi Bangla' and 'Gachipan' have big size leaf with moderate branching habit. The cultivar 'Bangla' have also moderate branching habit with medium size leaf. The cultivars 'Kakair', 'Maghai' and 'Meetha cum Bangla' have small size leaf with no branching habit. This confirms the existance of some diversity within 'Bangla' group as reported by Ganguly and Gupta (1974 a).

'Meetha' Group

This group was represented by a lone member namely 'Meetha Calcutta'. The leaves are small, cordate to roundish shape, acute leaf tip. The basal lobes are less conspicuous than that of 'Bangla' and 'Sanchi' groups. The margin of lamina is entire usually but some times lower portion is undulate. The leaf texture is coriaceous and leaf colour is dark green with characteristic yellowish spots. Leaf lamina has palmately reticulate venation with prominent 4 to 6 secondary veins. Petiole length was 5.72 cm and internodal length was 5.53 cm with green colour. Low branching habit was observed.

The characteristic taste, yellowish spots on the leaf differentiate this cultivar from the rest of the cultivars.

'Sanchi' Group

This group included two cultivars viz. 'Pachai Kodi' and 'Kariele'. The leaves are small, broadly ovate with long

tapering attenuate leaf tips. The base is lobed but the lobes are less prominent than that of 'Bangla' group. Leaf margin is entire. The venation being palmately reticulate with 6 to 8 prominent divergent secondary veins. Internodal colour is pinkish green and length ranged between 6.06 to 6.39 cm. Petiole length ranged between 5.46 to 5.71 cm. The leaves are dark green in colour and texture is coriaceous. No branching habit was observed.

The above morphological features characterize these two cultivars and justify their placement in 'Sanchi' group.

'Kapoori' Group

The types studied under this group were 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur'. Observations showed that all the three cultivars have narrow ovate leaves. The margin of lamina is entire. Sometimes the basal portion of marginal lamina is undulate. The leaf apices are acuminate and the leaf bases not lobed as in 'Bangla' and 'Sanchi' groups.

Leaves have a prominent midrib with 4 to 6 secondary veins which run nearly parallel to the midrib and not curved as in other groups. Venation is palmately reticulate. Petiole length ranges between 5.44 to 5.91 cm and internodal length ranges between 5.81 to 6.88 cm with green colour internodes. The leaf colour is yellowish green to light green colour and texture is membranous. Heavy branching habit was observed.

Observations of these thirteen types clearly enabled to put them into four distinguishable groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori'. The cultivars within the group showed almost similar morphological characters (Table 17). Similar results on morphological characters were reported by Rawat (1985) recognized 'Bangla', 'Desawari', 'Kapoori', 'Meetha' and 'Sanchi' groups. Ganguly and Gupta (1973 & 1974) and Ganguly (1984) also recognized 'Bangla', 'Sanchi' and 'Meetha' cultivars from West Bengal market on the basis of morphological characters of the leaf.

5.2 GROWTH ANALYSIS PARAMETERS.

Based on growth analysis parameter R-value which indicate the leaf shape, the thirteen cultivars were categorized into four groups. In 'Bangla' group the R-value ranged in between 1.41 to 1.44 (cordate to roundish leaf shape) while in 'Meetha' group 1.46 (cordate to roundish) and in 'Sanchi' group ranged in between 1.54 to 1.56 (broadly ovate leaf shape). In 'Kapoori' group it ranged between 1.50 to 1.54 (narrowly ovate).

Other growth analysis parameter like specific leaf weight did not help in categorization of the thirteen cultivars since the differences were statistically non-significant.

5.3 PHYSIOLOGICAL PARAMETERS

Presently the leaf epidermal and micrometrical characters viz. stomatal size and frequency, stomatal index, palisade ratio

Table 17 General Morphology of Four Distinct Groups of Betelvine

Character	BANGLA	MEETHA	SANCHI	KAPOORI
Leaf size	Small to large	Small	Small	Medium
Leaf shape	Cordate to roundish, basal lobes most prominent	Cordate to roundish, basal lobes less prominent	Broadly ovate, basal lobes less conspicuous than Bangla	Narrowly ovate, basal lobes not well developed
Leaf tip	Acuminate	Acute	Attenuate	Acuminate
Leaf texture	Coriaceous	Coriaceous	Coriaceous	Membranous
Margin of lamina	Entire	Entire, sometimes lower portion is undulate	Entire	Basal portion is undulate
Leaf colour	Light to dark green	Dark green with characteristic yellowish spots	Dark green	Yellowish green to light green
Venation	Palmately reticulate, with 4-6 secondary veins, curved	Palmately reticulate, 4-6 secondary veins, curved	Palmately reticulate, 6-8 secondary veins, prominent and curved	Palmately reticulate, 4-6 secondary veins parallel to mid-rib

and veinlet termination number of thirteen cultivars of betelvine have been studied to use them as a tool for identification of different cultivars.

Microscopic study of epidermal surface of four distinct groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori' has been performed and it was found that the stomata were absent in upper epidermis and were present in lower epidermis. In respect of all the above parameters, the cultivars differed widely. The ranges of stomatal size (22.20×14.8 to 31.08×23.68 μm), stomatal frequency (128.79 to 197.55 mm^{-2}) stomatal indices (12.44 to 15.02), palisade ratio (4.97 to 7.85) and veinlet termination number (5.70 to 13.27 mm^{-2}) indicated wide divergence of the cultivars with respect to each parameter studied.

These studies eventhough found valuable in identifying different genera or species (Wallis and Dewar, 1953; Hall and Melville, 1954 and Paliwal and Harjal, 1975) could not be used in the present study as the results obtained were overlapping and failed to provide any diagnostic information.

The results of the present studies are supported by Ganguly and Gupta (1973) who concluded that the twelve types of 'Bangla' cultivar of West Bengal could not be distinguished on the basis of such studies and their data also showed wide range and overlapping values for different parameters.

Das and Chattopadhyay (1984) in his studies of 17 cultivars of Midnapur district of West Bengal also stated that epidermal micrometrical characters were not reliable tool in identification of cultivars, thus supporting the present findings.

5.4 ORGANOLEPTIC STUDIES

Organoleptic evaluation of betelvine leaves in terms of pungency, flavour and fibre were also useful in identification and categorization of the cultivars under study into four distinct groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori' (Table 18). The leaves of the seven cultivars of 'Bangla' group were observed to be pungent, aromatic and fibrous while the leaves of two cultivars of 'Sanchi' group were highly pungent, aromatic and fibrous. This is contrary to the findings of Rawat (1985) which may be attributed to the sensitivity of the 'Bangla' and 'Sanchi' groups due to change in agro-climatic conditions of the tract. The leaves of 'Meetha' group were observed to be least pungent with characteristic fennel like aroma, sweet palatable taste and less fibrous while the leaves of three types of Kapoori group were least pungent with mild flavour and fibrous leaves. This is in agreement with the results reported by Rawat (1985).

5.5 CHEMICAL CHARACTERISTICS

In the present study, gas liquid chromatography of essential oils, its constituents and chlorophyll content gave consistent and reliable results for the categorization of

betelvine cultivars (Table 18). Such type of studies have been carried out by Rawat et al. (1985 & 1989).

The leaves of thirteen cultivars belonging to four groups, when hydrodistilled, yielded essential oil of light to dark yellow colour. The oils were aromatic, sweet, pleasant to sharp pungentⁱⁿ taste. The percentage of essential oil of leaves of different cultivars varied from 0.086 to 0.512 on fresh weight basis. It is evident that the 'Meetha' group yielded higher percentage (0.512) followed by 'Bangla' group (0.16 to 0.465). The oil content was the least in 'Kapoori' group (0.086 to 0.126). The oils of 'Bangla', 'Sanchi' and 'Meetha' groups have higher specific gravity and were heavier than water while the oils of 'Kapoori' cultivars have lower specific gravity and were lighter than water. It was observed that heavier oils generally have clove like spicy odour and sharp pungent taste due to higher percentage of phenols present in them. The lighter oils have pleasant odour and aromatic, mild taste with terpenes as their major constituents. These results were supported by Sharma et al. (1982 & 1983).

The oils from the thirteen types were examined by gas liquid chromatography and on the basis of pattern of the recorded chromatograms pertaining to number and size of peaks. These cultivars were categorized into four groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori'. Similarly Rawat (1985) also classified 19 cultivars into five groups viz. 'Bangla', 'Desawari', 'Sanchi', 'Meetha' and 'Kapoori' based on gas liquid chromatographic studies.

