STUDIES ON FLORAL BIOLOGY AND QUALITY CHARACTERS OF CUSTARD APPLE (*Annona squamosa* L.) TYPES.

A THESIS SUBMITTED TO
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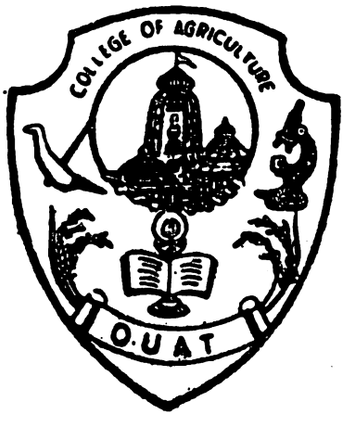
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE

(HORTICULTURE)

BY

Debasis Mahanty



DEPARTMENT OF HORTICULTURE,
COLLEGE OF AGRICULTURE
Orissa University of Agriculture & Technology
BHUBANESWAR

1995

THESIS ADVISOR,

DR. J. M. PANDA.

DEDICATED TO
MY BELOVED PARENTS

Dr. J. M. Panda, Ph.D.,
Reader, Department of Horticulture,
College of Agriculture,
Orissa University of Agriculture and
Technology, Bhubaneswar - 751 003

Bhubaneswar,
Dated, the 7th December 1996

CERTIFICATE - I

This is to certify that the thesis entitled "**Studies on Floral Biology and Quality Characteristics of Custard Apple (Annona squamosa) types**" submitted for the degree of **Master of Science in Agriculture (Horticulture)** of the Orissa University of Agriculture and Technology, Bhubaneswar, is a faithful record of *bona fide* and original research work carried out by **Sri Debasis Mohanty** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation have been fully acknowledged by him.

(J. M. PANDA)

Forwarded Dean CA

Head
Department of Horticulture
College of Agriculture
O.U.A.T. Bhubaneswar

CERTIFICATE - II

This is to certify that the thesis entitled **"Studies on Floral Biology and Quality Characteristics of Custard Apple (Annona squamosa) types"** submitted by Sri Debasis Mohanty to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of Master of Science in Agriculture in the subject of Horticulture has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

Advisory Committee

24/12/96

Dr. Ø. M. Panda,
Reader,
Department of Horticulture
College of Agriculture,
O.U.A.T., Bhubaneswar,
Major Advisor/Chairman.

24.12.96

External Examiner

24/12/96

Dr. T. Moharana
Head of the Department,
Horticulture,
College of Agriculture,
O.U.A.T., Bhubaneswar
Member

24.12.96

Dr. Parsuram Sahoo
Asstt. Professor
Dept. of Seed Technology
College of Agriculture,
O.U.A.T., Bhubaneswar
Member

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Debasis Mohanty

Bhubaneswar
Dated 7.12.96

DEBASIS MOHANTY

ABBREVIATIONS AND MATHEMATICAL SYMBOLS

et al.	and others
C.D.	critical difference
cm.	centimeter (s)
°C	degree celsius
°F	degree Fahrenheit
mg	milligram (s)
g	gram (s)
kg	kilogram (s)
i.e.	idest (that is)
oz.	ounce
viz.	videlicet (namely)
*	denotes an operation
/	per
:	proportion or ratio
±	plus or minus
>	is more than
<	is less than
	the sum of the terms
%	percentage

LIST OF TABLES

TABLE	PARTICULARS	PAGE
1.	Meteorological observations at Bhubaneswar during the period of study (Feb '95 to Dec '95)	19
2.	Meteorological observations at Bhubaneswar during the period of study (Feb '96 to Oct '96)	19
3.	Place of collection and general characteristics of custard apple fruit types	26
4.	Class intervals of the qualitative characters of custard apple	37
5.	Duration of flowering in Annona squamosa (green and red type)	41
6.	Pattern of flowering in Annona squamosa (green and red type)	43
7.	Stages of flower bud development in Annona squamosa (green and red type)	45
8.	Days taken from flower bud initiation to full bloom in green and red type	46
9.	Total time required for completion of anthesis	48
10.	Time of anthesis in Annona squamosa	49
11.	Time of anther dehiscence in Annona squamosa	50
12.	(a) Pollen size of Annona squamosa	52
	(b) Pollen viability studies in Annona squamosa	52
13.	(a) Percentage fruitset under natural pollination in Annona squamosa	54
	(b) Percentage fruitset under controlled self pollination	54

14.	Total yield per plant of various types of custard apple	56
15.	Average weight of fruits of custard apple types	57
16.	Average number of segments per fruit of custard apple types	58
17.	Average percentage of peel in custard apple types	59
18.	Average pulp content (%) of fruits of custard apple types.	60
19.	Average number of seeds per fruit of custard apple types	62
20.	Average weight of seeds per fruit of custard apple types	63
21.	Summary of findings on physical characters of custard apple fruit types	64
22.	Total soluble solid content of custard apple fruit types	65
23.	Percentage of titrable acidity content of fruit types	66
24.	Ascorbic acid content of custard apple types	68
25.	Total sugar content of various custard apple types	69
26.	Percentage of reducing sugar of the custard apple fruit types	70
27.	Summary on chemical composition and yield of custard apple fruit types	71
28.	T.S.S. : Acid ratio of various types of custard apple	72
29.	Index score analysis of physical characters of custard apple types	74
30.	Index score analysis of chemical composition of custard apple types	76

31.	Custard apple types with their total scores by index score technique	77
32.	Grouping of custard apple types following metroglyphic analysis	80
33.	Similarity coefficient matrix	82
34.	Composition of clusters obtained by numerical classification	81
35.	Correlation matrix	83

LIST OF ILLUSTRATIONS

FIGURE	PARTICULARS	PAGE NO.
1.	Custard apple growing states in India	1.a
2.	Meteorological observations, Temperature (°C), RH (%) year 1995	19.a
3.	Meteorological observations, Temperature (°C), RH (%), year 1996	19.a
4.	(a) Duration and pattern of flowering in Annona squamosa (green type)	43.a
	(b) Duration and pattern of flowering in Annona squamosa (red type)	43.a
5.	Changes in length and girth of flower buds during different stages of development in Annona squamosa	46.a
6.	Morphological features of flowers of Annona squamosa	46.b
7.	(a) Time of anthesis of Annona squamosa (green type)	49.a
	(b) Time of anthesis of Annona squamosa (red type)	49.a
8.	Total yield per tree of different custard apple types	55.a
9.	Average weight of fruits of different custard apple types	57.a
10.	Average pulp content (%) of fruits of custard apple types	60.a
11.	Average no. of seeds per fruit of custard apple types	62.a
12.	Total soluble solid content of different custard apple types	65.a
13.	Percentage titrable acidity of different	

	custard apple types	66.a
14.	Ascorbic acid content of different custard apple types	67.a
15.	Total sugar content of different custard apple types	69.a
16.	T.S.S. : Acid ratio of different custard apple types	72.a
17.	Index score analysis and results	78.a
18.	Scatter diagram by metroglyph analysis of custard apple types	79.a
19.	Dendogram based on S_G values following UPGMA strategy	82.a
20.	Superposition of results of metroglyphic analysis over that of numerical classification	104.a

LIST OF PLATES

PLATES	PARTICULARS	AFTER PAGE
1.	Flowers of green and red type of custard apple	24
2.	Fruits of green and red type of custard apple	24
3.	Harvest index of custard apple fruits	14
4.	Flowering twig with various stages of bud development.	44
5.	Stages of flower bud development	44
6.	Variation in shape of segments of custard apple fruits	58
7.	T - 21; T - 6; T - 18; T - 22; T - 3; T - 14 types	81
8.	T - 16; T - 20; T - 19; T - 28 types. - T - 17; -	81
9.	T - 2; T - 8; T - 27; T - 9; T - 11; T - 4 types	81
10.	T - 24, T - 25 types	106
11.	T - 1 (Keonjhar type - I)	106
12.	T - 3 (Khireitangi type - I)	106
13.	T - 6 (Bainda type - II)	106
14.	T - 14 (Paralakhemundi type - I)	106

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CONTENTS

CHAPTER		PAGE
	CERTIFICATE - I	I
	CERTIFICATE - II	II
	ACKNOWLEDGEMENT	III
	ABBREVIATIONS AND MATHEMATICAL SYMBOLS	V
	LIST OF TABLES	VI
	LIST OF ILLUSTRATIONS	IX
	LIST OF PLATES	XI
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	4
III.	MATERIALS AND METHODS	18
IV.	EXPERIMENTAL FINDINGS	40
V.	DISCUSSIONS	85
VI.	SUMMARY	107
VII.	CONCLUSION	114
VIII.	BIBLIOGRAPHY	116

CHAPTER I

INTRODUCTION

Introduction

During the last decade custard apple (Annona squamosa. Linn) has become a valuable plantation crop for arid regions, watershed, and drought prone areas. Because of its ability to grow in saline and adverse soil conditions, plantations under this crop are fast increasing in waste lands and shallow soils. The present area under this crop is reported to be 40,000'ha. spread over the states of Andhra pradesh, Tamilnadu, Orissa, Assam, Rajsthan, Maharastra, Madhyapradesh, Gujrat & Bihar. Apart from its use as a plantation crop under adverse soil conditions, this plant bears sweet, lucious fruits with a classic flavour which can have a variety of uses. But since most of the plants are of seedling origin there is a great variation in the quality of fruits obtained from them. Hence, in order to provide quality planting materials of elite types for plantation programmes it is necessary to carry out selection of better types from the existing lot. This process of crop improvement through screening to make a suitable selection and if necessary to select suitable parents for the breeding programme, requires an indepth study of its flowering and fruiting process.

Custard apple has a peculiar flowering behaviour which begins with the complete shedding of the leaves from the plant and continues to flower and set fruit leaving only a short period before the commencement of next year's flowering. Hence, the long flowering and fruiting period in this crop

needs a thorough study to find out the productive and unproductive phases; the best time for pollination and fruitset under natural conditions. It may be of interest to manipulate these phenomenon to achieve a greater success in the flowering and fruiting of this crop. Therefore proper investigations will help in finding out the best productive phase and successful means of pollination to obtain higher fruit set . It is expected that these studies will pave the way to formulate a breeding programme for this crop to obtain high yielders by suitable crossings.

As a first step in crop improvement programme it will be necessary to select suitable types out of this large mass of seedling progenies spread over the Orissa state. This necessitates survey of various local elite types and study of their growth and yield characters. In order to be assured of the quality of fruits, analysis of quality characters of fruits like its weight, pulp content, total soluble solid, sugar and acid content is of prime importance. This dessert fruit of delicious taste contains large number of seeds which is not preferred by consumers as well as it stands in the way of its adequate use by the preservation industry. Hence, in assessing the quality parameters of elite types, fruits with less seeds is to be given due weightage. Over and above every thing taste of the fruits also varies inspite of its high fructose sugar and low acid content and in any selection organoleptic scoring should be given utmost

priority. Thus the desirable characters of better types may be based on the following characters like (i) High Yield, (ii) High fruit weight, (iii) High Pulp percentage, (iv) Less number of seeds / fruit, (v) A suitable sugar acid blend and finally the flavour judged by proper scoring.

Keeping these afforesaid discussions in view, this study was divided into two parts.

Part I Studies on floral biology of custard apple.

Part II Studies on yield and quality characters of various types of custard apple.

Objectives of this study under part - I are as follows.

* To study duration and pattern of flowering, phases of bud development, time of anthesis and anther dehiscence.
* To study the time of stigmatic receptivity, pollination and fruitset.

In the Part II of the experiment the objectives were as follows.

* To select high yielders.
* To select fruits of higher weight, high pulp percentage and less number of seeds/fruit.
* To estimate the quality of fruits like T. S. S. , acidity, ascorbic acid and Sugar content.
* To take up index scoring, metroglyph analysis and numerical classification of fruit types for clustering of desirables ones with suitable characters to make an effective selection of a type for Orissa state.

CHAPTER - II

REVIEW OF LITERATURE

Review of Literature

PART - I

Custard apple is assuming importance as a valuable plantation crop in arid regions, water shed and drought prone areas. In these areas, the cultivation of this crop is increasing during the last decade. At this juncture, there is necessity of providing quality planting materials of ellite varieties. This is possible through crop improvement which can be achieved by adopting suitable breeding methods. In order to achieve success in breeding it is necessary to be throughly acquainted with the floral biology of this crop. The relevant research findings related to study on this aspect of Annona squamosa and other Annona species have been reviewed follows:

Flower buds appeared along with vegetative flushes on the one season old shoots. some flower buds also appeared on older wood but percentage of such flower buds was negligible. The flowers were extra axiliary, opposite to the leaves in all Annona species as observed by Thakur and Singh (1965). Similar findings have also been reported in Annona squamosa by Nalwadi et. al. (1975)

Duration and period of flowering

The season and duration of flowering varies with different species of Annona as reported by Hayes (1957).

There was commencement of flowering in the last week of March in Annona glabra, Annona atemoya, Annona cherimola and

Annona squamosa but in last week of April in case of Annona reticulata. The flowering was ceased in last week of August in Annona squamosa (green and red type); Annona atemoya and Annona cherimola; However, flowering was ceased in the first week of June and middle of November in case of Annona glabra and Annona reticulata respectively as reported by Thakur & Singh (1965).

The flowering reached at its peak during April 2nd week in Annona squamosa (green and red type) and Annona glabra; during 1st week of May in Annona atemoya and Annona cherimola and during 1st week of June in Annona reticulata. These observations were recorded under Delhi condition by Thakur and Singh (1965)

But Nalwadi et.al (1975) reported that A. squamosa (green type) flowers from mid April to mid July with peak during May under Dharwar (Karanataka) condition. Kumar and Singh (1977) reported that in Annona squamosa var. Sahibganj the flowering continued from March to August with maximum flowering during April - May under Sabour condition.

Flower bud development

According to Thakur and Singh (1965) different species of Annona took about 27 to 35 days for complete bud development (i.e from bud initiation to anthesis) and pass through.

But Nalwadi et. al (1975) are of the view that the flowers of Annona squamosa took on an average 29 to 34 days from visual initiation of flower bud to complete blooming with

an average of 30.8 days. In Annona reticulata, the total period from bud initiation to anthesis took 45 days as reported by Farooqi (1970), where as in Annona atemoya the period was 31 days for complete bud development as reported by kshirsagar et.al (1976).

Anthesis

According to Thakur and singh (1965), the anthesis in different species of Annona continues through out the day with their peak period in the morning and evening time, specifically between 5.30 to 8.30 am in A. squamosa (green & red type) and between 2.30 to 5.30 pm in A. glabra and A. reticulata. But in A. cherimola, two peak periods of anthesis were observed (i. e between 5.30 to 8.30 am and 2.30 to 5.30 pm.) Similarly in A. atemoya two peaks were observed (i.e. between 11.30 to 2.30 pm and 2.30 to 5.30 pm), under Delhi condition. In Dharwar (Karnataka) condition, the anthesis in Annona squamosa commenced early in the morning at 6am and continued till 6pm with maximum at 6am and minimum at 6pm. Beyond 6pm there was no anthesis as reported by Nalwadi et.al (1978).

Kumar and Singh (1977) reported that maximum anthesis was between 17.30hrs and 5.30 hrs in Var. Sahibaganj of Annona squamosa under Sabour condition. Kshirsagar et.al (1976) reported that maximum anthesis of 60 to 82 % buds occurred between 5 to 8 am. in Annona atemoya.