Table 18 Organoleptic evaluation and chemical characteristics of four distinct groups of Betelvine

Character	BANGLA	MEETHA	SANCHI	KAPOORI
1. <u>Organoleptic evaluation</u> (Taste & aroma)	Pungent, aromatic and fibrous	Least pungent, sweet palatable taste with characteristic fennel like aroma, less fibrous	Highly pungent, aromatic and fibrous	Least pungent, mildly flavoured and less fibrous
2. <u>Chemical characteristics</u>				
Essential oil (%)	0.16 to 0.465	0.512	0.183 to 0.205	0.086 to 0.126
Eugenol (%)	45.18 to 57.39	20.27	50.89 to 56.09	17.00 to 23.16
Anethol (%)	-	54.93	-	-
Terpenyl acetate (%)	0.23 to 0.54 (traces)	8.73	14.02 to 26.39	34.21 to 48.76
Total chlorophyll content (mg g ⁻¹)	1.68 to 2.35	1.80	2.83 to 3.02	1.03 to 1.32

'Bangla' Group

The oil constituents of the following seven cultivars, 'Karapaku', 'Bangla', 'Gachipan', 'Godi Bangla', 'Kakair', 'Maghai' and 'Meetha cum Bangla' on close examination had the same pattern of chromatograms (Figures 8 to 14). The number of peaks and their area in all the seven cultivars were similar. Eugenol and methyl eugenol were the major constituents identified in all the seven cultivars. Terpenyl acetate and α -terpineol were observed in traces only in 'Godi Bangla' and 'Kakair' cultivars. The characteristic clove like aroma and pungency of 'Bangla' group was due to high concentration of eugenol (45.3 to 57.4%) in the oil.

'Meetha' Group

The essential oil of 'Meetha' was yellowish in colour with fennel-like odour and sweet taste due to the presence of anethol (54.93%). Other major constituents were eugenol, terpenyl acetate and α -terpineol. The chromatograph of this cultivar was quite distinct from other types studied (Fig. 15).

'Sanchi' Group

The oils of 'Pachai Kodi' and 'Kariele' were similar in taste and odour and yellowish in colour but the chromatograms recorded showed little variation in peaks on GLC examination which may be due to instrumental error (Fig. 16 & 17). High pungency of 'Sanchi' group was due to the presence of eugenol

Fig. 8. Gas Liquid Chromatograms of
Essential oil of PIPER BETEL L.
Cv. 'KARAPAKU'

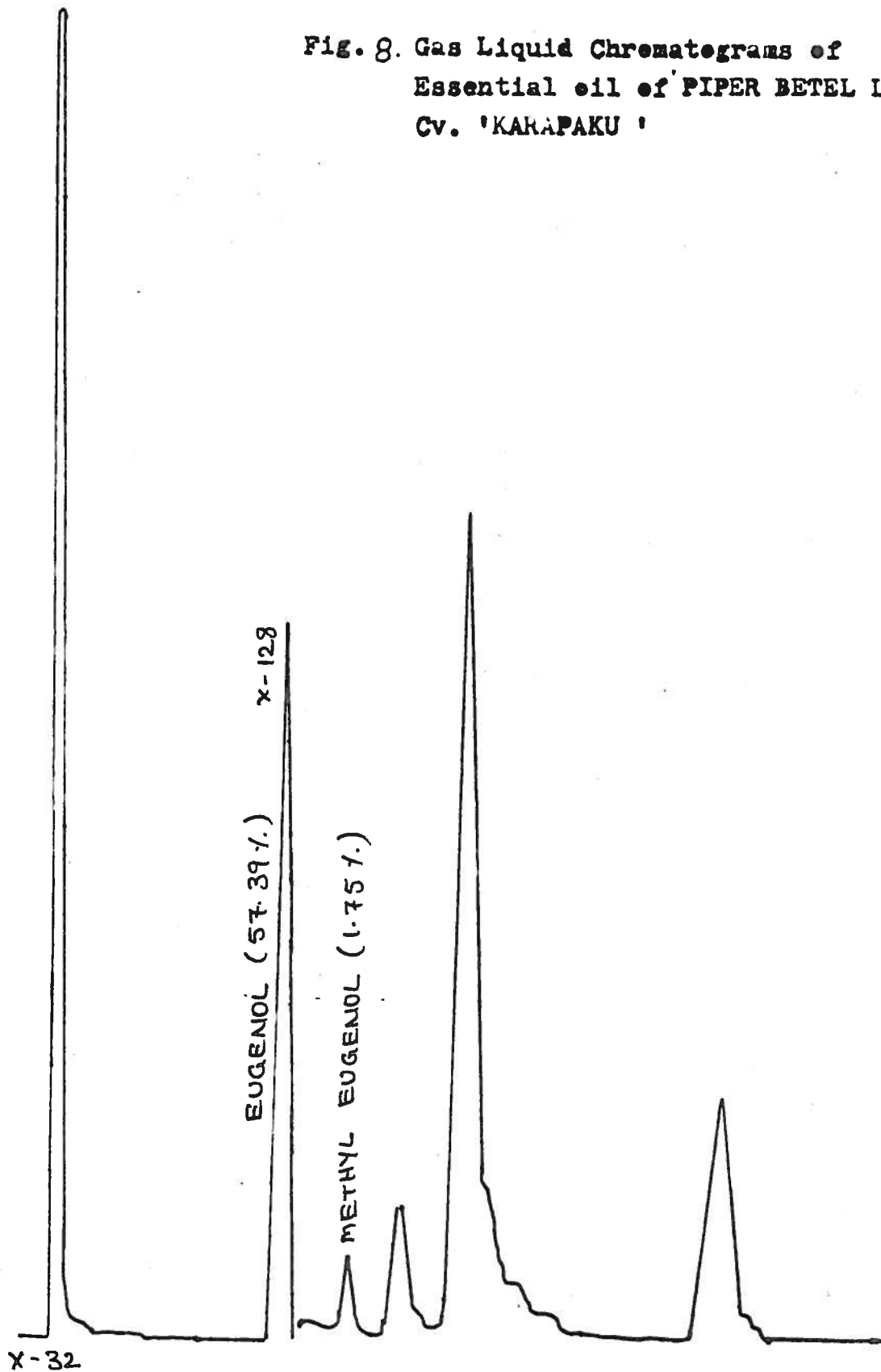


Fig. 9. Gas Liquid Chromatograms of
Essential oil of PIPER
BETEL L. Cv. 'BANGLA'

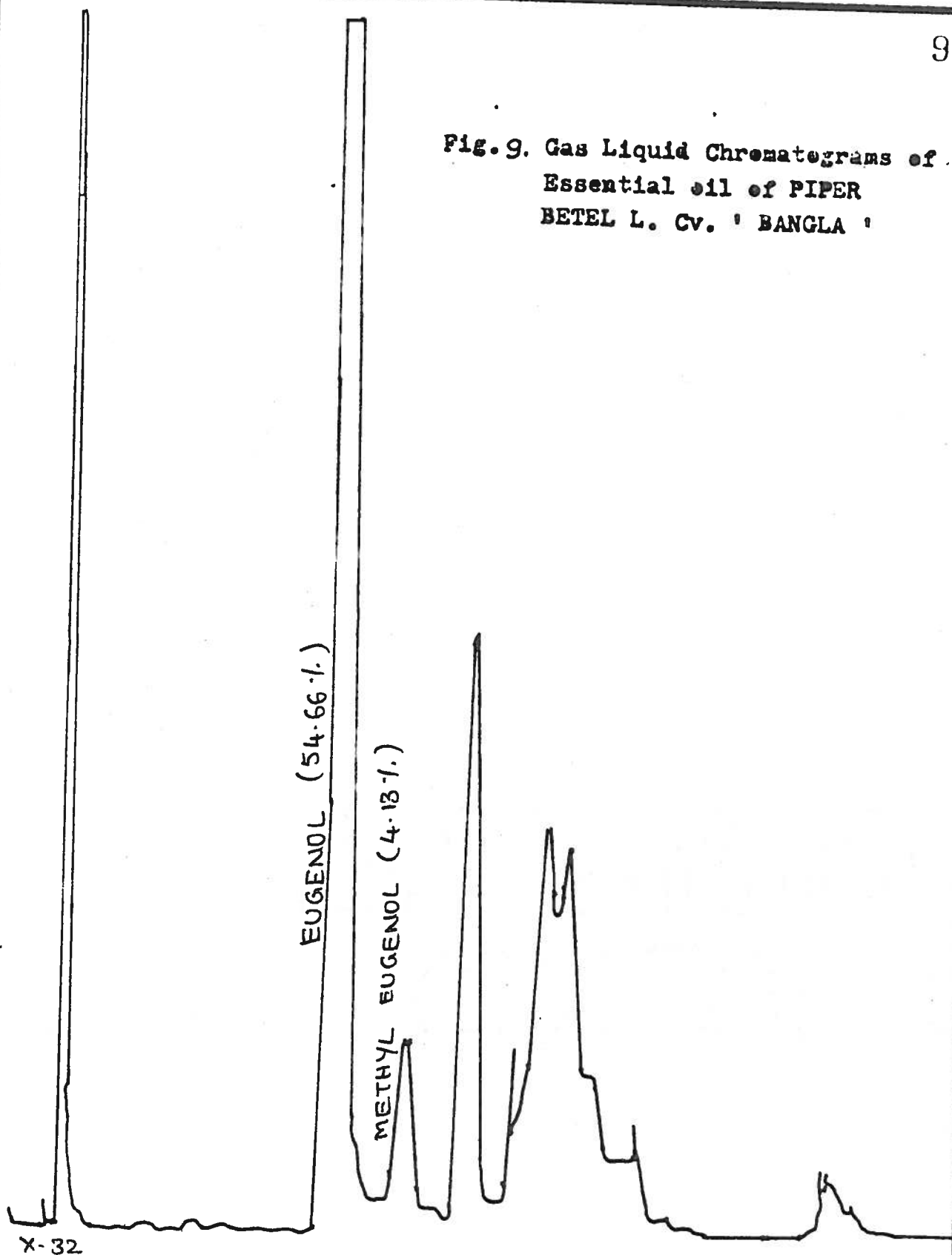


Fig. 10. Gas Liquid
Chromatograms of
Essential oil of
PIPER BETEL L.
Cv. ' GACHIPAN '

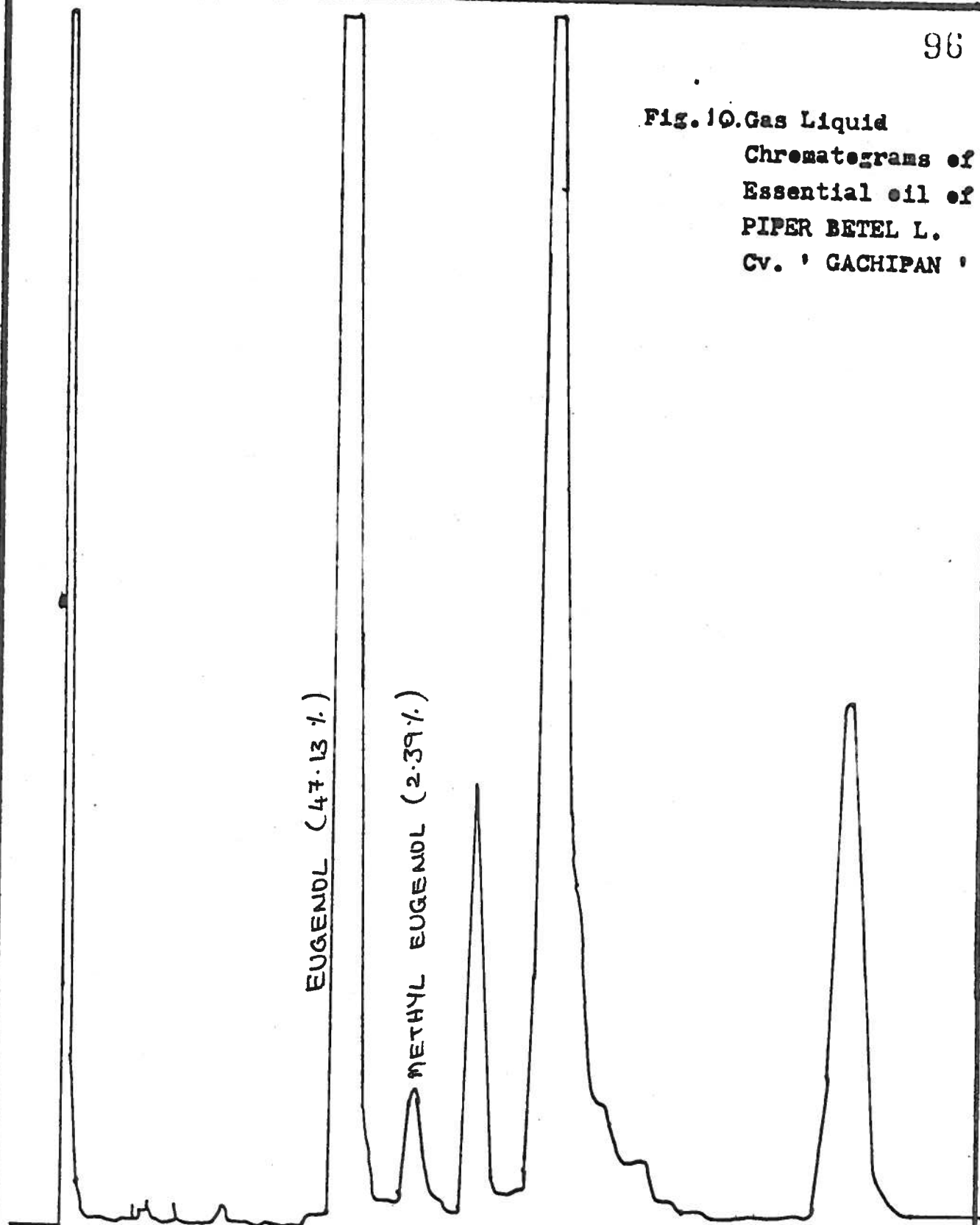


Fig. 11. Gas Liquid Chromatograms of Essential Oil of PIPER BETEL L. Cv. 'GODI BANGLA'

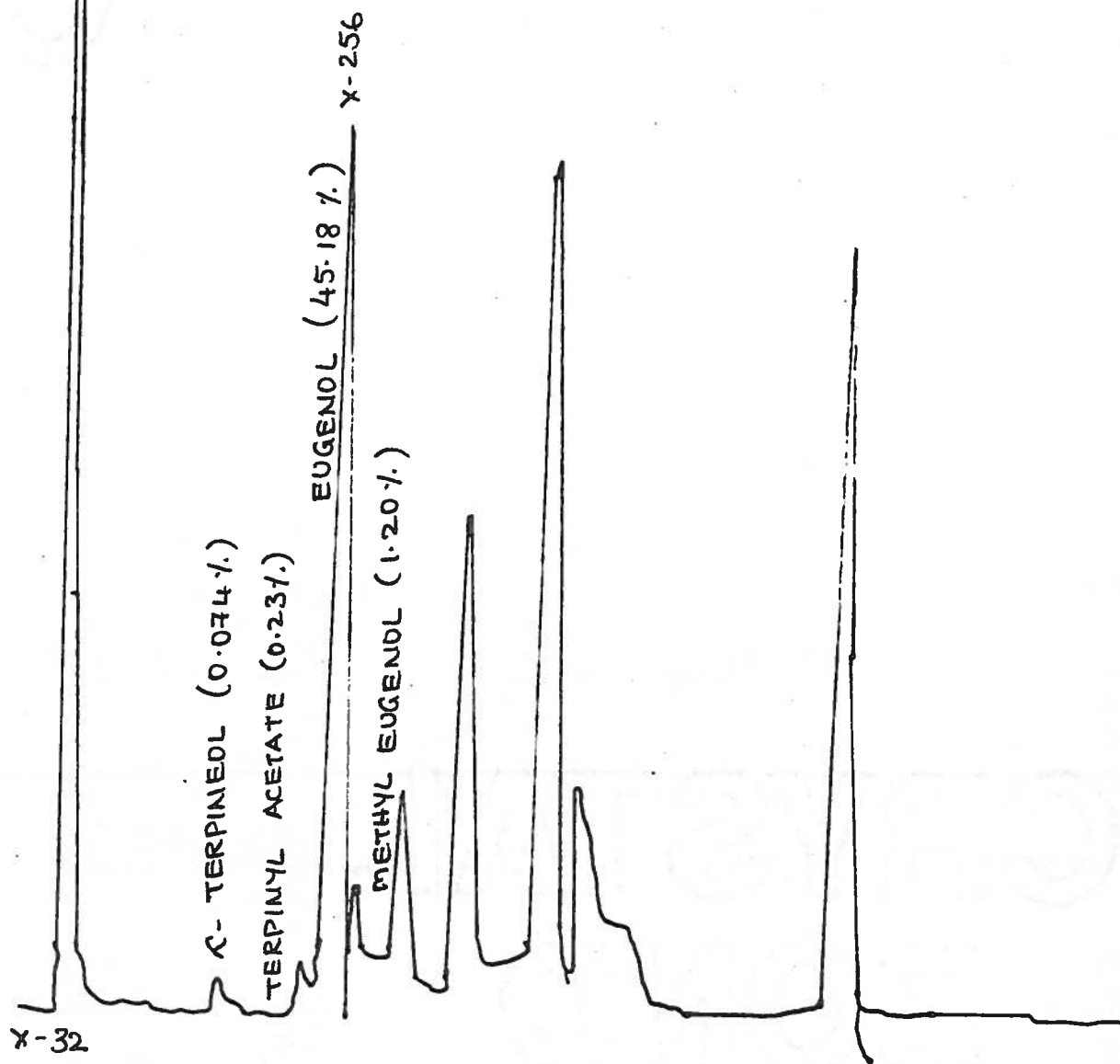


Fig. 12. Gas Liquid Chromatograms of Essential Oil
of PIPER BETEL L. Cv. ' KAKAIR '