Anther dehiscence

The reports of different investigators on the time of anther dehiscence are divergent as reported below.

Ahmed (1935) observed that in Annona matured anthers are positively hygroscopic hence higher huimidity favours anther dehiscence. Annona cherimola and Annona squamosa shed pollen in the afternoon hours from 3.30 to 6 pm (Webster, 1910). But Venkatratnam (1959) reported that in Annona squamosa dehiscence took place between 4 am to 8 am. While in Annona cherimola and Annona reticulata it was from 4pm to 8pm and, in Annona glabra from 12 midnight to 4am under Hyderabad condition.

Thakur et.al (1965) reported that in A atemoya, A cherimola, A. rerticulata and A squamosa (green & red type), anther dehiscence took place through out the day but maximum was between 11.30 to 2.30 pm. in all the species . In A glabra dehiscence was between 4am - 5am and at no other time of the day under Delhi condition.

Nalwadi et. al (1975) reported that anther dehiscence took place between 12 midnight and 4 am with a peak at 2 am in Annona squamosa under Dharwar condition. Kshirsagar et.al (1976) reported that maximum anther dehiscence took place between 12 noon to 2pm in A atemoya.

Kumar & Singh (1977) reported maximum anther dehiscence between 11.30hrs. to 14.30hrs in A squamosa under sabour condition.

Pollen Studies

Pollen morphology

The pollens in all Annona species are compound. A compound pollen grain comprise four individual pollen grains closely packed within a thin covering . The pollen grains posses a thick exine without germ pore.

The average size of the individual pollen grain of the diploid species was found to be ranging between 36.5µto 45.8µ (i,e,.in A squamosa, A. cherimola, A. reticulata and A atemoya) where as it was 94.8µ in A. glabra, a tetraploid species. The larger pollen size of the latter is owing to its higher ploidy status as reported by Thakur and Singh (1965).

Nalwadi et.al (1977) reported that shape of the dry pollen of A. squamosa was round to oval with an average length and breadth of 54.3µ and 45.0µ respectively.

Pollen fertility

Thakur and Singh (1965) observed that the percentage of fertile pollens as per acetocarmine test was found to range from 55.9% in A atemoya to 80.4% in A cherimola. Nalwadi et. al (1977) reported that 89.4% pollens were fertile and 10.6%

were sterile by aceto carmine test is A. squomosa. Farooqi et. al (1970) also observed 86.4% fertile and 13.6% sterile pollen in A reticulata.

Stigma receptivity

Thakur and singh (1965) observed that the stigmas were receptive a day before the anthesis. The respectivity was highest at the time of anthesis and then decreased abruptly . By the time of anther dehiscence, the stigmas in all diploid species had turned almost non-receptive. However in A glabra the receptivity was retained for a longer time and 37 to 50 percent of the stigmas were receptive at the stage of anther dehiscence.

Farooqi et.al (1970) reported that in A reticulata, the stigma was receptive a day prior to anthesis with most receptive condition on the day of anthesis and later it declined to non-receptive condition after five days of anthesis. Nalwadi et. al (1975) reported that in A. squamosa the stigma was receptive from a day prior to opening of flower to two days after opening of the flower. The percentage of receptive stigma was 30% one day prior to opening of flower and 88% on the day of opening, 32% one day after opening and 8% two days after opening of flower. From, third day onwards after opening of flower the stigma was non receptive in Annona squamosa.

Pollination and fruit set

Thakur and singh (1965) reported that fruit set by hand pollination was high ranging from 44.4 percent to 60 per cent among different species, where as fruit set was below 6 percent in open pollination and self pollination. Lack of suitable pollinating agents, protogyny, hypogyny, short receptivity, delayed dehiscence after anthesis and low pollen germination appeared to be the causes of low fruit set under natural conditions.

Bautista (1975) in his study of 6 improved clones of Annona cherimola stated that higher percentage of fruit set was achieved by self pollination and artificial crossing than by open pollination. Kshirsagar (1976) reported that hand pollination in atemoya resulted in 70 percent fruit set. Kumar & Singh (1977) reported that low fruit set of about 8% occured naturally in var. sahibganj of Annona squamosa.

PART - II

Most of the cultivated custard apple types are of seedling origin and hence show wide variation in the qualitative characteristics of fruits. This provides a good scope to study and select superior types from among the lot. Some of the works taken up in this regard at various places of India and abroad have been presented in this chapter.

Variation in yield of seedling progenies of custard apple :

A wide variation is observed in the yield of custard apple seedlings as observed from the reports of different workers. It was reported by Singh et.al (1963) that 60 to 70 fruits/plant were obtained per year but Roy et.al (1964) recorded yield of 50 to 100 fruits/plant/year. Mangave (1982) recorded maximum fruit yield of 46.75 kg. per tree with an average fruit weight of 322.41g. Jagtap and Kokate (1991) observed that yield varied from 40,3 to 50.98 kg./ plant.

Studies on Physical Characters of fruits :

The earliest work carried out by Naik (1949) at Kodur revealed that the weight of custard apple fruits varied from 6.2 oz to 12.0 oz, while the number of seeds varied from 20 to 38 per fruit. In a detailed study of the custard apple fruits, Singh et al. (1977) observed that size of fruits, weight of fruits, number of fruits per plant, number of areoles and number of seeds in the fruit were found to vary form 6.8 x 6.6

cm to 7.5cm x7.3cm ; 185 to 193g, 55 to 70 number ; 87 to 95 number and 24 to 30 number respectively.

In an attempt to select promising custard apple types from Pemigiri region of Maharastra; Jagtap and Kokate(1991) observed that number of seeds; percentage of pulp of fruits varied from 22 to 27 number and 70.8 to 82.42 percent respectively. During an evaluation of fruits of 35 types of custard apple seedlings to identify superior types, Singh et al. (1993) found that average fruit weight ranged between 60.45 to 150.53g; fruit size (length varied between 4.45 to 6,46 cm. and diameter varied between 5.26 to 7.07 cm.)

After a preliminary screening on the physio- chemical characters of 24 custard apple types, Kumar (1994) reported that fresh weight, number of segments per fruit, peel %, pulp%, number of seeds per fruit and weight of seeds per fruit varied between 90.0 to 231.0 g ,72.75 to 100.05 numbers ; 32.15 to 56.52 %, 39.71 to 65.21 % ; 10.0 to 54.75 numbers and 3.8 to 19.1 g respectively.

Studies on chemical composition of fruit samples

In 1953, Stahle from Florida reported that in custard apple fruit, the total sugar content varied from 12.4 to 16.6% and acidity from 0.26 to 0.65% . He ascribed these differences to be due to agro-climatic conditions under which the crop was grown and also due to inherent characters and variation in sampling of the fruits.

In 1972, Nakasone reported that the fruits of sour sop (Annona muricata L.) contained 16 to 17 % T.S.S. and 0.83 to 0.92 % acidity.

In studying the physio-chemical properties of custard apple, Singh et al. (1977) reported that the percentage of total sugar, acidity and T.S.S. in the pulp were recorded as 15.6; 0.016 and 19.5 respectively. The ascorbic acid content was observed to be 1.10 mg per 100g.

While comparing two types of fruits of Annona squamosa with regard to acidity and the content of total, reducing and non reducing sugars, Mazumdar (1977) found that seeded berries were larger and had higher sugar content. The reducing and non reducing sugar in custard apple fruits varied between 9.92 to 19.1 % and 0.69 to 0.86% respectively.

Chowdhury et al. (1985) reported that the ascorbic acid content of custard apple fruits varied from 0.74 to 1.03 mg/100 gm. of pulp. Reducing and non reducing sugars varied from 9.48 to 11.73 % and 0.64 to 0.82% respectively . The T.S.S. ranged from 21.10 to 21.90% while the protein content ranged from 1.49 to 1.53%.

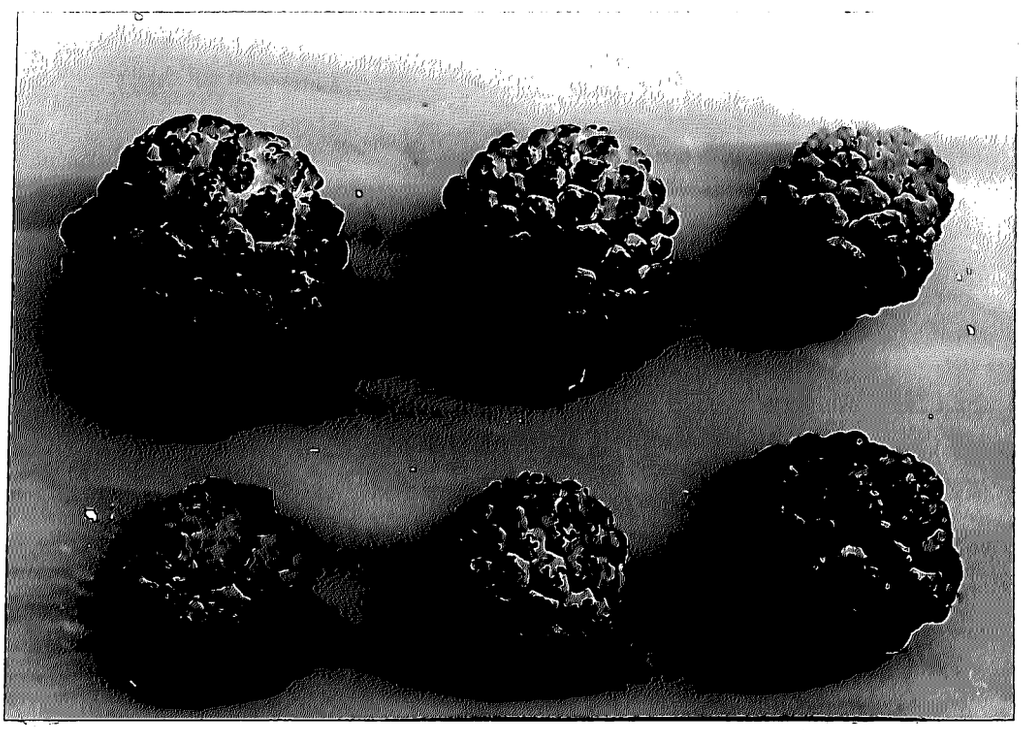
It was reported by Maia et.al. (1986) that in custard apple, the pulp was of low acidity with high water and sugar content and low in protein , lipid and ascorbic acid.

In the year 1991, Shete et al. reported that a wide range of T.S.S. (17.7 to 28 %) was observed among different seedlings of custard apple (Annona squamosa) .

In an attempt to select promising custard apple types from pemigiri region in Maharashtra, Jagtap and Kokate (1991) observed that acidity, reducing sugar and T.S.S. of custard apple fruits varied from 0.127 to 0.142% ; 23.80 to 24.94% and 26.5 to 29.1% respectively . The T.S.S. : acid ratio of the fruit was found to be 194.0.

Singh et al. (1993) evaluated fruits of 35 types of custard apple seedlings to identify superior types. They found high variation in fruit quality as the total soluble solids ranged from 8.36 to 20.27% and organoleptic rating varied from 60.7 to 77% .

After analysis of the fruits of Annonas cv Barbados seedling (BS) and Washington-97 (W-97) for their biochemical constituents from fruit set to harvestable maturity and at ripe stage, Pai (1993) found that T.S.S. was 22.6 and 24.0% for B.S. and W-97 upto harvest maturity and then increased rapidly with ripening. Total sugar for B.S. was 5.42% and 15.18% at harvest mature and at ripe stage respectively but for W-97 it was 0.96 % and 14.84% respectively. Fructose was the major sugar during mature and ripe stages. Total acidity was low (0.077 to 0.27%) in annona fruits. It decreased upto 75 days of fruit development and then increased till ripe stage (0.107% for B.S and 0.154% for W-97). Total tannins were high (0.942% for B.S. and 1.279 % for W-97) for fruit samples 15 days after harvest which decreased to 0.127% and 0.159% respectively at ripe stage.



Harvest index of custard apple fruits

After a preliminary screening on the physio-chemical characters of 24 custard apple types, Kumar (1994) reported that T.S.S. titrable acidity; ascorbic acid; total and reducing sugar content ranged between 17.5 to 26.5%, 0.092 % to 0.216%; 9.9 to 24.47 mg per 100 g.; 7.14 to 14.28% ; 5.65 to 11.11% respectively.

Harvest index of custard apple fruits :

Ezzat et al. (1974) observed that the light green colour of the fruit and yellowish white colour between the carpels are indications of fruit maturity.

Rao (1974) reported that the maturity of custard apple fruit was ascertained when the texture of the fruit became soft and colour of the fruit skin was light yellow between the segments of the skin.

Correlation studies on different qualitative characters of custard apple fruits.

Kumar (1994) after a study of different custard apple types in Orissa reported that there exists a significant positive correlation between fruit weight, seed number, and seed weight but it is negatively correlated with peel content. However it had non significant positive correlation with segment number and pulp content .

Studies on screening of superior types of custard apple :

Nakasone(1972) reported that the variations in fruit size and quality among the 35 seedlings tested (open pollinated seeds from a single tree) were no greater than those found among the fruits of a single tree.

Shete et al. (1991) screened 137 types taking into account average fruit weight; pulp %; number of seeds per fruit, T.S.S. % and yield. They found 24 types promising and selected different superior types on the basis of characters under study:

(i) Number of seeds/fruit was low in type- 25; 39; 32 and 123.

(ii) Better pulp % was recorded in type - 39;43;124;126;199;220;237.

(iii)The desirable characters as good yield potential; less seed content, large fruit size, higher T.S.S.; was found to be most outstanding in seedling type 25.

Jagtap and Kokate (1991) screened 92 trees on the basis of variation in physio-chemical composition of fruit and yield potential of trees and selected 5 promising seedling types for multilocational trial which are as follows:

P-36 - Big round fruits with bold size areoles, average fruit weight 515g; Pulp = 82.03 %; T.S.S. = 28.2% acidity = 0.127 % and yield 50.98 kg/tree

P-42 - Medium sized, round shape, very sweet with mild

flavoured fruits, pulp - 82.42%, T.S.S. = 28.02%, acidity 0.135%, seeds - 26 number and yield 46 kg/tree.

D - 77 - Medium size, spherical fruits with pleasant flavour, pulp - 75%, T.S.S 26.5%, acidity - 0.142%, seeds - 27 number and yield - 44 kg/tree.

Y - 72 - Spherical fruits suitable for long distance transport, pulp - 70.8%, T.S.S - 29.1% and yield 43.76 kg/tree.

D - 90 - Medium size, round fruits, pulp 73.3% seeds - 22 number, yield 40.35 kg/tree and sugar; acid ratio - 143.5.

Kumar (1994) after screening on the physico - chemical characters of 24 custard apple types, selected 4 types to be of superior quality i.e. S 7; S 16; S 12 and S 14. The characteristics of these four types are as follows :

Sample No. **Character (S)**

S 7 - Big size fruit weight = 178 g., light yellow cdour, bold segments, pulp = 65.21% T.S.S = 22%, acidity = 0.176%

S 16 - Big fruit, fruit weight = 180.25 g., small segments, pulp = 58.66%, T.S.S = 21% acidity = 0.184%.

S 12 - Big fruits , small segments, light yellow colour, fruit weight - 205 g, pulp = 53.63 %, T.S.S. = 21.5%, acidity = 0.108 %.