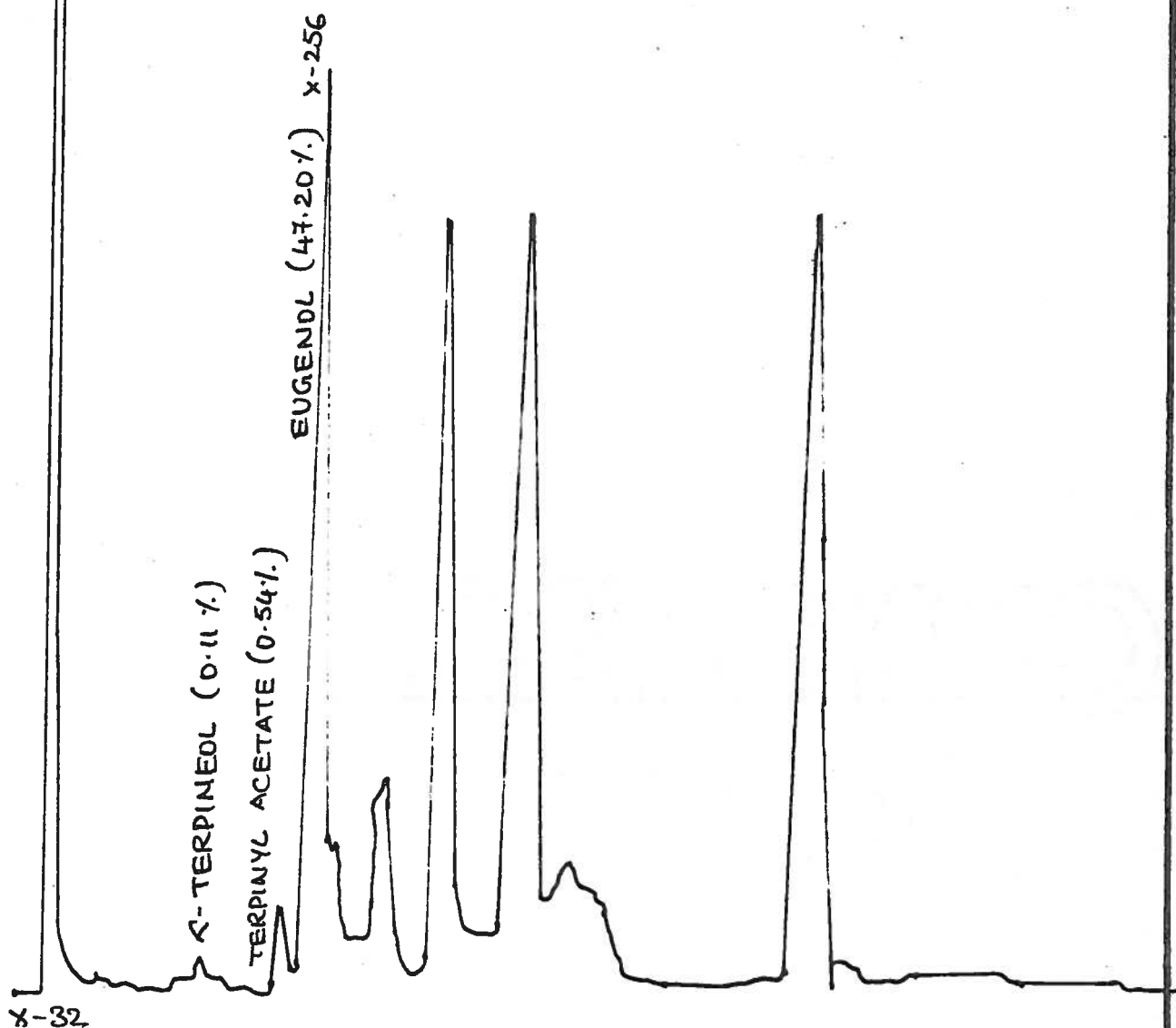


Fig. 13. Gas Liquid Chromatograms of
Essential Oil of PIPER BETEL L.
Cv. ' MAGHAI '

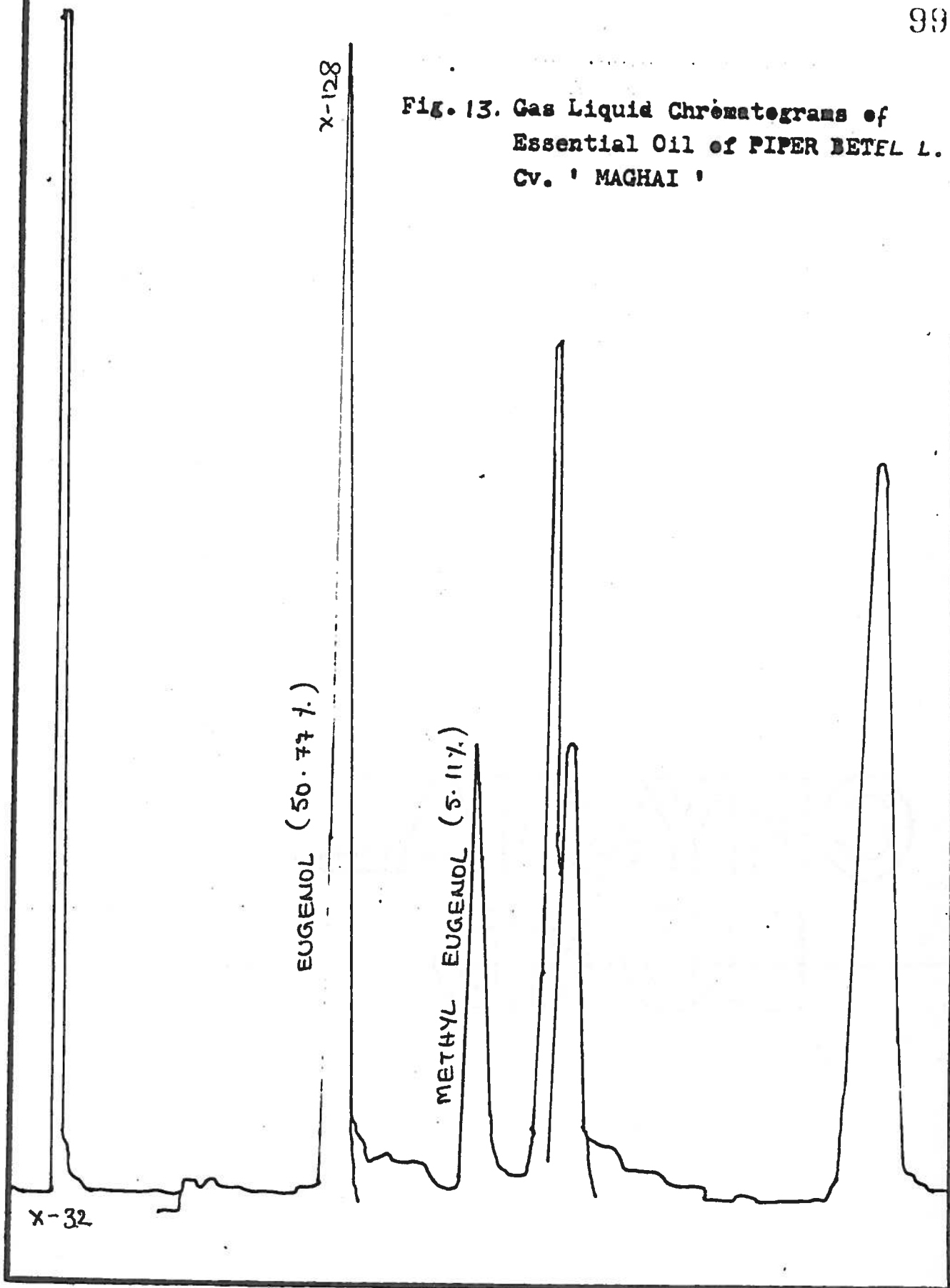


Fig. 14. Gas Liquid Chromatograms of Essential Oil of PIPER BETEL L. Cv. 'MEETHA CUM DANGLA'

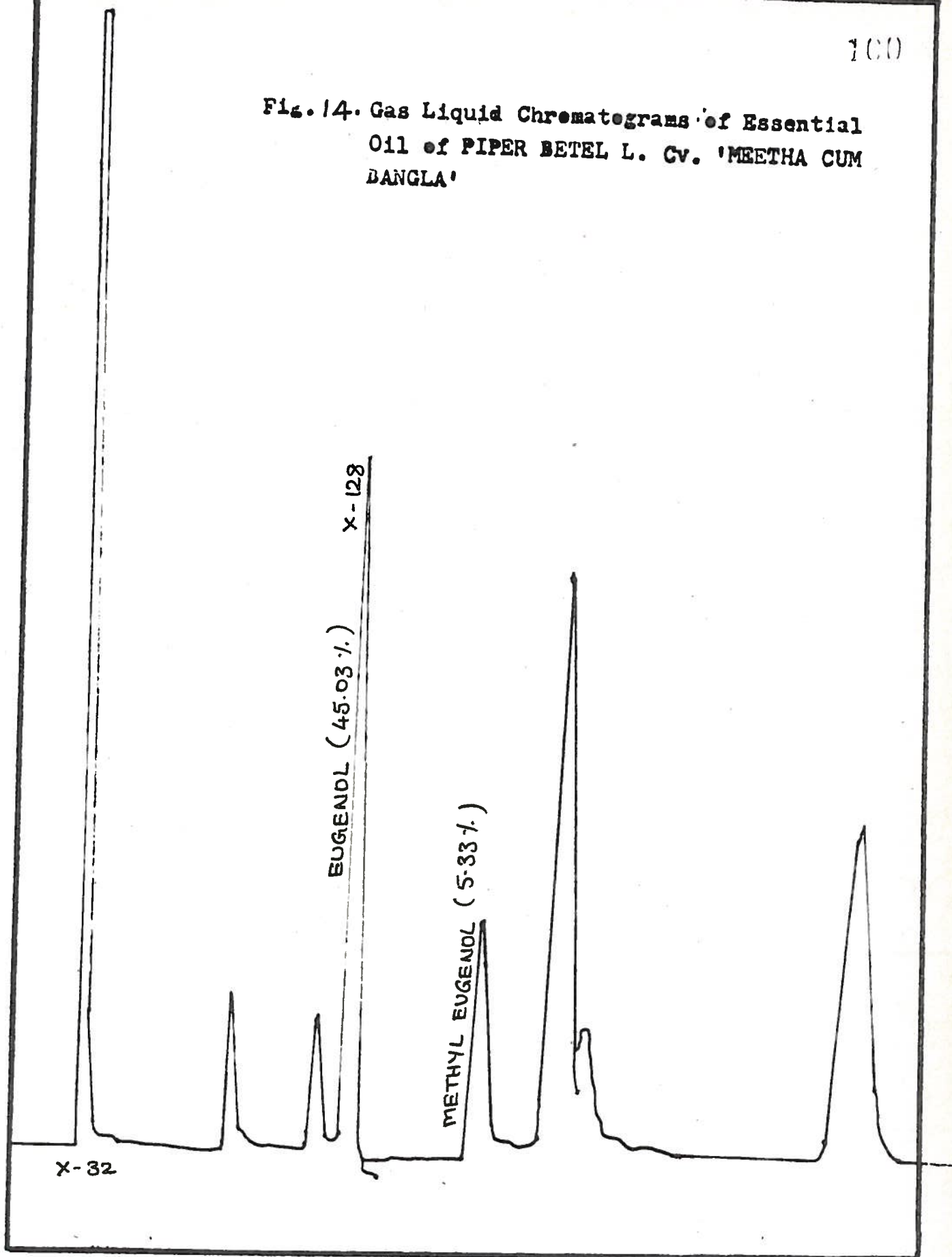


Fig. 15. Gas Liquid Chromatograms of
Essential Oil of PIPER
BETEL L. Cv. 'MEETHA CALCUTTA'