S 14 - Big fruits , bold segments light green in colour, fruit weight = 231.g, pulp = 59.95%, T.S.S.= 19.5 %, acidity = 0.168% Ascorbic acid = 20.9 g/ 100g.

CHAPTER - III

MATERIALS AND METHODS

Materials and Methods

PART I

Objective :

In order to undertake crop improvement of Annona squamosa, it is essential to know regarding its floral biology. Accordingly this study was undertaken to know the season of flowering; developmental process of flower bud; anthesis; anther dehiscence; pollen morphology, viability and stigma receptivity. So that suitable breeding technique can be developed for this crop.

Location of the experimental site :

This investigation was undertaken in custard apple trees grown in the Horticultural research station, O.U.A.T and in the residential quarters in Bhubaneswar city. This place is situated at a lattitude of 20° 15'N and longitude of 85° 52'E; which is about sixty kilometers away from Bay of Bengal at an altitude of 25.5 meters above the mean sealevel.

Climatic condition

The climatic condition of the place is warm and moist with hot summer and comparatively mild winter. Maximum amount of rainfall is generally received during the months of July to October. Data on weather condition for the year 95-96 have been presented in table - 1 & 2 and illustrated in Fig -. 2 & 3

Table No- 1 Meteorological Observations at Bhubaneswar during the period of study (Feb' 95 to Oct' 95)

MONTH	Temperature			Relative Humidity			Rainfall	Bright sunshine hour & (hrs)
	Max	Min	Mean (0_c)	Morning	Afternoon	Mean (%)	(mm)	
Feb- 95	31.8	18.7	25.3	92	45	68	4	8.9
Mar	34.8	21.8	28.3	90	43	66	2	8.8
Apr	37.4	24.9	31.2	89	48	69	2	8.0
May	43.6	26.3	30.4	91	65	78	9	7.2
June	34.2	26.7	30.4	89	72	80	13	4.1
July	31.8	25.8	28.8	93	77	84	16	3.7
Aug	32.4	29.7	29.0	93	77	85	22	4.8
Sep	31.9	25.5	28.7	93	75	84	17	4.8
Oct	30.5	23.5	27.0	93	75	83	19	6.2
Nov	29.2	19.0	24.2	90	58	74	7	7.8
Dec	28.9	14.7	21.8	92	44	67	0	9.0

Table No- 2. Meteorological Observations at Bhubaneswar during the period of study (Feb' 96 to Oct' 96)

MONTH	Temperature			Relative Humidity			Rainfall	Bright sunshine hour & (hrs)
	Max	Min	Mean (0_c)	Morning	Afternoon	Mean (%)	(mm)	
Feb- 96	30.9	18.3	24.5	95	46	70	2	9.4
Mar	35.0	22.6	28.6	92	47	69	1	8.1
Apr	36.9	24.5	30.7	89	45	67	4	8.6
May	37.5	26.8	32.1	87	55	71	5	8.4
June	34.1	25.4	29.8	90	68	79	14	8.2
Jul	32.8	25.3	29.0	92	72	82	16	5.4
Aug	30.9	25.0	27.9	93	79	86	25	4.3
Sep	33.1	25.1	29.1	93	68	80	8	7.5
Oct 96	31.9	23.1	27.4	93	62	77	9	7.6

Fig - 2

Meteorological observations,
Temperature (^{o}C), RH (%)
Year 1995

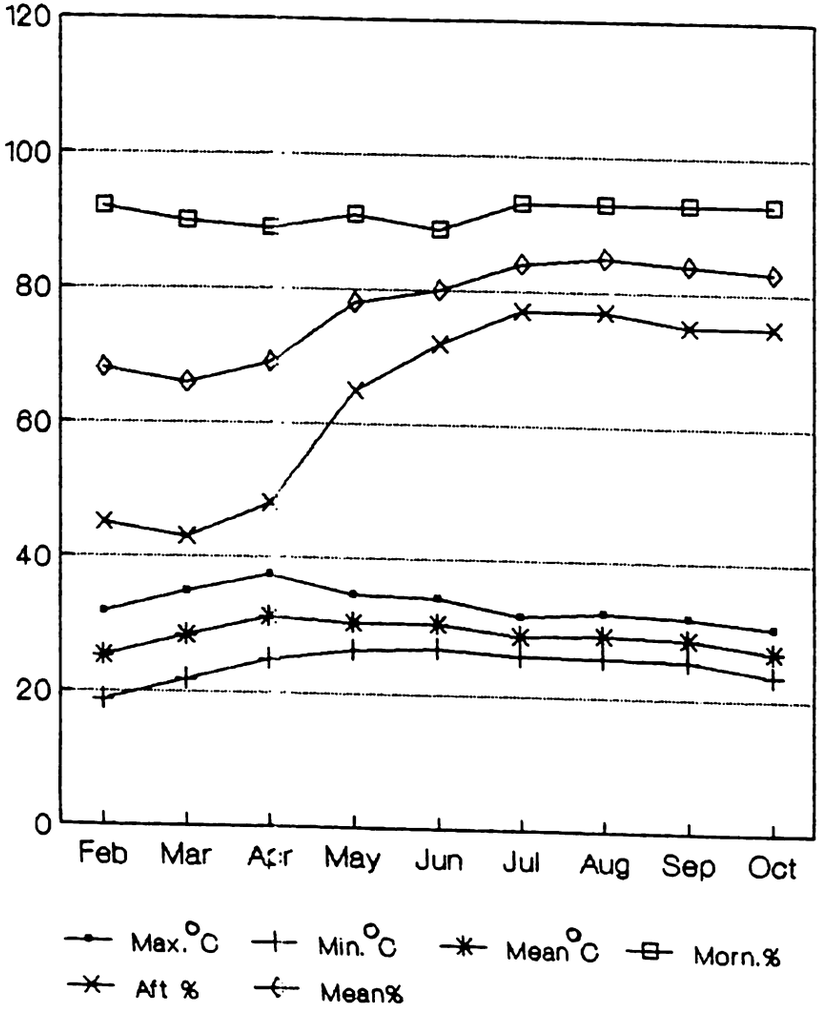
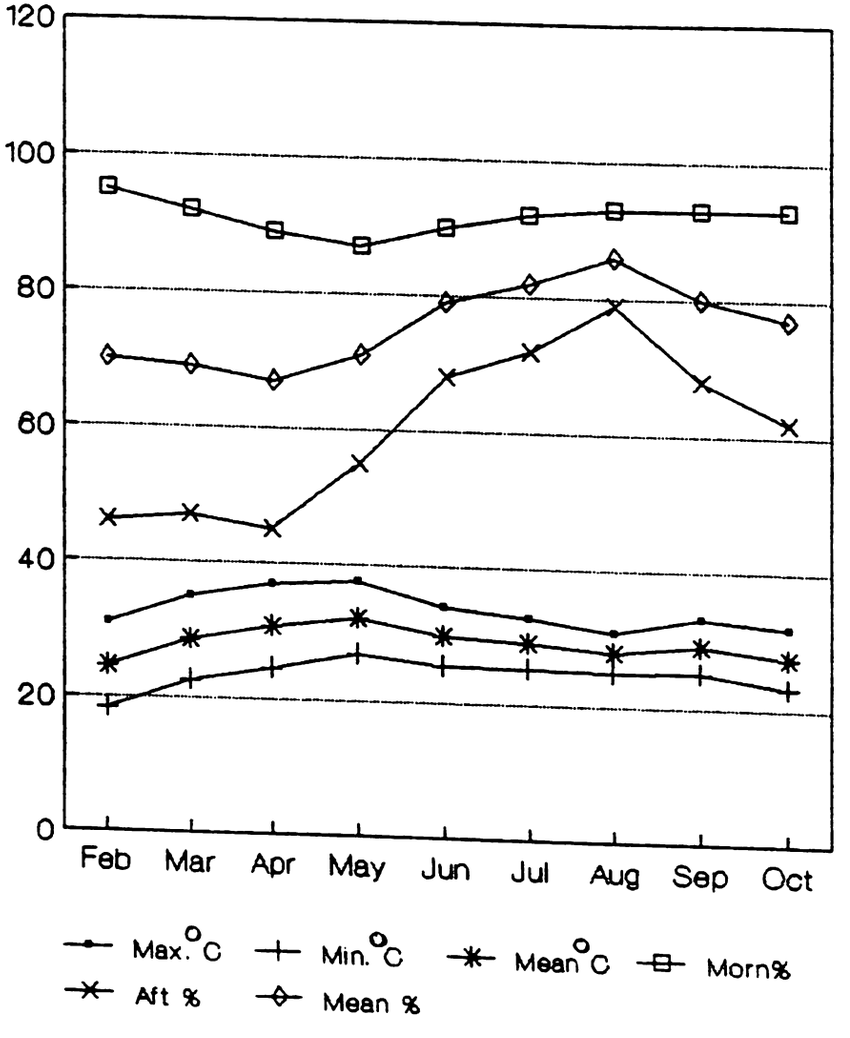


Fig - 3

Meteorological observations,
Temperature (^{o}C), RH (%).
Year 1996



Selection of trees

Healthy, vigorous, disease free trees grown under similar management condition were utilised for this study. Out of which three trees each from green and red type were selected for the study. Each tree served as one replication.

Selection of branches

Five laterals from each tree were randomly selected from the peripheral region of the tree. The new shoots appearing on these - lateral branches were labelled for recording observations on the date of initiation of flower bud; duration of flowering; developmental stages of flower bud, anthesis , anther dehiscence; pollen viability, duration of stigmatic secreations ; pollination and fruit set etc

Recording the observations

The observations were recorded from February '95 to October '95 and again repeated in the next year (i.e. February '96 to October '96).

Vegetative growth in relation to flowering.

After shedding of the leaves from the tree in the last week of December, new flushes that appeared were examined for development of flower buds. Later on observations were recorded on these developing buds to study position of flower bud on the shoot and time of cessation of flowering.

Duration of flowering

Observations were recorded regarding the time of initiation and cessation of flowering in both the types of custard apple. Difference between these two indiccated the duration of flowering.

Pattern of flowering

Observation were recorded regularly at 15 days interval regarding number of buds per shoot in both the years and both the types. From these observations, information regarding different phases of flowering with their peak period and intensity of flowering at different phases was obtained.

Flower bud development.

Observations were recorded daily on buds in the selected branches to know various stages of development of flower bud. In each stage the length and girth of flower buds were measured with the help of scale and vernier calliper respectively . The measurement of length of bud was made from the base of calyx to the apex and girth at maximum bulging point. The average values of length and girth of flower buds were recorded.

The number of days required for the bud to bloom and from each development stage to next were recorded . Finally average value was calculated. Colour changes of flower buds was also noted at each stage.

Flower Morphology.

Individual flowers were collected and their different morphological features like the type of flower, calyx, corolla, androecium, gynoecium were observed with a hand lens and recorded .

Anthesis

The flower buds on the selected branches which were to open on the following day were closely observed for study on anthesis. The number of flowers opened were counted by marking with white paint at the base on the flowers after their opening at an interval of six hours through out the day for three days to ascertain regarding the time of anthesis. The in order to confirm the exact time of anthesis buds were observed at hourly interval for one week . Average number of buds bloomed at a particular hour was found out.

Anther dehiscence

The flower buds on the selected shoots were examined at hourly interval commencing from 24 hours before anthesis to 24 hours after anthesis to ascertain the time of dehiscence of anthers Duration of anther dehiscence as well as its peak time was found out. The mode of anther dehiscence was observed with the help of a hand lens and recorded.

Studies on pollen morphology and viability

The pollens were collected from freshly opened flowers and were mounted on a clean glass slide and examined under microscope to know its shape. The colour of the pollen grains was observed under handlens. The pollen size was measured by means of stage and occular micro meter fitted to the microscope. Average values of 5 observations on pollen size was recorded.

For ascertaining pollen viability acetocarmine test was done. Pollens from a freshly dehisced anther was collected over a slide and 2 to 3 drops of acetocarmine was added to it. Then pollens were examined under microscope and number of viable pollens was found out and converted to percentage.

This study was carried out at monthly interval from the first phase of flowering and continued till complete cessation of flowering to know variation in pollen viability in different months.

Duration of stigmatic secretions

This was ascertained by examining the stigma with hand lens from one day prior to anthesis upto one day after the anthesis at hourly intervals. The receptive condition of stigma was indicated by secretion of fresh, shining liquid from the stigmatic surface. When this secreation dried up it indicated the cessation/duration of stigmatic secretions.

Pollination and fruitset.

150 flowers buds were labelled prior to their opening and bagged to study controlled self pollination. Similarly another 150 buds were labelled and left as such to find out the extent of natural pollination. Then observations were recorded regarding the number of buds that set fruits. From that percentage fruit set by controlled self pollination and natural pollination was calculated.

Flowers of green and red
type of custard apple

Fruits of green and red
type of custard apple

PART - II

Objective :

The seedling progenies of custard apple show wide variation in their growth yield and quality characters, which needs to be screened for finding out superior types with desirable characters. This has become essential to meet the requirement of quality planting materials in plantation programmes taken up in water shed areas and dryland zones.

Experimental Site and Period of Study

This investigation was carried out in the post harvest laboratory of the Department of Horticulture, Orissa University of Agriculture and Technology during the months of September - December'95. The temperature and relative humidity of the laboratory during the period of study has been presented in table number - 1 & 2

Sampling and Collection of Fruits

Healthy, disease free, high yielding [redacted] plants of custard apple growing in different parts of the state were selected for this study during August,1995. The trees were divided to four sectors i.e. North, South, East and West and, five shoots from each sector specifically from peripheral region were randomly selected and tagged. At maturity, five fruits from each sector were collected from these shoots for study of their qualitative characters. The

fruits were collected from various places in Orissa as mentioned in table- 3 .

TABLE NO.-3 Place of collection & general cahracters of custard apple fruit types.

Types	Place of Collection and address	Characteristics
T1	In front of Govt. Hospital, Keonjhar	Big fruits, round shape large, hexagonal segme-nts, light green in colour, distinct whitish coloured intersegmental space.
T2	Satyasai Mahal, Udala, Keonjhar.	Large fruits; green in colour; spherical shape; segments not so distinct and preshed.
T3	Lambodar Nayak, Khireitangi, near-Suakati, Keonjhar.	Large size fruit, dark green in colour. Hexagonal segment with a little inter segmental space.
T4	C. Kapila, Near Urban Co-op Bank, Baripada.	Medium fruit size, segments visible but notprominent; light green coloured fruit with spherical shape and compressed top.
T5	Chandara Jena, Village- Bainda, Near-Redhakhol, Angul dist.	Medium size fruits; distinct large segments; conical fruit shape ; Light green colour with partial pink flush at intersegmental portion.

T6	Bansidhar Sahoo, Village - Bainda, Near-Redhakhol, Angul Dist	Large, round fruits light green in colour, bold segments with no distinct intersegmental space. Segments are closely spaced.
T7	Qr.No-IVR/304,Unit-6 Bhubaneswar	Medium size fruits with medium size areoles and distinct intersegmental space. Light green in colour with ashy appearance in general.
T8	Harihara Das,Badasashan sahi Keonjhar.	Heart shaped fruits with medium segments; dark green in colour with greenish white intersegmental region.
T9	Qr No- ,O.U.A.T colony Bhubaneswar	Round fruits with conical base and flat top. Medium size segments light, green in colour with no distinct inter segmental portion which is cream coloured.
T10	QrNo- 3R-43, O.U.A.T Colony Unit-8, Bhubaneswar	Heart shaped fruits with tetragonal segm-ents. Light green coloured with white coloured intersegmental portion.