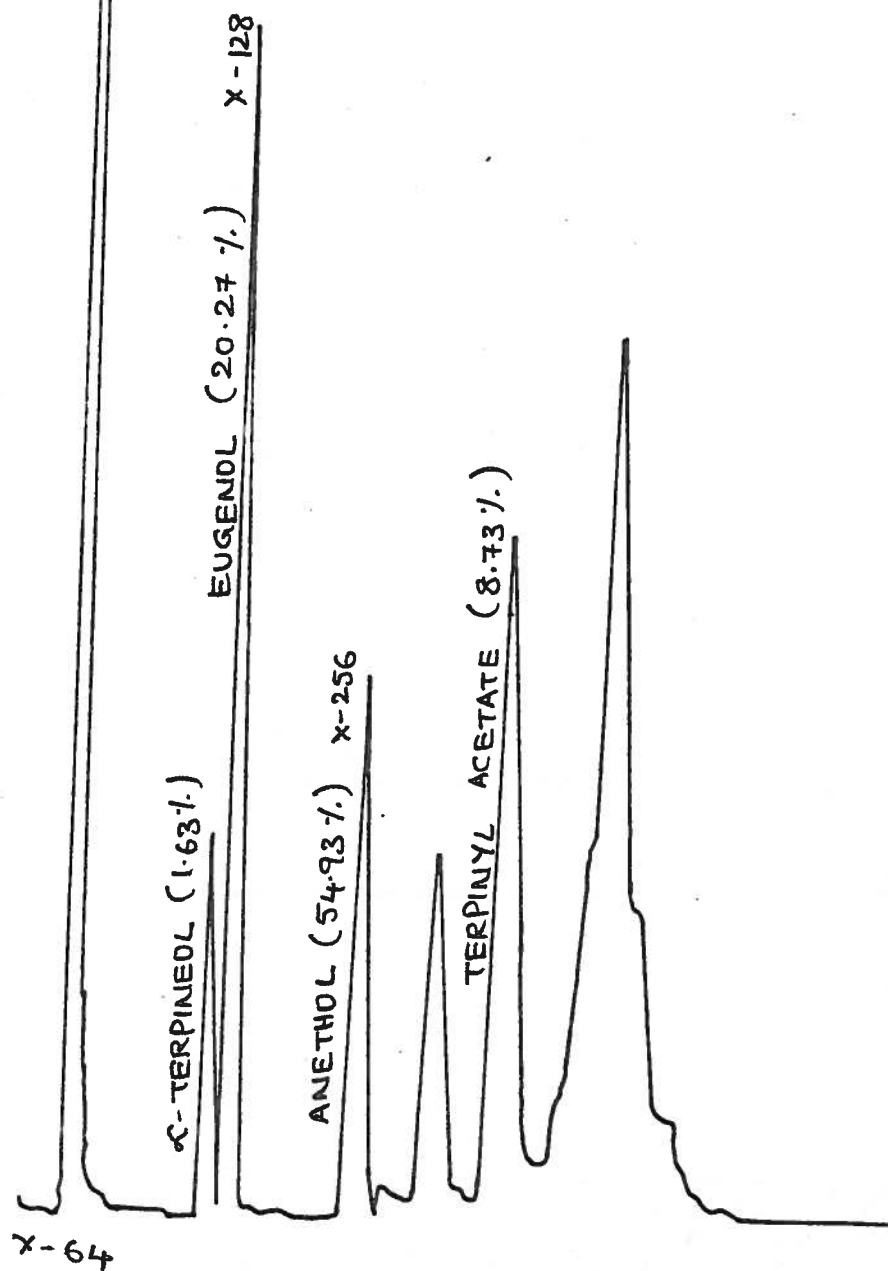
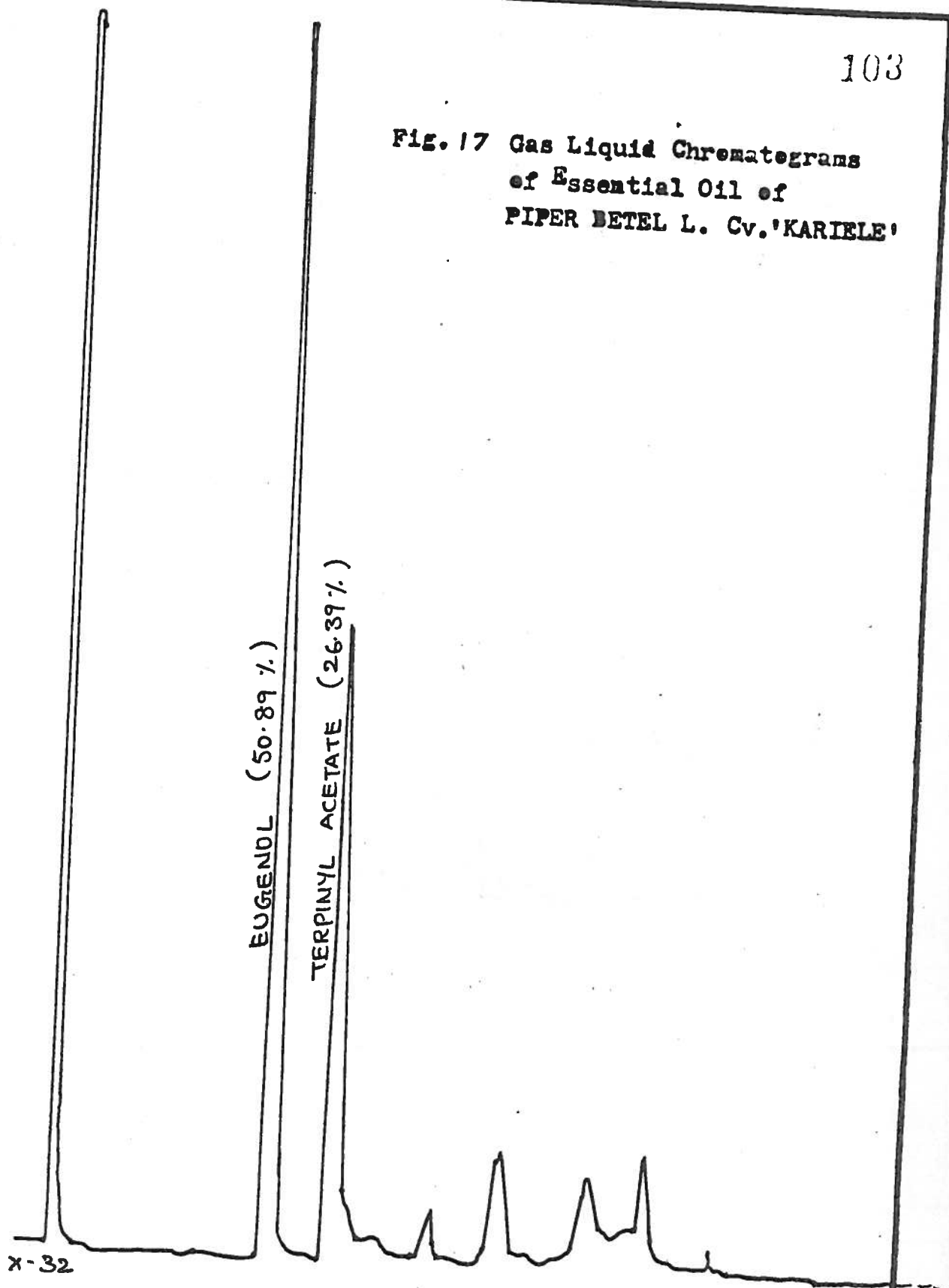


Fig. 17 Gas Liquid Chromatograms
of Essential Oil of
PIPER BETEL L. Cv. 'KARIELE'



(50.9 to 56.09%). Other major constituent identified was terpenyl acetate and its presence was conspicuous in the oils of the 'Pachai Kodi' and 'Kariele' as compared to other cultivars studied and hence these two cultivars were placed under 'Sanchi' group.