T11	M.Vaikuntham, Ananda Sarani, Badakhemundi saiextension, Berhampur (G.M)	Medium fruit size; light green colour, round fruits with not so distinct interseg-mental space.
T12	Rabindra Mahanti,Village-Madhunanda,P.O-Remuna, Balasore.	Medium to large fruits with small segments, green in colour, heart shape and flat base. Interseg-mental Portion is not so distinct.
T13	Radha Basanta Nibas, Pudamari, Berhampur, Ganjam.	Fruits small in size, round in shape with very large segments, light green in colour, and segments are sightly pressed
T14	Bisambare Bada, SeriRelli street. Near-Lakshmi Talkies Ward no-6, Gajapati Dist	Large, round to heart shaped fruits, dark green in colour, medium sized tetra-gonal segments light with a little intersegmental space.
T15	Village-Baghajhar, Kukudakhandi block, Dist-Ganjam.	Medium sized, heart shaped fruits with small segments, light green in colour, less interseg-mental space.
T16	Sarat Pattanaik, Chikiti town At/Po-Chikiti, Ganjam	Medium size, round shape fruits, with top compressed, light green

		in colour with distinct intersegmental space.
T17	D. Satyanarayana, Chhatrapur town, At/Po-Chhatrapur, Ganjam.	Medium fruit size bold segments light green in colour with light cream coloured intersegmental space and tetragonal segments.
T18	Jugal Kishore Maharana, House no-3R/1 Delta colony, Unit-8, BBSR-3.	Small sized roundish fruits with medium size segments and light green in colour.
T19	G. S. Pattanaik, House no- BE/67, Baramunda Housing board colony, Bhubaneshwar.	Medium round fruits fruits medium sized and hexagonal segments. Intersegmental space not so distinct with light green colour as a whole.
T20	Kirtana Jena, Postatala Janga, Puri Dist.	Small round fruits with small hexagonal and light green segments.
T21	Qr no- M - 101 Baramunda Housing Board colony Bhubaneswar	Small round fruits with small to medium sized segments. Intersegmental-space is light pink in colour.
T22	Qr No- N-1/57 Nayapalli, Near Ekamra Kanan, Bhubaneswar	Small to medium size fruits with round shape. Segments are small and placed

		close to each other with light cream colour inter space.
T23	Qr.No- VF - 16 O.U.A.T Colony,Unit-8 Bhubaneswar	Large fruits, spherical in shape yellowish green in colour and tetragonal segments.
T24	O.U.A.T Orchard Horticulture Research Station OUAT, Bhubaneswar	Medium fruits with red colour hexagonal segme-nts and almost round in shape.
T25	Medicinal Plant Scheme Horticulture Research Station OUAT, Bhubaneswar	Medium fruits with red colour tetragonal segments, round fruits with flat base.
T26	Qr.No-IVR/245, Unit-VI Bhubaneswar.	Small fruits, light green in colour, round shape with flat base and medium size segments and no distinct inter segmental space.
T27	Raniguda Farm Rayagada Koraput	Small, cordate fruits, small and closely spaced segments, dark green in colour.
T28	Near krushna Garage, Ganga nagar chhack, Unit - 6, Bhubaneswar.	Small to Medium fruits bold segments, light green in colour; with cream coloured inter-segmental space.

Characters Studied

Observations were recorded on the following characters of custard apple fruits

A. Physical Characters :-

1. Average Weight of the fruits(g):

The weight of the fruits harvested from the tagged shoots of various sectors of the plants were weighed on a balance and recorded. The average fruit weight was found out.

2. Average number of segments :-

Number of segments per fruit under observation was counted and recorded. The average number of segments was calculated out.

3. percentage of peel :

Fruits were opened and the pulp along with seeds were removed by the help of a stainless steel spoon and weight of peel was recorded and expressed as percentage of the total fruit weight.

4. Percentage of pulp:

In order to separate the seeds from the pulp extracted from the fruit the fruit extracts were diluted in water and the procedure followed by Kumar (1994). The pulp thus obtained was homogenous and freefrom seeds which was weighed and expressed as percentage of total fruit weight.

5. Average Number of Seeds:

Number of seeds per fruit under observation was counted and the number of seeds per fruit was found out.

6. Average Weight of Seeds (g);

Weight of seeds per fruit under observation was recorded after separating them from pulp. The average weight was found out and expressed in grams.

B. Biochemical Studies

7. Total soluble solids (T.S.S)

The total soluble solid content of custard apple pulp was recorded by a hand refractometer and the average T.S.S content was found out and recorded as percentage of T.S.S. type wise.

8. Titrable acidity (%)

Total titrable acidity of custard apple pulp was estimated by preparing a solution with 10g of the representative fruit sample. The total volume was made up to 100ml. by adding distilled water and then filtered. Twenty milliliter of this filtrate was taken in a 100ml. conical flask and titrated against accurately standardized 0.1N sodium hydroxide solution using 2 drops of phenolpthalein as indicator. The end point was indicated by the light pink colour. The results were expressed as percentage of citric acid as suggested by Ranganna(1977).

Calculation

1 ml. of 0.1 N NaOH = 0.0064 g. of citric acid (64 is the equivalent weight of citric acid)

$$\% \text{ of citric acid} = \frac{\text{Titrate value X Normality of alkali X volume made up X 64 X 100}}{\text{ml. of filtrate taken for estimation X volume of sample taken X 1000}}$$

9. Ascorbic acid content (as per Jacob, 1958 in mg./100g.) :

20 g. pulp from a known weight of fruit sample was taken in a conical flask. The total volume was made up to 100 ml. by adding distilled water and filtered. 10 ml. of this filtrate was taken in a 100 ml. conical flask, followed by addition of 20 ml. of distilled water and 2 ml. of one percent starch solution as indicator. Then it was titrated rapidly against an accurately standardised 0.1 N iodine + potassium iodide solution (13g. of iodine + 24 g. of potassiumiodide in 1000 ml. of water) to a violet end point. The titration value was recorded and ascorbic acid content was expressed in mg./100g. of edible portion.

Calculation

Each ml. of iodine solution is equivalent to 0.88 mg. of ascorbic acid.

$$\text{Ascorbic acid (mg./100g)} = \frac{0.88 \times \text{litre X 100 X 100}}{\text{Weight of sample taken (20g) X volume taken for estimation (10ml.)}}$$

10. Total sugar as per Lane and Eynon (1960) :

10 g. of pulp from the representative sample was taken in a conical flask. To it 50 ml. of distilled water was added followed by addition of 5 ml. of 2 N Hcl. The sample was boiled for 10 minutes for conversion of non reducing sugar to reducing sugar. Then it was cooled at room temperature. The sample was filtered and the solution was made neutral by adding 1 N NaOH with 2 drops of phenolpthalein indicator till a light pink colour was obtained. Then the sample was made to 100 ml. by adding distilled water.

5 ml. each of fehling 'A' and fehling 'B' solution was pipetted out to a 100 ml. conical flask to which 40 ml. of distilled water was added and the mixture was put over flame. When it started boiling, 3-4 drops of methylene blue indicator was added. Titration was carried out taking sugar solution in the burrette and fehling solution on the flame until a brick-red colour end point was reached and the titration value was recorded.

Calculation

10 ml. fehling solution = 50 mg. of glucose.

$$\% \text{ of total sugar} = \frac{\text{mg. of invert sugar(50) X Dilution(100) X 100}}{\text{Titrate value X volume of sample X 1000}}$$

11. Reducing sugar :

5g. of pulp from the representative sample was taken in a conical flask and the total volume was made upto 50 ml. by adding distilled water and filtered. This filtrate was taken in a burrette for titration.

5 ml. each of fehling 'A' and fehling 'B' solution was pipetted out to a 100 ml. conical flask to which 40 ml. of distilled water was added and the mixture was put over flame and at boiling 2-3 drops of methylene blue indicator was added. This was itrated against the sample solution taken in the lurrette to a brick-red end point. The volume of sample solution utilised was noted.

Calculation

10 ml. of fehlings solution = 50 mg. of glucose

% of reducing sugar

$$= \frac{\text{mg. of invert sugar (50) X Dilution (50) X 100}}{\text{Titrate value X volume of sample taken x 1000}}$$

12. Yield per plant under various types :

Average yield of the plants under various types was calculated by multiplying average weight of the fruits with total number of fruits borne and expressed in kg./plant.

Statistical analysis :

1. The data recorded on various characters of fruit samples were statistically analysed following a completely

Randomised Design (Gomez and Gomez, 1976) with 28 types replicated thrice. The significance of the types, were tested by 'F' test and the standard error of means and critical difference were calculated by using the fromulae mentioned below :

a. S. E. (m) for types $= \pm \sqrt{\frac{\text{Error mean square}}{\text{Number of replication}}}$

b. C. D. for type means =

= S. E. (M) x 1.414 X 't' value at error degree of freedom at 5% level.

II. Metroglyph and Index score analysis :

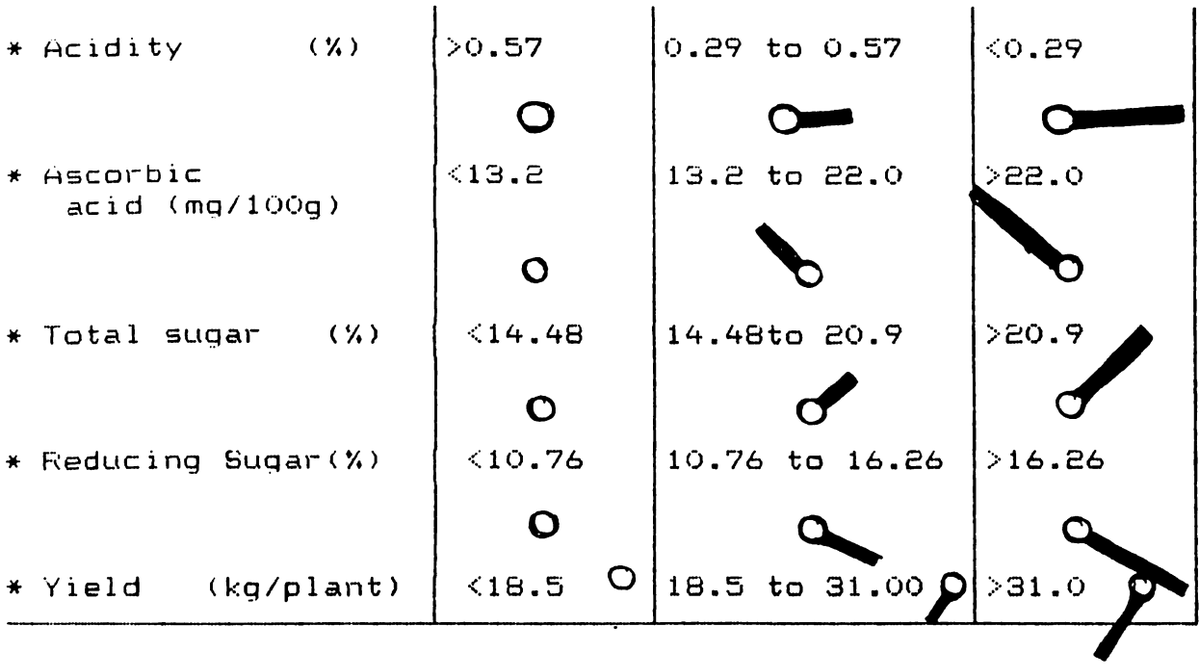
A number of metric traits were recorded but, metroglyph and index score analysis was carried out with those characters which were found to be economically important. Metroglyph and index score analysis was carried out as per the methods suggested by Anderson (1957). The class intervals of the various morphological traits are presented in Table No. – 4 The range in each character has been represented by the different positions of the rays on the glyph. The index scores have been obtained by allotting numerical values to the three grades of expression recognised in respect of each character and summing up the scores received by each type for all the eleven charecters. As suggested by Anderson (1957), different custard apple types have been awarded a value of 1 or 2 or 3 depending on desirability of the character. So, a maximum score one sample can get is 33.

Different types were presented in the scatter diagram taking fresh weight and pulp % as two variables and other characters were presented in from of rays on the glyph. Then they were grouped into 4 groups characterised by Gr - I (High pulp percentage and high fruit weight), Gr - II (High pulp percentage and low fruit weight), Gr - III (Low pulp percentage and high fruit weight) and Gr - IV (Low pulp percentage and low fruit weight).

Table No. 4 Class intervals of the qualitative characters of custard apple.

Qualitative Character	Index Values		
	1	2	3
* Fresh fruit weight (g)	<197.6	197.6 to 283	>283
* Pulp content (%)	<40.0	40.0 to 58.0	>58.0
* Peel Content (%)	>55.0	39.0 to 55.0	<39.0
* Seed number (no)	>50.0	31.0 to 50.0	<31.0
* Seed Weight (g)	>18.0	11.0 to 18.0	<11.0
* T.S.S (o brix)	<15.0	15.0 to 19.0	>19.0

* Acidity (%)	>0.57	0.29 to 0.57	<0.29
* Ascorbic acid (mg/100g)	<13.2	13.2 to 22.0	>22.0
* Total sugar (%)	<14.48	14.48to 20.9	>20.9
* Reducing Sugar(%)	<10.76	10.76 to 16.26	>16.26
* Yield (kg/plant)	<18.5	18.5 to 31.00	>31.0



III. Numerical taxonomic classification

A numerical classification of collected types was subjected to numerical taxonomic analysis (Sneath and Sokal, 1973) based on 12 characters (i.e. yield, fruit weight, number of segments, peel percentage, pulp percentage, seed number, weight of seeds per fruit, T. S. S. percentage, acidity percentage, ascorbic acid content total and reducing sugar percentage). The S_G (similarity coefficient of Gower) values were calculated for the purpose and a dendrogram was constructed based on S_G values following a UPGMA (unpaired group mean averages clustering strategy. Then final conclusion regarding superior types with desirable character was identify.

IV. The data recorded on different parameters of custard apple types were analysed for their correlation and character association studies. As per the procedure given by Panse and Sukhatme (1985).

A. Simple Linear Correlation Coefficient

$$r = \frac{XY}{\sqrt{X^2 \cdot Y^2}}$$

The significance of the simple linear correlation coefficient were tested by comparing the computed 'r' value to the tabular 'r' value with (n-2) degrees of freedom at 5% and 1% level of significance.

CHAPTER - IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

PART - 1

The results of the study on floral biology of custard apple (green and red type) have been presented in this chapter . The data recorded on various characters pertaining to the floral biology has been presented under appropriate heads.

Vegetative growth in relation to flowring :

It was observed that the flower bud development followed complete shedding of leaves at the latter part of December which was followed by the appearance of new vegetative flushes towards the end of January. These vegetative flushes contained rudimentary flower buds in the extra axillary position of the newly developed shoots mostly and few were borne on the older branches of both green and red types of Annona squamosa. These flower buds were borne in clustures of two to five in newly developed shoots but singly when it appeared on the older branches .

Duration of flowering

It was observed that, the flower buds of Annona squamosa developed in the last week of march in green type, where as in the 2nd week of march in red type. The development of new flushes containing flower buds continued upto the first week of September in green type but in red type flowering process ceased by 2nd week of July in the year 1995.

Table no- 5 **Duration of flowering in Annona squamosa (green and red type)**

Flowering time	Green type			Red type		
	Year		No. of. flushes	Year		No. of. flushes
	1995	1996		1995	1996	
Initiation of flowering	March last week	February last week	THREE	March 2nd week	Feb 2nd week	TWO
Cessation of flowering	September 2nd week	September 3rd week		July 2nd week	August 1st week	
First flush/ phase	Mar 26th to June 2nd	Feb 21st to April 24th		Mar 15th to Jun 17th	Feb 18th to June 1st	
Second flush/ phase	June 5th to July 15th	May 1st to July 21st		Jun 15th to Jul 10th	June 5th to Aug 5th	
Third flush/ phase	July 24th Sept 10th	July 20th Sept 18th		- No -	- No -	
Total duration of flowering	Five and half months	Nearly seven months		Nearly four months	Five and half months	

In 1996, flowering commenced form last week of February and 2nd week of February in green and red type respectively which continued upto the 3rd week of September and Ist week of August respectively in case of green and red types. These results have been presented in the table no -5 and graphically in Fig .4 (a),(b)

Pattern of flowering

It was observed that in both the types of Annona squamosa flowering was a continuous process for a definite period with varying intensity that can be observed form the table no-6 and fig -. 4(a), 4(b)

It was observed from the table and graph that in green type 3 peaks were observed in flowering in both the year 1995 and 1996; but in red type two peaks were observed in both the years. In green type, the 3 folowering phases were : 26th March to 2nd June '95; 5th June to 15th July and 24th July to 10th September '95 but in the year 1996, the respective phases were 21st February to 24th April; 1st May to 21st July and 20th July to 18th September. Similarly in red type two flowering phases were: 10th March to 19th June; 15th June to 10th July in 1995, but in the year 1996 the two respective phses were from 18th February to 1st June and 5th June to 5th August.

The peak period of flowering was observed in green type on pril 26th; July 10th and August 10th in the year 1995 but in the ear 1996, those pears were April 10th, June 26th and August 0th. Similarly, in red types April 26th and June 26th were the vo peaks in 1995 and also in 1996.

Table No. 6 Pattern of flowering in Annona squamosa (green and red type).

Date of observation	Average no of flower & shoot			
	Green type		Red type	
	1995	1996	1995	1996
Feb 25th	-	0.3	-	0.8
Mar 10th	-	3.2	0.6	2.9
Mar 26th	0.9	4.8	6.6	4.8
Apr 10th	9.8	18.5	10.8	10.2
Apr 26th	20.5	10.2	16.4	18.2
May 10th	16.8	0.9	14.8	9.3
May 26th	9.8	3.2	7.3	5.9
June 10th	0.8	5.4	3,5	2.2
June 26th	4.4	9.8	5,1	3.6
July 10th	6.8	4.9	3.8	1.3
July 26th	0.9	3.2	1.3	0.4
August 10th	4.95	4.8	0.0	0.1
August 26th	3.65	2.9	-	0.0
September 10th	0.0	1.4	-	-
September 26th	-	0.0	-	-
Grand average no. of flowers/shoot	7.66	5.25	6.92	4.97

Fig - 4 (a)

Duration and pattern of flowering in Annona squamosa (green type)

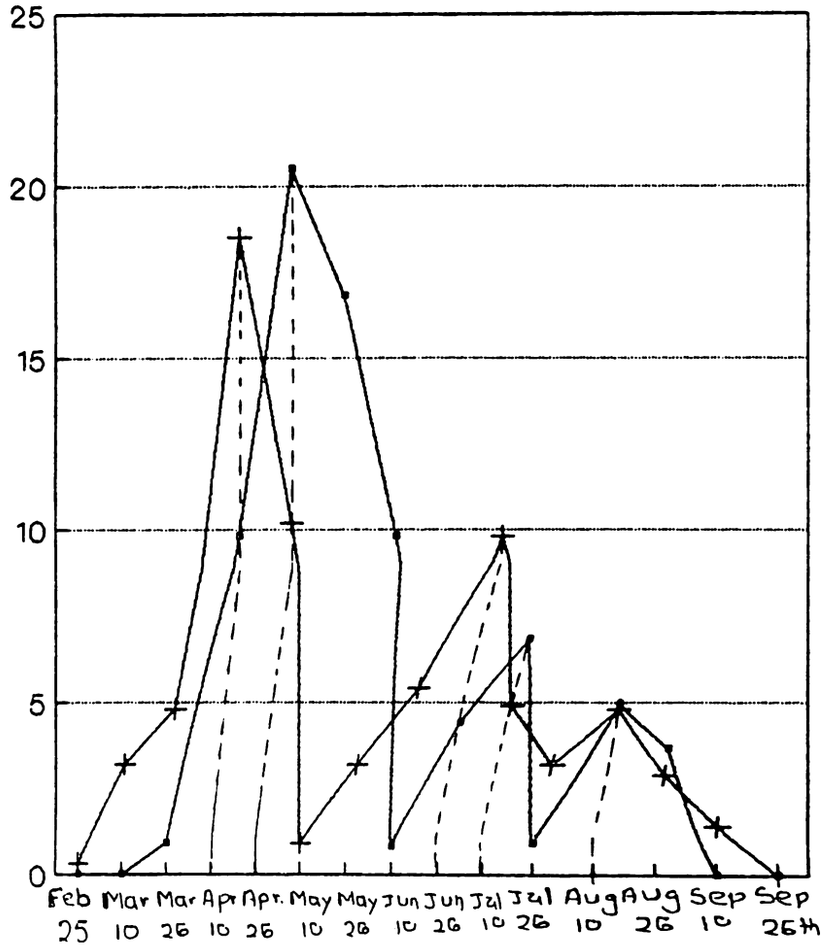
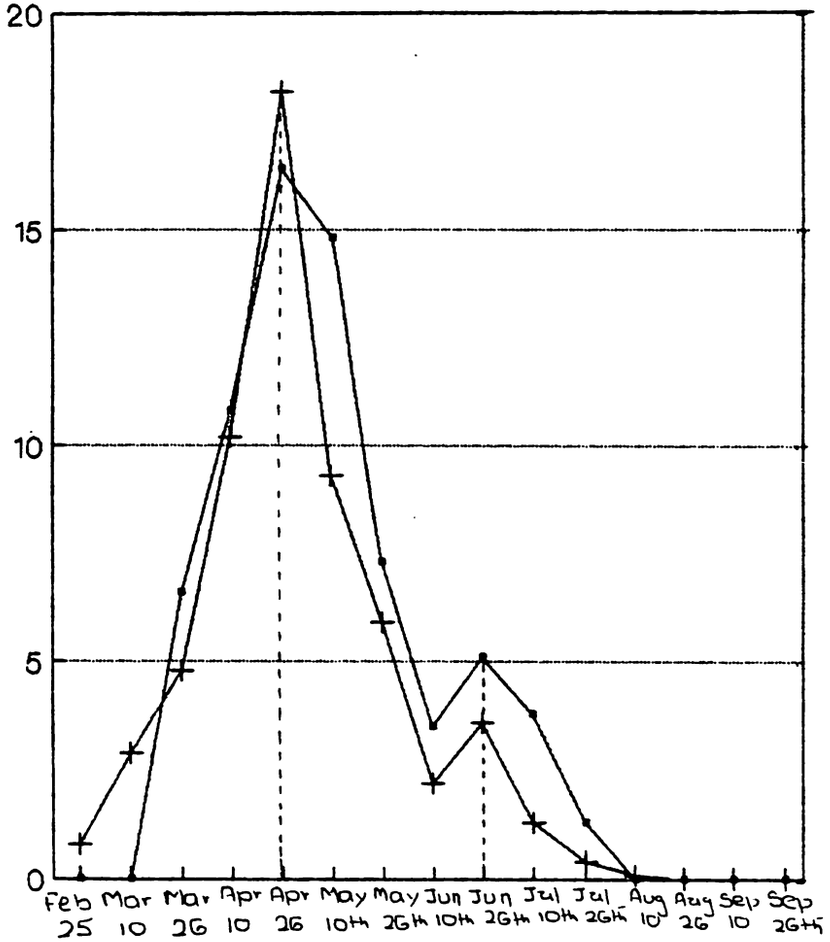


Fig - 4 (b)

Duration and pattern of flowering in Annona squamosa (red type)



Flower bud development

Systematic observations were recorded on the tagged shoots for the progress of bud development. These observations revealed the fact that the whole phase of bud development starting form bud initiation to full bloom condition can be divided into 5 phases as mentioned below ----

I Bud initiation phase ;

II Bud development phase ;

III Bud elongation phase ;

IV Bud plumping phase ;

V Bud transition phase ;

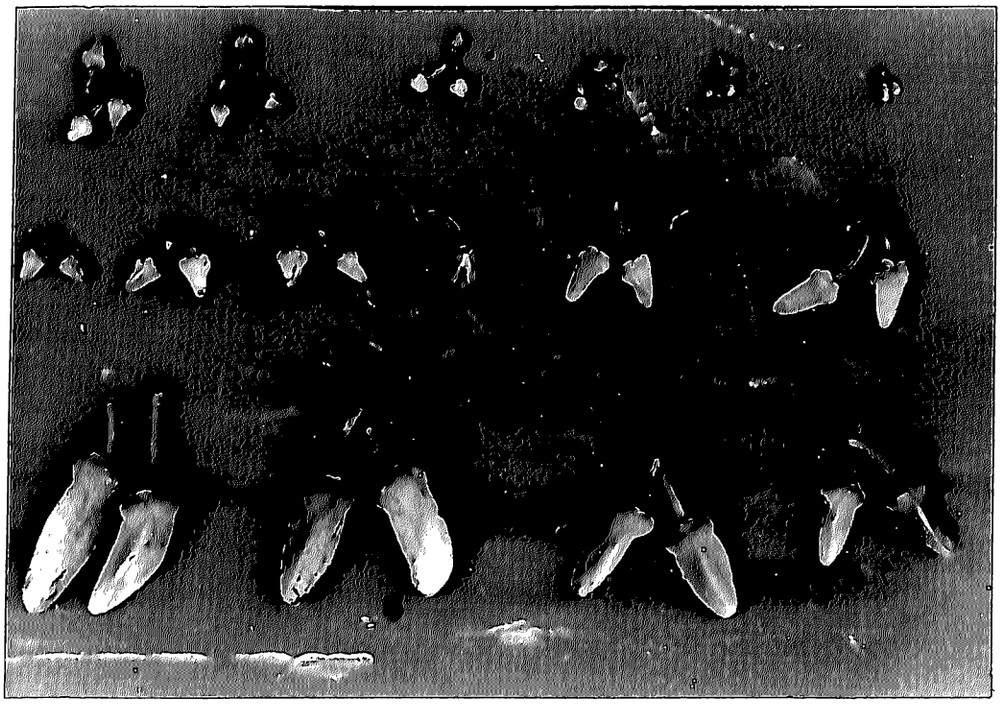
Detailed information regarding the above mentioned phases of bud development has been mentioned in table no - 7 and figure no. - 5 .

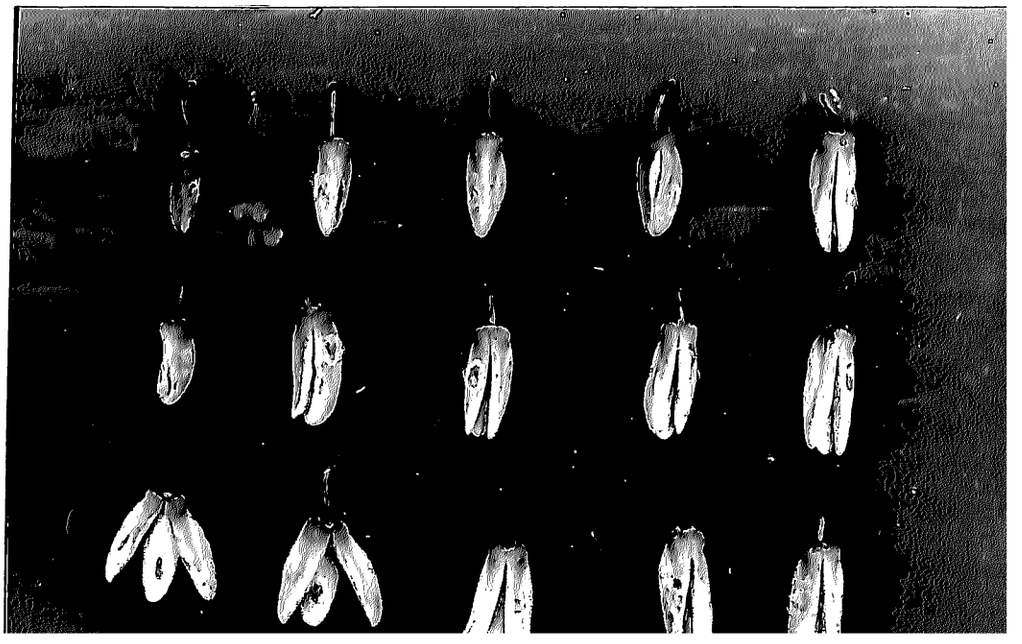
It was observed from the table - 8 that total time required for bud development ranged form 30 to 35 days and 28 to 32 days in green and red types respectively with an average of 31,85 days and 29.5 days respectively.

Flower morphology

A detail study of the flowers of custard apple types revealed that the flowers were solitary, and developed in in clusters of 2 to 5. They were complete regular, bisexual, hypogynous, trimerous. Calyx and carolla were modified to form tepals. Number of tepals found to be three, polytepalous, arranged in valvate aestivation. Stamens numerous, free, spirally

Flowering twig with various stages of bud development.





Stages of flower bud development

Table 7 Stages flower bud development in Annona squmosa (green and red type).

Change in	Size of the bud		Colour of the bud		Duration of each phase	
Shape of bud at each phase	Green type	Red type	Green type	Red type	Green type	Red type
Phase - 1 Bud initiation phase					4 days	3 days
(a) Rudimentary bud	Minute point	Minute point	Deep green	Light green	2 days	1 days
(b) Roundish, Minute bud	0.1cm.L Girth ($0.0314cm^2$)	0.1cm.L Girth ($0.0314cm^2$)			2 days	1 days
Phase - II Bud development phase					2 days	2 days
(a) Roundish bud with flat top	0.2cm.L Girth ($0.282cm^2$)	0.2cmL Girth ($0.125cm^2$)	Light deep	Light green	1 days	2 days
(b) roundish bud with pointed tip	0.3cmL Girth ($0.282cm^2$)	0.2cmL Girth ($0.125cm^2$)	green		1 days	1 days
Phase - III Bud elongation phase					20 to 24 days	20 to 22 days
(a) Bud tip elongates with slight increase in girth.	2.6cm to 3.5cm L	1.8cm to 2.4cm L	Light deep	Purplish green	20 to 24 days	20 to 22 days
(b) Increased tepal thickness.	Girth ($0.282cm^2$)	Girth ($0.124cm^2$)	green			
Phase - IV Bud Plumping phase					2-3 days	2-3 days
Elongated bud become plumpy with thickest petals	2.6 to 3.5cm L Girth (1.131 to $3.142cm^2$)	1.8 to 2.4cm L Girth (0.125 to $0.502cm^2$)	Light green	Sage green	2 to 3 days	2 to 3 days

Phase - V	Bud Transition Phase				2 days	1 to 2d
(i) Sutures along the tepal become distinct with tight tip. (ii) Sutures start to open from base to tip but tip is sight. (iii) Tip starts to open (iv) Tepals reflex outwards exposing whole interior floral part outside.	2.6cm to 3.5cm L Girth (1.131 to 3.142cm^2)	1.8cm to 2.4cm L Girth (0.125 to 0.502cm^2)	Bright Lustovous green	sage green	2 days	1 to 2 days
Total Duration -					30 to 35 days	28 to 32 days

Table 8 Days taken from flower bud initiation to full bloom.