'Kapoori' Group

Gas liquid chromatograms of the oils of 'Tellaku of Chennur', 'Tellaku of Ponnur' and 'Tellaku of Utukur' have similar pattern of peaks and their area. The number of peaks are more as compared to other cultivars (Figs. 18 - 20). Mild pleasant taste and least pungency of 'Kapoori' leaves was due to terpenyl acetate (34.21 to 48.76%). α -terpineol is also present (3.61 to 4.08%) in all the three types. Eugenol (17.0 to 23.16%) was less as compared to other cultivars.

Chlorophyll content

Observations on chlorophyll content in all four groups showed that maximum chlorophyll content was observed in the cultivars of 'Sanchi' group (2.83 to 3.02 mg g⁻¹). The leaves of 'Sanchi' group were dark green which could be due to the presence of maximum chlorophyll. It was followed by 'Bangla' group (1.67 to 2.30 mg g⁻¹). The light green colour of the leaves in 'Kapoori' group was due to the presence of low chlorophyll content (1.03 to 1.32 mg g⁻¹).

Fig. 18. Gas Liquid Chromatograms of Essential Oil of PIPER BETEL L. Cv. 'TELLAKU OF CHENNURU'

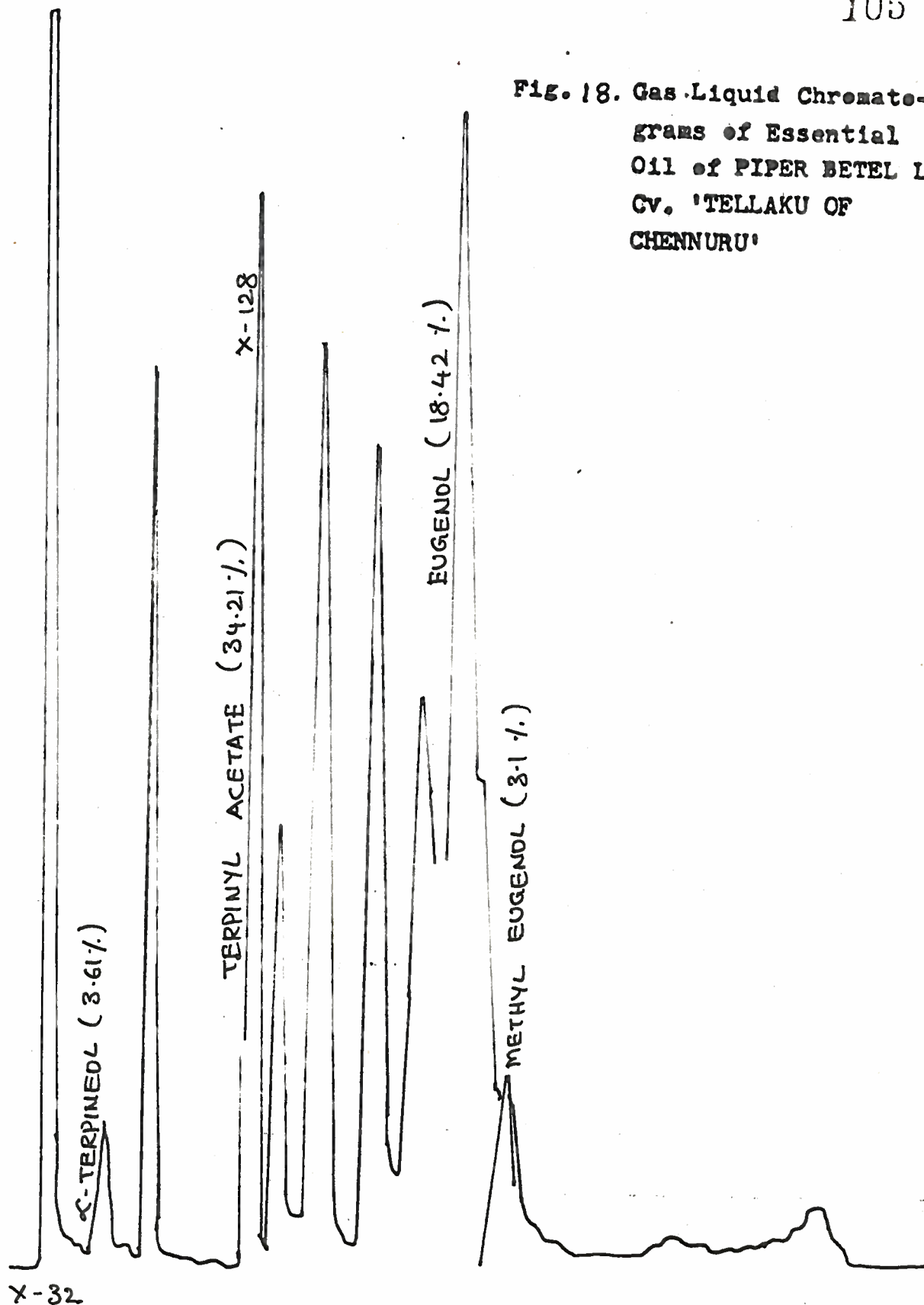


Fig. 19. Gas Liquid Chromatograms of Essential Oil of PIPER BETEL L. Cv. 'TELLARU OF PONNURU'

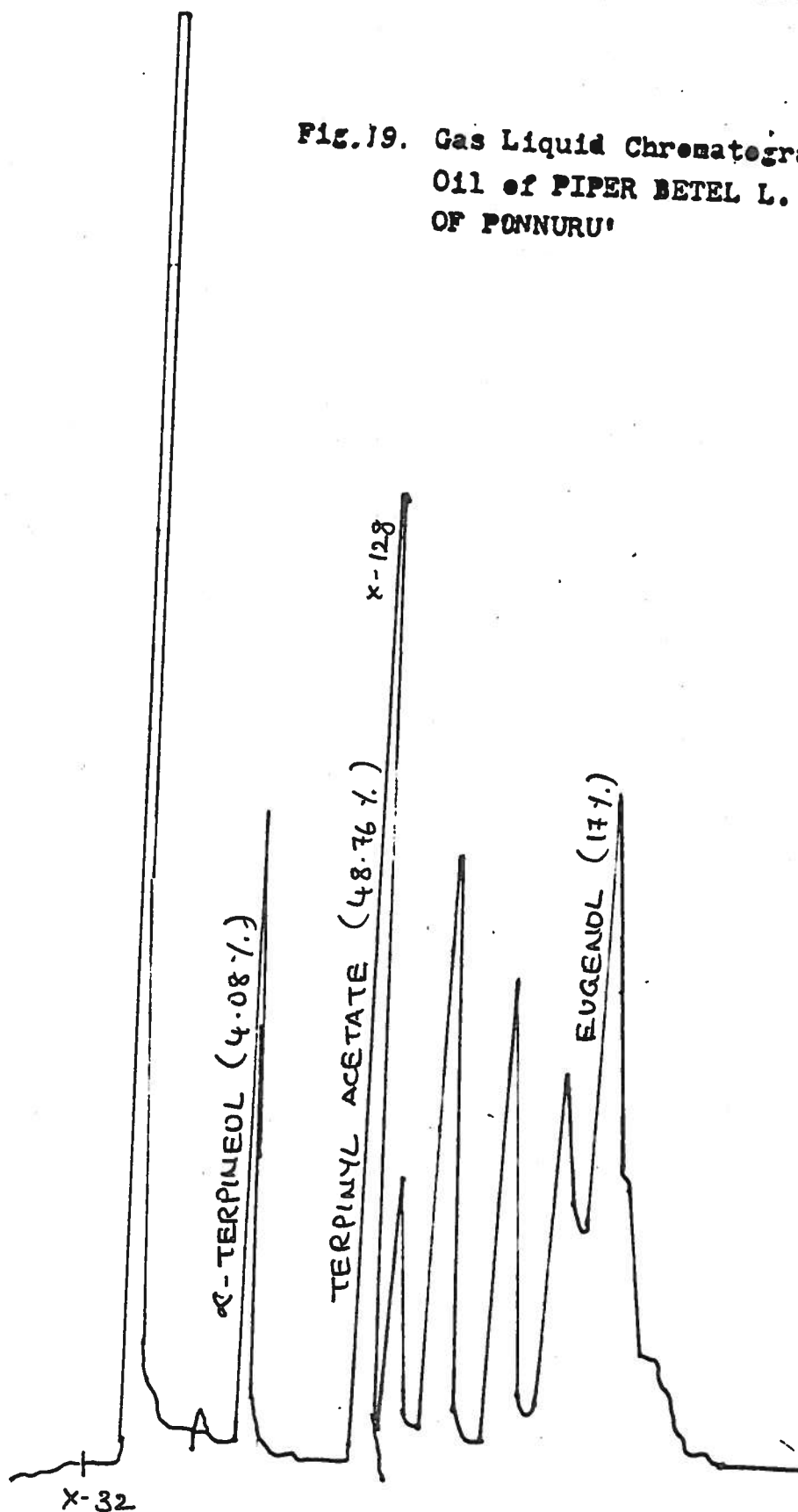
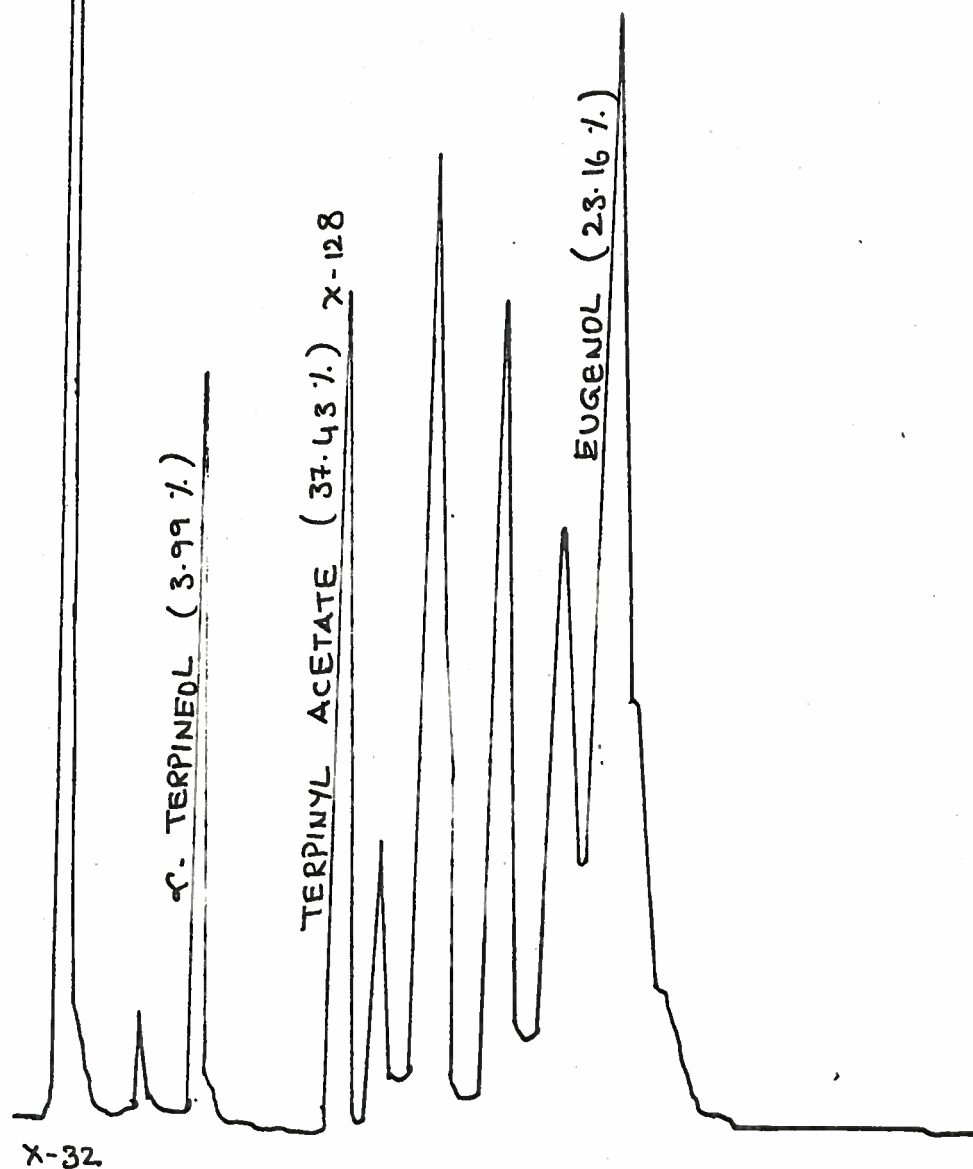


Fig. 20 Gas Liquid Chromatograms of Essential
Oil of PIPER BETEL L. Cv. ' TELLAKU OF
UTUKURU '



5.6 YIELD PARAMETERS

The thirteen cultivars belonging to four groups under study were observed for their vigour and yield of leaves. They were grown under uniform conditions in the experimental conservatory at Chintalapudi, Guntur district.

Studies on the growth behaviour have been undertaken in order to select cultivars with high yield potential. The four groups viz. 'Bangla', 'Kapoori', 'Meetha' and 'Sanchi' showed some heterogeny in growth behaviour and differed in their vigour as represented by number of leaves per vine and weight of leaves per vine. Maximum yield interms of leaf number and weight was recorded in 'Kapoori' group followed by 'Bangla' and 'Sanchi' groups. Meetha group was the weakest of all the four groups. Perhaps this cultivar has not adopted under the existing agro-climatic conditions. Similar results were also obtained by Rawat (1985).

5.7 GENETIC VARIABILITY STUDIES

Knowledge of genetic variability present in the crop species for the character under improvement depends upon the presence of variation in the germplasm and its utilisation in the breeding programme. The phenotypic expression is the result of interaction between genotype and environment. Hence, the total variance needs to be partitioned into heritable components so as to assess the true breeding nature of a particular trait.

Estimates of genotypic and phenotypic coefficients of variation for yield and its components are useful in designing

an effective breeding programme. The coefficient of variation alone cannot be used to partition the heritable components of variation. Burton (1952) suggested that a genetic coefficient of variation together with the heritability estimates would give the best picture of the amount of advance to be expected from selection. The heritability enables the plant breeder to base his selection on phenotypic performance for improvement of characters.

5.7.1 Genotypic and Phenotypic coefficient of variation

The coefficient of variation for genotype ranged from 3.72 in case of R-value to 129.0 in case of number of branches per plant, while the phenotypic coefficient of variation ranged from 4.25 in case of R-value to 134.0 for number of branches per plant. The traits number of branches per plant, number of leaves per vine, weight of leaves per vine, total chlorophyll content, leaf area and veinlet termination number showed high estimates of genotypic coefficient of variation. Although, for all the characters the phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation. The difference between PCV and GCV were narrow indicating that the influence of environmental factors on the traits is low. The genotypic coefficient of variation observed in the present investigation for petiole length, internodal length, R-value, specific leaf weight, stomatal size, stomatal frequency, stomatal index and palisade ratio was comparatively low. This indicates that these traits lacked flexibility and the variability

in the population was so low that it may not be possible for further improvement in these traits.

5.7.2 Heritability

High heritability values have been found to be useful in selection of superior types on the basis of phenotypic performance. The low heritability values suggested that they are highly influenced by environment.

In the present study low to high estimates of heritability (broad sense) were recorded for different characters. It was low for characters petiole length and specific leaf weight, indicating high influence of environment on these characters. While for the characters viz. stomatal size (width), stomatal frequency, stomatal index and weight of leaves per vine moderate estimates of heritability were recorded indicating the predominance of non-additive gene effects and environmental variation in the expression of these characters. The characters viz. leaf area, internodal length, number of branches per plant, R-value, stomatal size (length), palisade ratio, veinlet termination number, total chlorophyll content and number of leaves per vine showed high estimates of heritability indicating that a major part of the phenotypic variability in these characters was contributed by additive gene effects and hence can be improved by simple selection procedures.

5.7.3 Genetic Advance

Heritability with genetic advance was more value than the former alone in predicting the effect of selection. If the

heritability was mainly due to additive and non-additive gene effects the expected genetic advance would be low and if there was only additive gene effects a high genetic advance may be expected.

The genetic advance ranged from 0.0005 for the character specific leaf weight to 91.13 for weight of leaves per vine. The high values of genetic advance was recorded by weight of leaves per vine and number of leaves per vine. The traits leaf area and stomatal frequency showed moderate values of genetic advance while petiole length, internodal length, number of branches per plant, R-value, specific leaf weight, stomatal size, stomatal index, palisade ratio, veinlet termination number and total chlorophyll content showed low genetic advance. These results indicated that selections for these traits could be postponed to later generations.

It can be concluded from the aforesaid studies that the thirteen cultivars observed can be categorized into four distinct groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori'. In case of Piper betel L. that no single parameter studied is adequate enough to categorize the cultivars of betelvine and it is only the integrated approach which can be depended upon for such type of categorization. The study may also be helpful in planning a breeding programme of betelvine cultivars combining the superior growth and yield of 'Kapoori' with excellent leaf quality of 'Meetha'.

It has been observed that out of several parameters used, morphological characters and gas liquid chromatography of essential oil have been found to be most useful. Considering the large area under cultivation of betelvine and practically no work has been done on the improvement of this important crop in the State, the present studies bring out the need for extensive investigations on the chemistry of betel leaves and its essential oil which may throw some light on the possible use of this crop in the pharmaceutical, confectionary industries of the country. Also it may help to develop newer products from the betelvine crop and thereby assuring remunerative return to the cultivators.

SUMMARY

Betelvine (Piper betel L.), a perennial creeper is cultivated on commercial scale in many states of India. Very little research efforts have been put up so far towards the improvement of betelvine germplasm and its cultivation. There was a great confusion in the nomenclature of the existing cultivars grown in different regions of the country. Hence the present study was taken up with thirteen betelvine cultivars which are commercially important to identify their characters and cataloguing them based on morphological, physiological and biochemical characters.

The thirteen cultivars observed could be categorized into four groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori' on the basis of morphological characters of leaves. The types observed under each cultivar have similar leaf morphology. Prominent basal lobes coupled with cordate to roundish leaves in 'Bangla' group; narrowly ovate leaves having nearly parallel secondary veins in 'Kapoori', broadly ovate leaves with tapering apices in 'Sanchi' and characteristic yellow spots on leaf lamina having acute apices in 'Meetha' are some of the salient features observed in these groups.