Flower bud number	Date of initiation		Date of full bloom		No.of days taken to full bloom		Average No. of days to full bloom	
	1995	1996	1995	1996	1995	1996	1995	1996
Green type 1	June 5th '95	May 1st '96	5th July	3rd June '96	30	33		
2	"	"	7th July	31st May '96	32	30		
3	"	"	10th July	2nd June '96	35	32		
4	"	"	7th July	1st June '96	32	32		
5	"	"	9th July	31st May '96	34	31	31.8	31.9
6	"	"	5th July	4th June '96	30	30		
7	"	"	6th July		31	35		
8	"	"	7th July	2d June '96	32	34	31.85	
9	"	"	5th July		30	32		
10	"	"	7th July	31th May '96	32	30		
Red type 1	June 15th'95	June 5th '96	13th July	5th July '96	28	30		
2	"	"	13th July	6th July '96	28	31		
3	"	"	15th July	4th July '96	30	29		
4	"	"	17th July	3rd July '96	32	28		
5	"	"	15th July	5th July '96	30	30		
6	"	"	16th July	7th July '96	31	32	29.2	29.8
7	"	"	13th July	3rd July '96	28	28		
8	"	"	14th July	4th July '96	29	29		
9	"	"	13th July	6th July '96	28	31	29.5	
10	"	"	13th July	5th July '96	28	30		

Fig - 5

Changes in length and girth of flower bud during different stages of development in Annona squamosa.

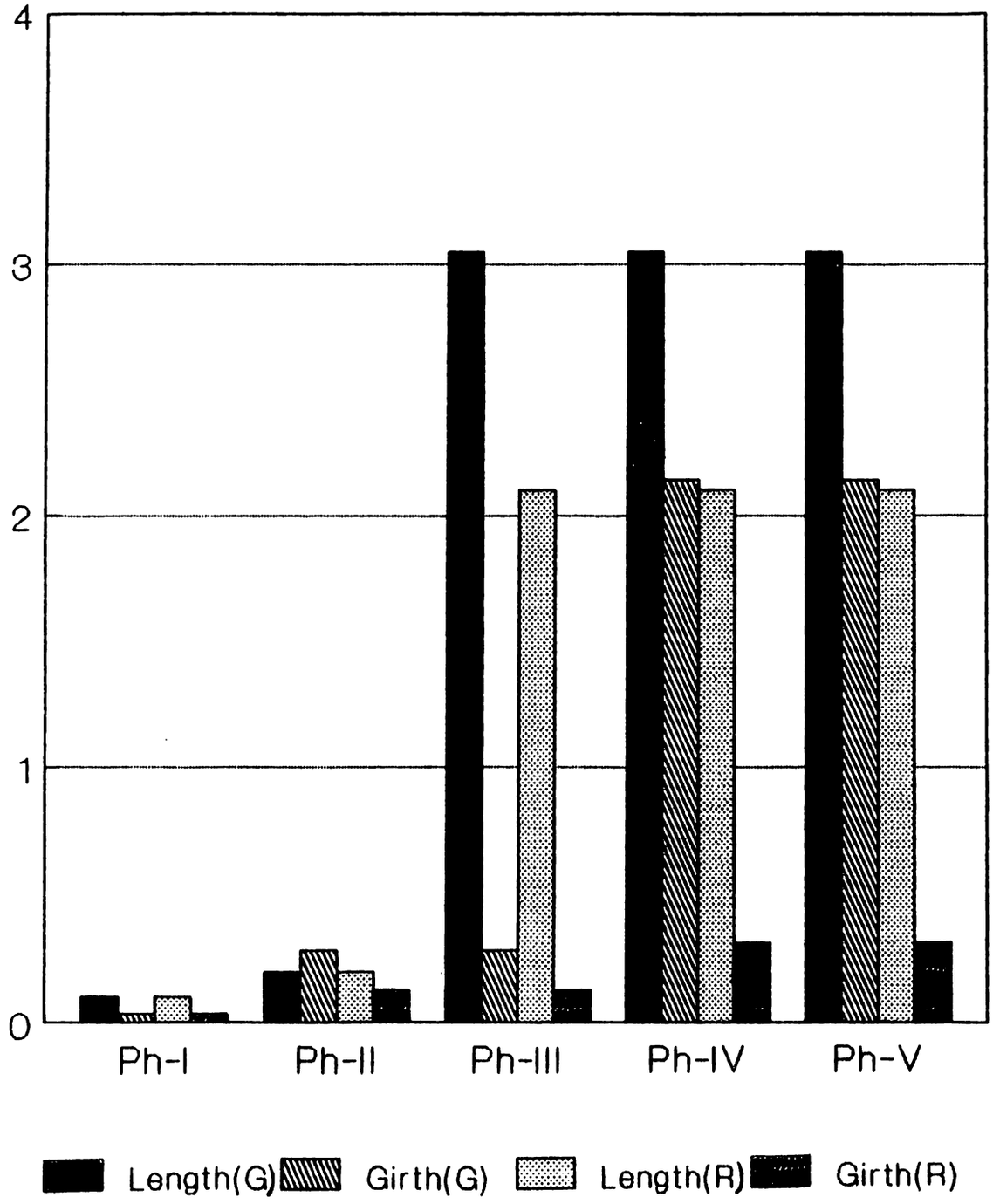
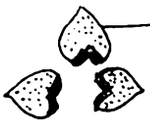
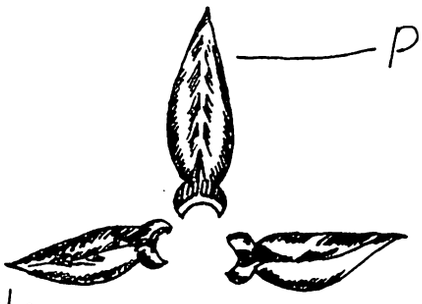


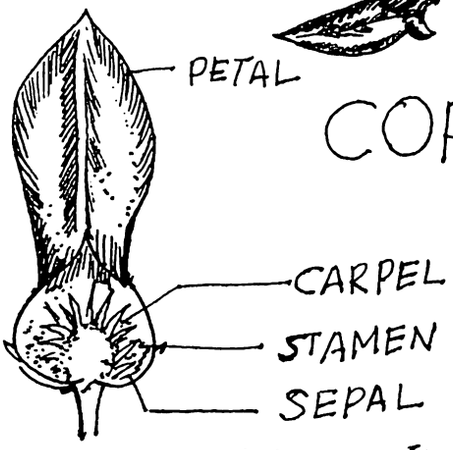
Fig - 6



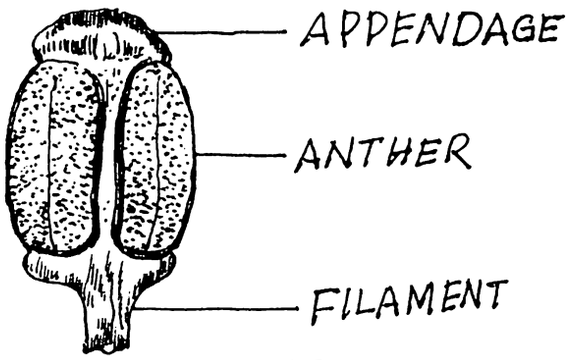
CALYX



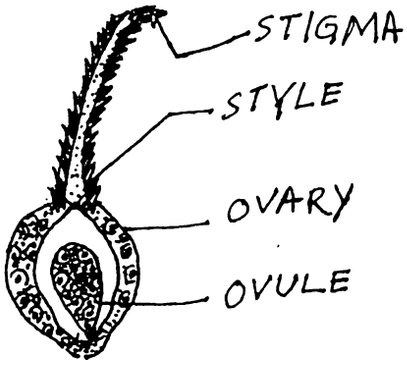
COROLLA



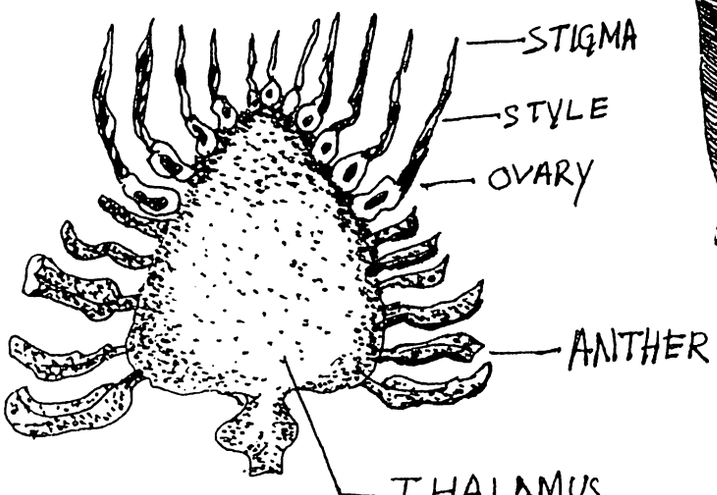
L.S. OF FLOWER



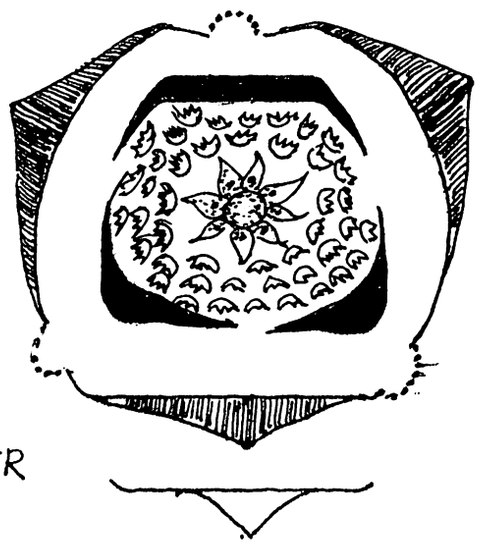
STAMEN



CARPEL



L.S OF THALAMUS



FLORALDIAGRAM

arranged on a slightly convex receptacle. Filaments short and thick, anthers linear, four celled, overtopped by a prolonged connective. Carpels numerous, apocarpous, spirally arranged on the raised receptacle succeding stamnes. Ovary superior, ovules arranged in marginal placentation, style absent, stigma small and simple. (figure no. 6). In case of green type, colour of flower is bright lustorous green. But in red types, colour of the fully opened flower is sage green.

Anthesis

It was observed that during anthesis the apices separated from each other and gradually the petals reflexed outwards till the pistils and stamens were exposed.

It was evident form the table -9 that this process took 34 to 38 fours and on an average green and red types took 36.13 hrs and 36.5 hrs respectively. It was observed form the table no --10, and figures no. - 7(a),(b) that the time of anthesis is restricted between 2.30 am to 6.30 am. Maximum percentage of flowers opened (i,e. 55.57 % and 48.42 %) between 5.30 am to 6.30 am in green and red types respectively. Minimum percentage of flowers opened between 2.30 am to 3.30 am in both types (i,e. 6.0%).

Anther dehiscence

It was observed that dehisence of anther took place a longitudinal slit which appeared near the basal end of pollen sac then proceeded towards the end. In some cases it also

Table No 9 Total time required for completion of anthesis.

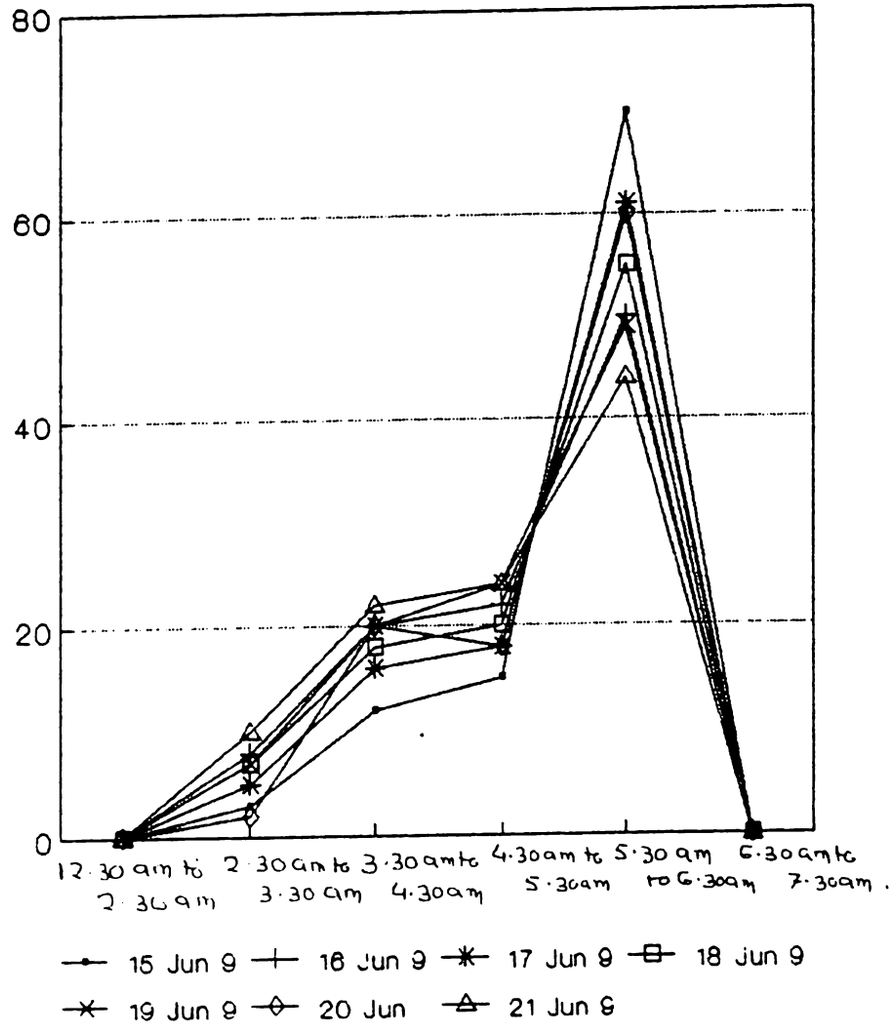
Bud no.	Initiation of anthesis	Completion of anthesis	Total time required	Average time required
Green type 1	4.30pm	2.30am	34hrs	
2	"	6.30am	38hrs	
3	"	5.30am	37hrs	
4	"	3.30am	35hrs	
5	"	6.30am	38hrs	
1	4.30pm	6.30am	38hrs	
2	"	6.30am	38hrs	
3	"	3.30am	35hrs	36.13hrs
4	"	2.30am	34hrs	
5	"	5.30am	37hrs	
1	4.30pm	2.30am	34hrs	
2	"	6.30am	37hrs	
3	"	3.30am	35hrs	
4	"	2.30am	34hrs	
5	"	6.30am	38hrs	
Red type 1	4.30pm	5.30am	37hrs	
2	"	6.30am	38hrs	
3	"	6.30am	38hrs	
4	"	3.30am	35hrs	
5	"	3.30am	35hrs	
1	4.30pm	2.30am	34hrs	36.5hrs
2	"	6.30am	38hrs	
3	"	5.30am	37hrs	
4	"	6.30am	38hrs	
5	"	3.30am	35hrs	

Table No. 10 Time of anthesis in Annona Squamosa.

	percentage of flowers opened.							
[Green type]	6.30am to 12.30pm	12.30to 6.30pm	6.30to 12.30am	12.30to 2.30am	2.30to 3.30am	3.30to 4.30a.	4.30to 5.30am	5.30to 6.30am
15th June '95	- Nil-	- Nil	- Nil	- Nil	3	12	(15)	70
16th June '95	- Nil	- Nil	- Nil	- Nil	8	20	22	50
17th June '95	- Nil	- Nil	- Nil	- Nil	5	16	18	61
18th June '95	- Nil	- Nil	- Nil	- Nil	7	18	20	55
19th June '95	- Nil	- Nil	- Nil	- Nil	7	20	24	49
20th June '95	- Nil	- Nil	- Nil	- Nil	2	20	18	60
21th June '95	- Nil	- Nil	- Nil	- Nil	10	22	24	44
Average for the Week	- Nil	- Nil	- Nil	- Nil	6.0	18.28	20.14	55.57
[Red type]	6.30 to 12.30pm	12.30 to 6.30pm	6.30 to 12.30am	12.30 to 2.30am	2.30to 3.30am	3.30to 4.30am	4.30to 5.30am	5.30to 6.30am
15th June '95	- Nil	- Nil	- Nil	- Nil	6	25	18	51
16th June '95	- Nil	- Nil	- Nil	- Nil	6	20	22	52
17th June '95	- Nil	- Nil	- Nil	- Nil	3	22	28	47
18th June '95	- Nil	- Nil	- Nil	- Nil	8	23	30	39
19th June '95	- Nil	- Nil	- Nil	- Nil	9	24	15	52
20th June '95	- Nil	- Nil	- Nil	- Nil	10	20	23	47
21st June '95	- Nil	- Nil	- Nil	- Nil	0	25	24	51
Average for the Week	- Nil	- Nil	- Nil	- Nil	6.0	22.71	22.85	48.42

Fig - 7(a)

Time of Anthesis in Annona squamosa (green type).



7(b)

Time of anthesis in Annona squamosa (red type).

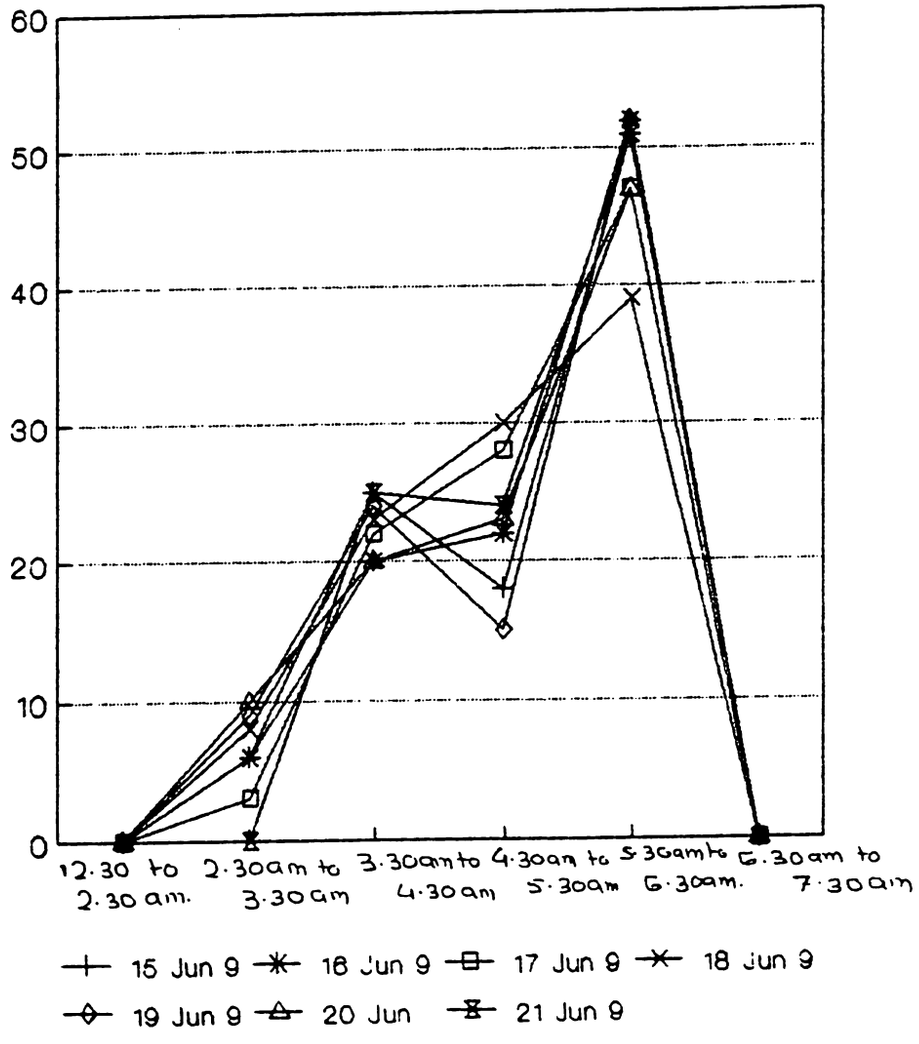


Table No 1 Time of anther dehiscence in Annona squamosa

Type	% anther dehiscence in flowers (number of flowers where anthers dehisced)					
	4.00-4.30pm	4.30-5.00pm	5.00-5.30pm	5.30-6.00pm	6.00-6.30pm	6.30-7.00pm
Green type	Nil	8.33	16.67	41.27	33.33	Nil
	0.01	(2)	(4)	(10)	(8)	( )
	Nil	21.05	15.78	42.10	21.05	Nil
	(0.0)	(4)	(3)	(8)	(4)	( )
Total number of flowers observed	43		Peak period of anther dehiscence		5.30 to 6.00pm	
Red type	Nil	7.69	23.07	46.14	23.07	Nil
	( )	(1)	(3)	(6)	(3)	( )
	Nil	18.75	12.5	50.0	18.75	Nil
	( )	(3)	(2)	(8)	(3)	( )
Total number of flower observed	29		Peak period of anther dehiscence		5.30-6.00pm	

appeared in the middle of pollen sac and then proceeded towards both the ends. It took about 3 minutes for repturing of the pollen sac after appearance of slit.

It is observed form the table - 11 that anther dehiscence started at about 4.30 pm and continued upto about 6.30 pm. after which there was no dehiscence. Maximum dehiscence of anthesis was observed between 5.30 pm to 6 pm.

Pollen studies .

Pollen Morphology

Shape of the pollen was found to be round to oval with yellow colour in green type and erythrite red colour in red type. It was observed form the table 12(a) that the diameter of pollen ranged between 53.15 µ to 53.8 µ in green type and between 47.816 µ to 48.26 µ in red type with an average diameter of 53.495 µ and 48.093 µ in green and red types respectively.

Pollen Viability

It was observed form the table 12(b) that % pollen viability ranged between 42.3% to 93.33% in green type and between 45.1% to 93.75% in red type with an average pollen viability of 68.125% and 65.818% in green and red types respectively.

Duration of Stigmatic secreation:

The stigma receptivity was marked by exudation of fresh and shiny secretions from the stigmatic surface. The stigmatic

Table 12(a) Pollen size of Annona squamosa

Date of observation	Average diameter in ocular div.		Average pollen dia in μ	
	Green type	Red type	Green type	Red type
25th March '95	9.56	8.62	53.15	47.927
25th April '95	9.63	8.675	53.54	48.233
25th May '95	9.65	8.60	53.654	47.816
25th June '95	9.65	8.675	53.654	48.233
25th July '95	9.68	8.68	53.820	48.260
25th Aug '95	9.56	-	53.153	-
Average	9.621	8.65	53.495 μ	48.093 μ

Table No 12(b) Pollen viability studies in Annona squamosa

Date of observation	No.of Pollen observed		No.of pollens stained		No.of pollens unstained		%of pollen viability	
	Green type	Red type	Green type	Red type	Green type	Red type	Green type	Red type
25th March 95	138	106	58	48	80	58	42.3	45.1
25th April '95	150	123	78	62	72	61	52.2	50.8
25th May '95	178	166	115	106	63	60	64.6	63.85
25th June '95	214	127	143	96	71	31	66.8	75.59
25th July '95	105	32	94	30	11	2	89.52	93.75
10th Aug '95	90	-	84	-	6	-	93.33	-

Average % pollen viability= Green = 68.125 Red = 65.818

secretion started one day prior to anthesis and reached its peak just at the time of anthesis after which stigmatic surface dried up which was two to three hours after anthesis. So the stigmatic secretions were stopped by the time when there was maximum anther dehiscence.

Pollination and fruit set:

The observations regarding percentage fruit set under controlled self pollination and natural poollination have been presented in table no. - 13(a);(b)

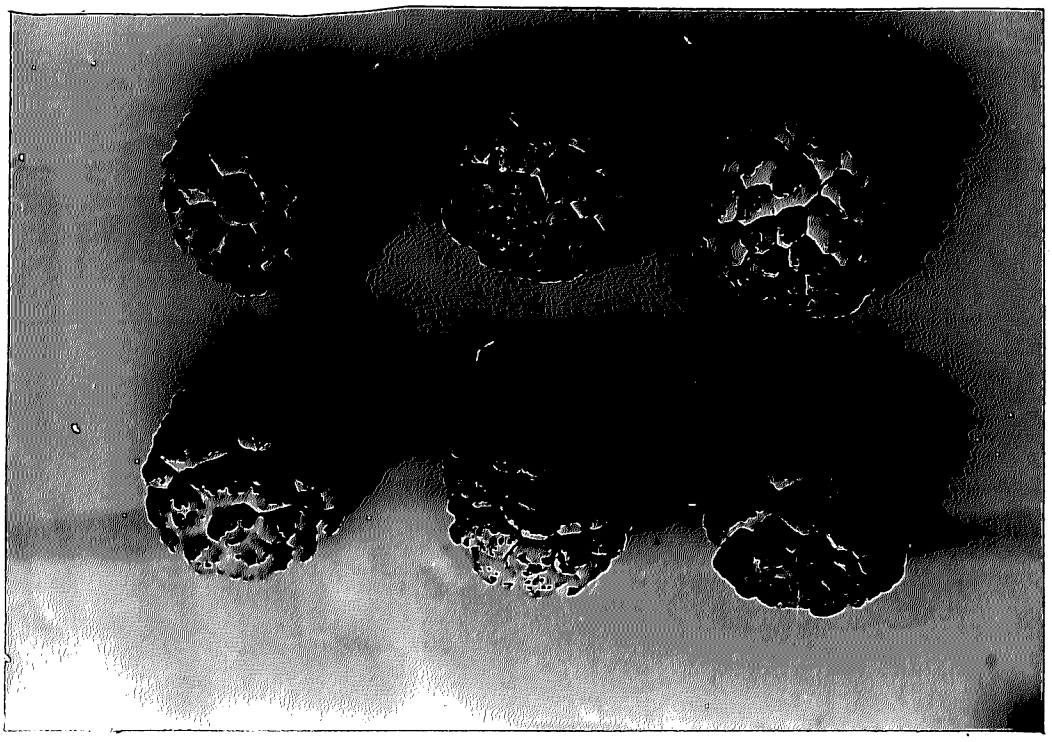
Persual of the data on percentage fruit set under different methods of pollination presented in table no. - 13 (a) and (b) revealed that there was only 3.33% fruitset under natural pollination and 0.75% fruitset under controlled self pollination. Therefore in total 4.08% fruitset by self and natural pollination.

Table No 13a Percentage fruit set under natural pollination in Annona squamosa

Number of flower buds observed	Total no. of buds observed	Number of buds setting fruit	Total no. of fruits set	% fruit set
15	150	0	5	3.33
15		1		
25		0		
20		0		
25		2		
15		0		
15		1		
20		1		

Table No. - 13b) Percentage fruit set under controlled self pollination.

Number of flower buds bagged	Total no. of buds bagged	Number of buds setting fruit	Total no. of fruits set	% fruit set
20	150	0	2	0.75
15		0		
15		0		
25		0		
15		0		
20		1		
25		1		
15		0		



Variation in shape of segments of custard apple fruits

PART - II

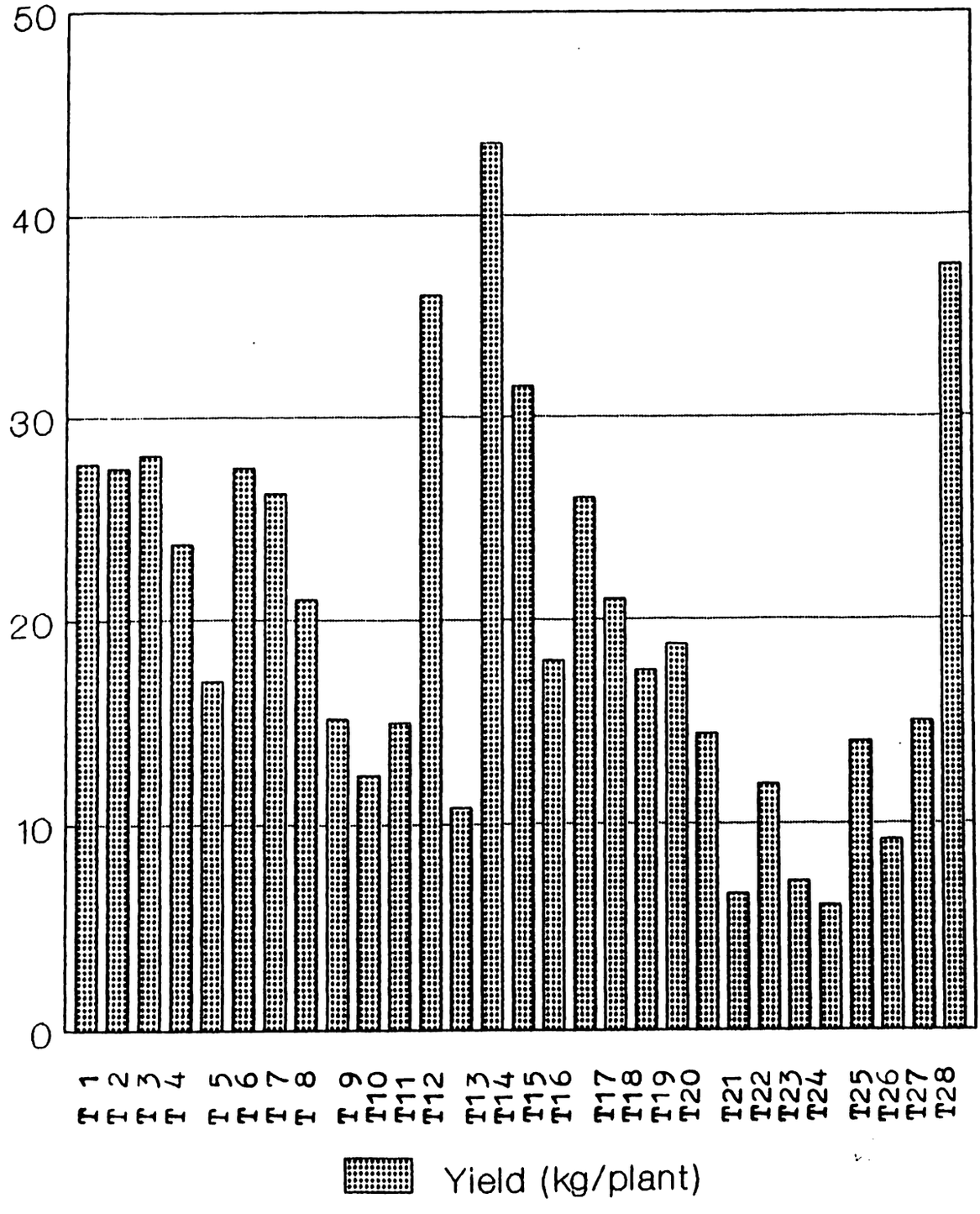
The data recorded on yield and qualitative characters of custard apple fruit types during post harvest stage were subjected to statistical analysis. The analysed data on various characters have been presented in the tabular form with the relevant standard error of means i.e. S.E.(M) and critical differences (C.D) at 5% level. Also the correlation and association among the characters were found out. Further the data were subjected to metroglyph analysis and index score analysis. Then similarity coefficient was also calculated to have a numerical classification of different types. The interpretation of results on various characters have been presented in this chapter.