Physiological parameters viz. stomatal size, stomatal frequency, stomatal index, palisade ratio and veinlet termination number of leaves revealed that the results thus obtained were found to be overlapping and could not be used as parameters for identification of cultivars.

Growth analysis parameters such as R-value and specific leaf weight were studied. The results of specific leaf weight were statistically non-significant.

Organoleptic evaluation of betelvine leaves in four groups were carried out in terms of pungency, flavour and fibre. The leaves of 'Bangla' group were pungent, aromatic and fibrous while the leaves of 'Meetha' group were sweet and palatable taste with characteristic fennel-like aroma. Highly pungent, aromatic and fibrous leaves were observed in 'Sanchi' group. The leaves of 'Kapoori' group were least pungent and less fibrous with mild flavour.

Essential oils, which constitute the flavour of aroma of the leaves from the thirteen cultivars were examined by GLC. The chromatograms of the cultivars within the corresponding group had similar pattern but it had marked differences from one group to another. The variation in chemical constituents and their proportion in the essential oil and chlorophyll content of different cultivars were also observed to be reliable marker for the identification of cultivars. These observations also support the categorization into four groups on the basis of morphological characters of the leaf.

Observations on yield parameters showed some heterogeny in growth behaviour and differed in their vigour as represented by number of leaves produced per vine and weight of leaves per vine. Maximum growth and yield of leaves were observed in all the cultivars of 'Kapoori' group, followed by 'Bangla' and

'Sanchi' groups. Poor growth was observed in 'Meetha' cultivar.

Estimates of genetic components of variation indicated that though for all the characters the phenotypic coefficient of variation was slightly higher than genotypic coefficient of variation, their differences were narrow. Heritability in broad sense was found to be high for leaf area, number of branches per plant, stomatal size, palisade ratio, veinlet termination number, total chlorophyll and number of leaves per vine due to additive gene action. The traits leaf area, number of leaves per vine and weight of leaves per vine showed high genetic advance along with high heritability values indicating their utility for straight selection.

It can be concluded from the aforesaid studies that the thirteen cultivars observed can be categorized into four distinct groups viz. 'Bangla', 'Meetha', 'Sanchi' and 'Kapoori'. It has been observed that out of several parameters used, morphological characters and gas liquid chromatography of essential oil have been found to be most useful.

LITERATURE CITED

- Allard R W 1960 Principles of Plant Breeding. John Wiley and Sons Inc., London and New York p 485.
- *Anonymous 1969 Wealth of India (Raw materials). Council of Scientific and Industrial Research, New Delhi 8: 83-94.
- Arnon D L 1949 Copper enzymes in isolated chloroplasts
I Polyphenol oxidase in Beta vulgaris L. Plant Physiology 24: 1-15.
- *Atal C K, Dhar K L and Singh Jagdev 1975 The Chemistry of Indian Piper species. Lloydia 38: 256-264.
- *Burkill I H 1935 Dictionary of Economic products of the Malay Peninsula P. betel L. Crown Agents pp 1737-1742.
- *Burton G W 1952 Quantitative inheritance in grass. Proceedings 6th International Grassland Congress 1: 277-283.
- Burton G W and Deurane B N 1953 Estimating heritability in tall fescuss (Festuca arundinaceae) from replicated clonal material. Agronomy Journal 45: 478-481.
- Chattopadhyay N C, Das A K, Das S and Misra A K 1984 Phytochemistry of betel leaves and some aspects of storage. Proceedings of Group Discussion on Improvement of Betelvine cultivation. Eds. S D Khanduja and V R Balasubramanyam, NBRI, Lucknow pp 139-145.
- Chibber H M 1912 The morphology and histology of Piper betel L. (The betelvine). Journal of Linnean Society of Botany 41: 357-83.
- Cochran W G and Cox G M 1950 Experimental design. John Wiley and Sons Inc., New Delhi.
- *Das A K and Chattopadhyay N C 1984 Studies on the standardisation of betelvine cultivars of Midnapur district. Proceedings of National Workshop on Betelvine, Eds. S K Roy et al. The Agricultural Society of India, Calcutta pp 23-32.
- Ganguly P 1984 Varietal classification and quality control in West Bengal. Proceedings of Group Discussion on improvement of betelvine cultivation. Eds. S D Khanduja and V R Balasubramanyam, N B R I, India. pp 94-100.
- Ganguly P and Gupta D 1973 Identity of betel leaf (Piper betel L.) in West Bengal Part I Indian Agriculture 17: 251-255.
- *Ganguly P and Gupta D 1974 a Identity of betel leaf (Piper betel L.) in West Bengal market Part II Indian Agriculture 18: 37-45.

- Ganguly P and Gupta D 1974 b Identity of betel leaf (Piper betel L.) in West Bengal market. Part III 'Sanchi' variety. Indian Agriculture 18: 249-252.
- Guenther D 1952 The essential oil. D Von Nostrand and Inc. New York 5: 160-161.
- *Hall J P and Melville C 1954 Veinlet termination number - Some further observations. Journal of Pharm. Pharmacol. 6: 129-133.
- Hiscox J D and Israel Stan G F 1979 A method for the extraction of chlorophyll from leaf tissue without maceration. Canadian Journal of Botany 57: 1332-1334.
- Maiti S 1989 The Betelvine. Extension Bulletin 5, I I H R, Bangalore.
- *Mohandas K K and Shah G L 1980 Epidermal studies in some Indian varieties of Piper betel L. with a note on their taxonomic significance. Journal of Ecological and Taxonomical Botany 1: 83-93.
- *Murthy Y S 1959 a Studies in the order piperales V. A contribution to the study of floral morphology of some species of Piper. Proceedings of Indian Academic Science (Sect. B) 49.
- *Murthy Y S 1959 b Studies in the order piperales IV. A contribution to the study of vegetative anatomy of three species of Piper. Proceedings of National Academic Science India (Sec. B) 31-38.
- Narayana Reddy R 1984 Betelvine research in Andhra Pradesh. Proceedings of Group Discussion on improvement of betelvine cultivation. Eds. S.D. Khanduja and V.R. Balasubrahmanyam, NBRI, Lucknow, India pp 125-128.
- *Paliwal G S and Harjal Nilima 1975 Some aspects of foliar venation with particular reference to the angiosperms. Symposium on form, structure and function in plant, current trends in life sciences. Today and Tomorrow's printers and publishers, New Delhi 8: 1-26.
- Pant D D and Benerjee R 1965 Structure and Ontogeny of stomata in some Piperaceae. Journal of Linnean Society (B) 50: 223-228.
- Rawat A K S 1985 Studies on the classification of betelvine (Piper betel L.) cultivars. Thesis submitted to the National Botanical Research Institute, Lucknow for the award of Ph.D. degree.
- Rawat A K S, Benerjee R and Balasubrahmanyam V R 1989 Chemical polymorphism of essential oil of Piper betel L. grown in India. Feddes Repertorium 100 7-8, 331-334.

- Rawat A K S, Mishra S K and Balasubrahmanyam V R 1989 Leaf Area Determination in Betelvine (Piper betel L.). Journal of Plantation Crops 17 (2): 131-132.
- Rawat A K S, Sharma M L and Balasubrahmanyam V R 1987 Essential oil of Betel leaf (Piper betel L.) Cv. 'Meetha'. Indian Perfumer 31 (2): 146-149.
- Rawat A K S, Tripathi R D, Khan A J and Balasubrahmanyam V R 1989 Essential oil components as markers for identification of Piper betel L. cultivars.
- *Salisbury E J 1927 On the causes and ecological significance of stomatal frequency, with special reference to woodland flora. Phil Trans Roy Soc (B) 216: 1-65.
- Sharma M L, Rawat A K S and Balasubrahmanyam V R 1982 Essential oils of betel leaves (Piper betel L.) Vr. 'Kapoori'. Indian Perfumer 26: 134-137.
- Sharma M L, Rawat A K S and Balasubrahmanyam V R 1983 Essential oils of betel leaf (Piper betel L.) Vars. 'Ramtek' and 'Desi Bangla'. Indian Perfumer 27: 91-93.
- Sharma M L, Rawat A K S and Balasubrahmanyam V R 1987 Studies on essential oil of betel leaf (Piper betel L.) Part III Vars. 'Desi Deswari' and 'Mahoba Desawari'.
- Singh K K, Johri J K and Balasubrahmanyam V R 1988 Standardization of leaf sampling technique in betelvine for chemical analysis. Journal of Plantation Crops 16 (2): 105-109.
- Singh B P and Joshi L K 1973 Cultivation and diseases of betelvine (Piper betel L.). Technical Bulletin No.23 p 6.
- Sprone K R 1948 A note on a rapid clearing technique of wide application. New Phytology 47: 290-297.
- *Trease G E and Evans W C 1972 Text Book of Pharmacognosy. Bailliers Tindall, London.
- *Ueda, Einosuke and Sasaki Toyosaku 1951 Chemical constituents of the leaves of Piper betel L. Journal of Pharmacological Society (Japan) 71: 559-560.
- *Wallis T E and Dewar T 1933 Dutch and the leaves of other species of Borosma, a comparative study of their anatomy Quarterly Journal of Pharmacology and Pharmacognosy.

*Original not seen

AFAU CENTRAL LIBRARY

Acc No

Date

D. 3915

9.10.92

AFAU CENTRAL LIBRARY
HALL 1 2 50-100