Total Yield per tree of various types :

The data recorded on yield per tree of various types were statistically analysed and the analysed data have been presented in table no- 14 & figure no. - 8 .

It was revealed from Table- that there was a variation in yield from 6 Kg. to 43.5kg/tree with a mean yield of 19.24kg/tree. The highest yield was recorded in T-14 (43.5kg) which was significantly superior to rest of the types. This was followed by T 12 and T 15 where the yield was 35.0 and 31.5 kg/tree and they were statistically at par with each other. The lowest yield was recorded in T 25 (6kg/tree) which

Fig - 8 **Total yield per plant of different custard apple types**



was at par with T 22 (6.6kg); T 27 (9.2kg) and T 13 (10.8kg).

Table No.- 14 Total yield per plant of various types of custard apple

Types	Yield (Kg/tree)	Type	Yield (Kg/tree)
T1	27.75	T15	31.5
T2	27.5	T16	18.0
T3	28.12	T17	26.0
T4	23.75	T18	21.0
T5	17.0	T19	17.5
T6	27.5	T20	18.75
T7	26.25	T21	14.4
T8	21.0	T22	6.6
T9	15.2	T23	11.9
T10	12.4	T24	7.2
T11	15.0	T25	6.0
T12	36.0	T26	14.0
T13	10.8	T27	9.2
T14	43.5	T28	15.0
SE (M) ± 1.7288 [redacted] Mean = 19.2437 Kg/tree.			

Physical Character(s) :

Average weight of fruits

The data recorded on the average weight of fruits under various types were statistically analysed and the analysed data have been presented in table No. 15 and illustrated

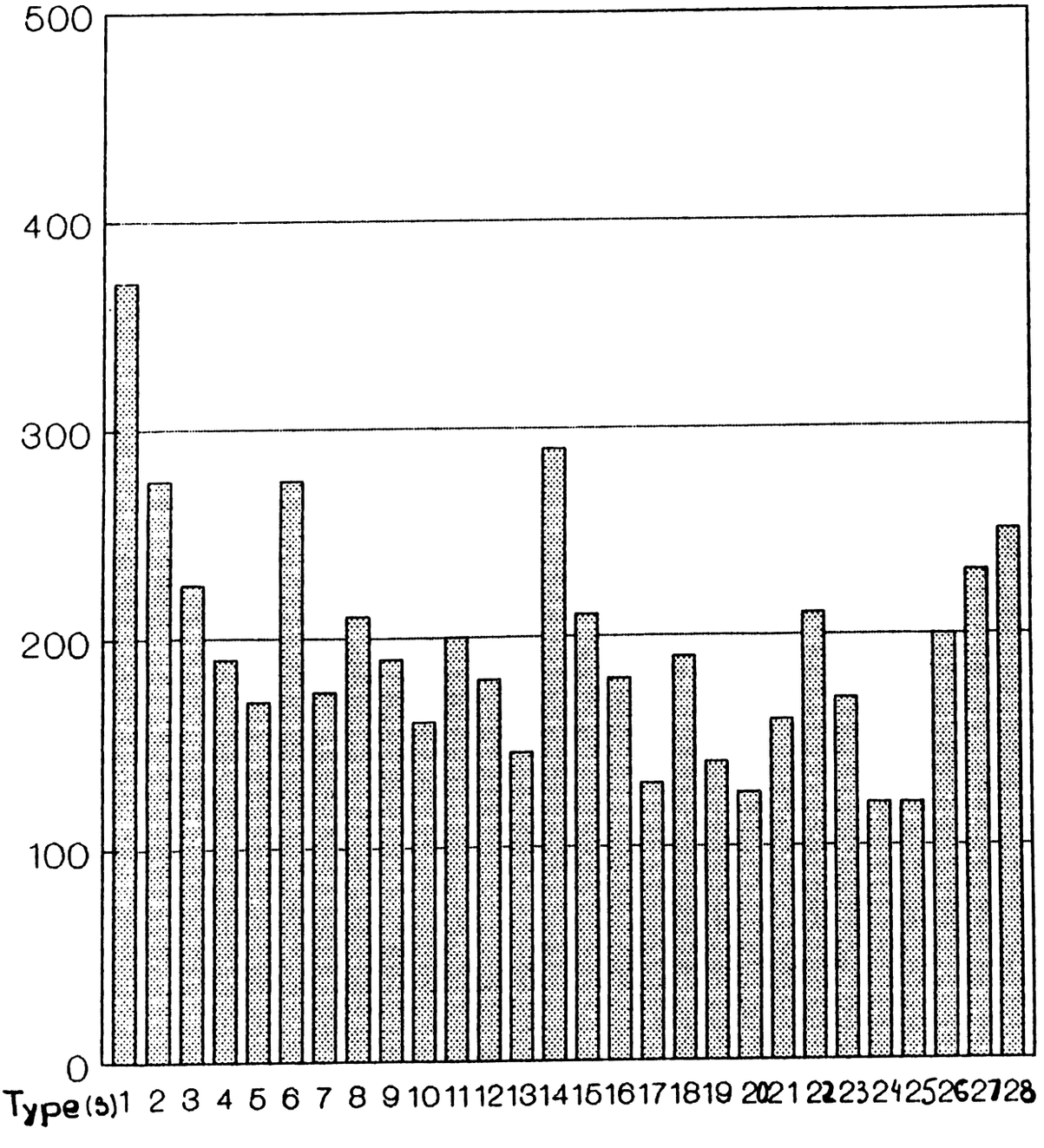
graphically in Figure. 9

Table No. - 15 Average weight of fruits of custard apple.

Type	Fruit Weight (g)	Type	Fruit Weight (g)
T1	370	T15	210
T2	275	T16	180
T3	225	T17	130
T4	190	T18	190
T5	170	T19	140
T6	275	T20	125
T7	175	T21	160
T8	210	T22	210
T9	190	T23	170
T10	160	T24	120
T11	200	T25	120
T12	180	T26	200
T13	145	T27	230
T14	290	T28	250
S.E. (M) ± 11.249 C.D (0.05)= 32.577 Mean= 192.5			

It was revealed from the Table -15 that the average weight of fruits ranged from 110 g. to 370g. with a mean fruit weight of 192.5g. The Maximum fruit weight of 370g. was recorded in T 1 which was significantly superior to rest of the types. This was followed by T 14 ; T 2 and T6 where the fruit weight ranged from 275 to 290g. and they were found to

Fig-9 **Average weight of fruits of different custard apple types.**



be at par with each other. The Minimum fruit weight of 110g. was recorded in T 22.

Average number of segments per fruit

The data relating to the number of segments per fruit was statistically analysed and the analysed data have been presented in table No. 16

Perusal of the data in table - 16 revealed that average number of segments per fruit ranged from 55 to 215 with a mean value of 99.35. Maximum no of segments (215) was recorded in T1. In T18 ; T11 T26 ; T27 ; T25 and T3, the average no of segments ranged between 115 to 125 and they were statistically at par with each other. The lowest number of segments (55) was recorded in T 13 which was statistically at par with T9 (60 no of segments).

Table No.- 16 Average no. of segments per fruit of custard apple types

Type No.	Number of segments per fruit	Type No.	Number of segments per fruit
T1	215	T15	93
T2	125	T16	107
T3	115	T17	87
T4	95	T18	123
T5	82	T19	80
T6	90	T20	78
T7	84	T21	83
T8	93	T22	98

T9	60	T23	75
T10	78	T24	105
T11	121	T25	115
T12	92	T26	116
T13	55	T27	116
T14	94	T28	107
SE (M) ± 5.5009 C.D (0.05)= 15.929 Mean = 99.357.			

Peel percentage of fruits

The data recorded on the peel percentage of fruits were statistically analysed and the analysed data have been presented in table- 17

The data presented in table - 17 revealed that the peel content of fruits under various types varied from 22.85 to 76.9% with a mean of 47.998%. Lowest peel % (22.85%) was recorded in T15 which was at par with T1 (28.7%) and they were significantly different from other types. The peel content of fruits varied from 30.47% to 35.44% in T 23 ; T 21 ; and T 12 which were statistically at par with each other. Highest peel percentage was recorded in T 7 (76.9%) which was significantly different from rest of the types.

Table No.- 17 Average percentage of peel in custard apple fruits types

Type No.	Peel content (%)	Type No.	Peel content (%)
T1	28.7	T15	22.85
T2	31.8	T16	61.62

T3	37.78	T17	50.46
T4	47.4	T18	62.8
T5	69.82	T19	40.14
T6	46.54	T20	43.43
T7	76.9	T21	30.93
T8	49.76	T22	58.63
T9	50.21	T23	30.47
T10	50.93	T24	64.25
T11	55.35	T25	47.9
T12	35.44	T26	49.85
T13	68.27	T27	54.08
T14	41.72	T28	34.92
SE (M)± 2.576	CD (0.05) - 7.462	Mean =	47.998%

Pulp content of custard apple fruits

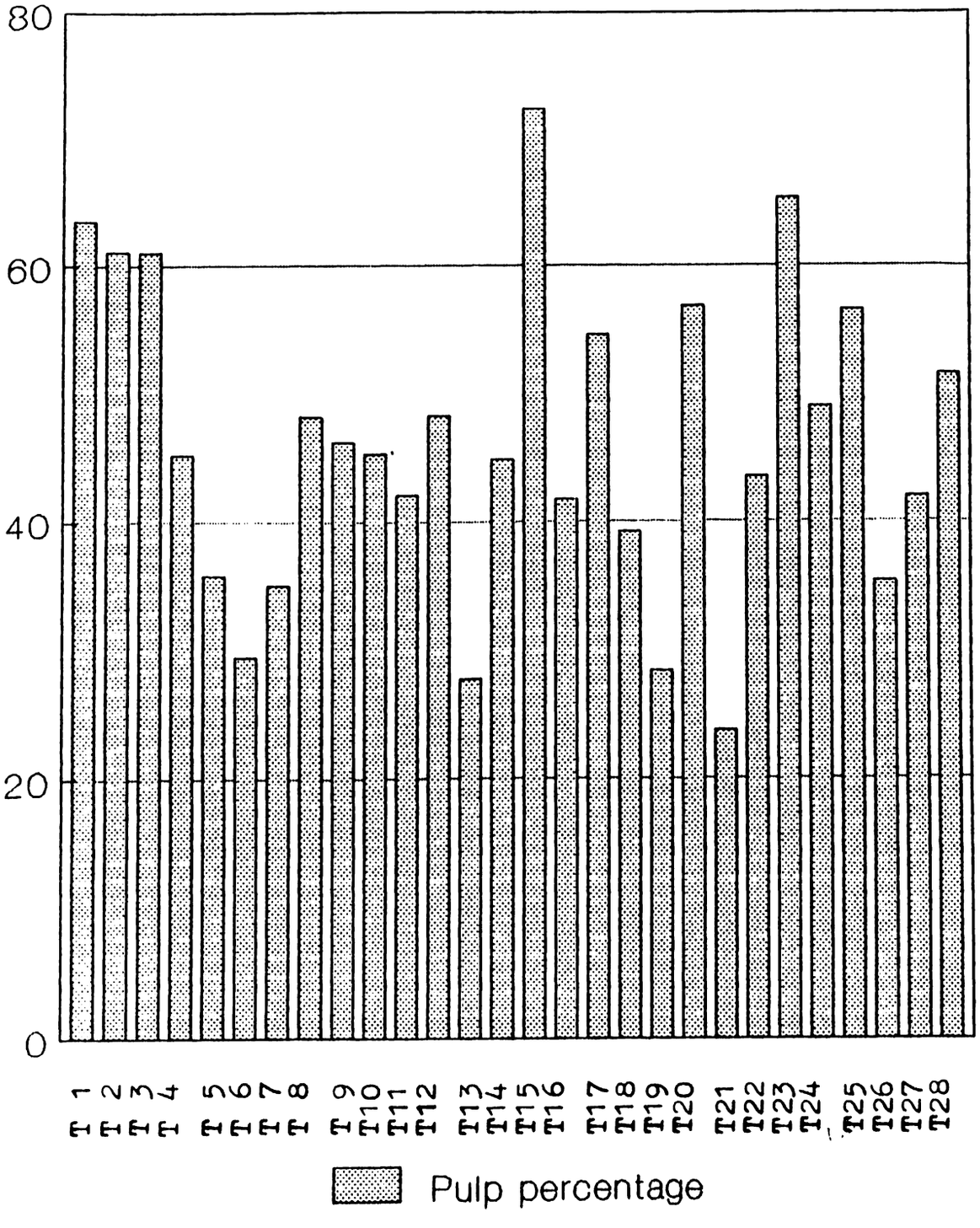
The data relating to the pulp content of fruits were statistically analysed and analysed data have been presented in table 18 and illustrated graphically in Fig. 10

Table No- 18 Average Pulp content (%) of fruits of custard apple types.

Type	Pulp content (%)	Type	Pulp content (%)
T1	63.62	T15	72.42
T2	61.09	T16	41.66
T3	61.02	T17	54.53
T4	45.2	T18	39.12

Fig - 18

Average pulp content (%) of fruits of custard apple types



T5	35.76	T19	28.35
T6	29.5	T20	56.78
T7	35.0	T21	23.75
T8	48.23	T22	43.45
T9	46.21	T23	65.41
T10	45.3	T24	49.0
T11	42.05	T25	56.5
T12	48.33	T26	35.2
T13	27.72	T27	41.86
T14	44.82	T28	51.52
S.E (M) ± 2.2984 CD (0.05). 6.656		Mean- 46.142.	

It was observed from the table-18 that in general pulp content of fruits ranged from 23.75% to 71.42% with a mean pulp content of 46.14% in fruit types. The maximum pulp % (71.42%) was recorded in T 15 which is at par with T 23 which recorded 65.41% pulp. The pulp % of fruits ranged between 61.02% to 63.62% in T 1, T 2, T 3, which were at par with each other and next to the highest category. Minimum pulp % (23.75%) was recorded in T 21.

Number of seeds per fruits

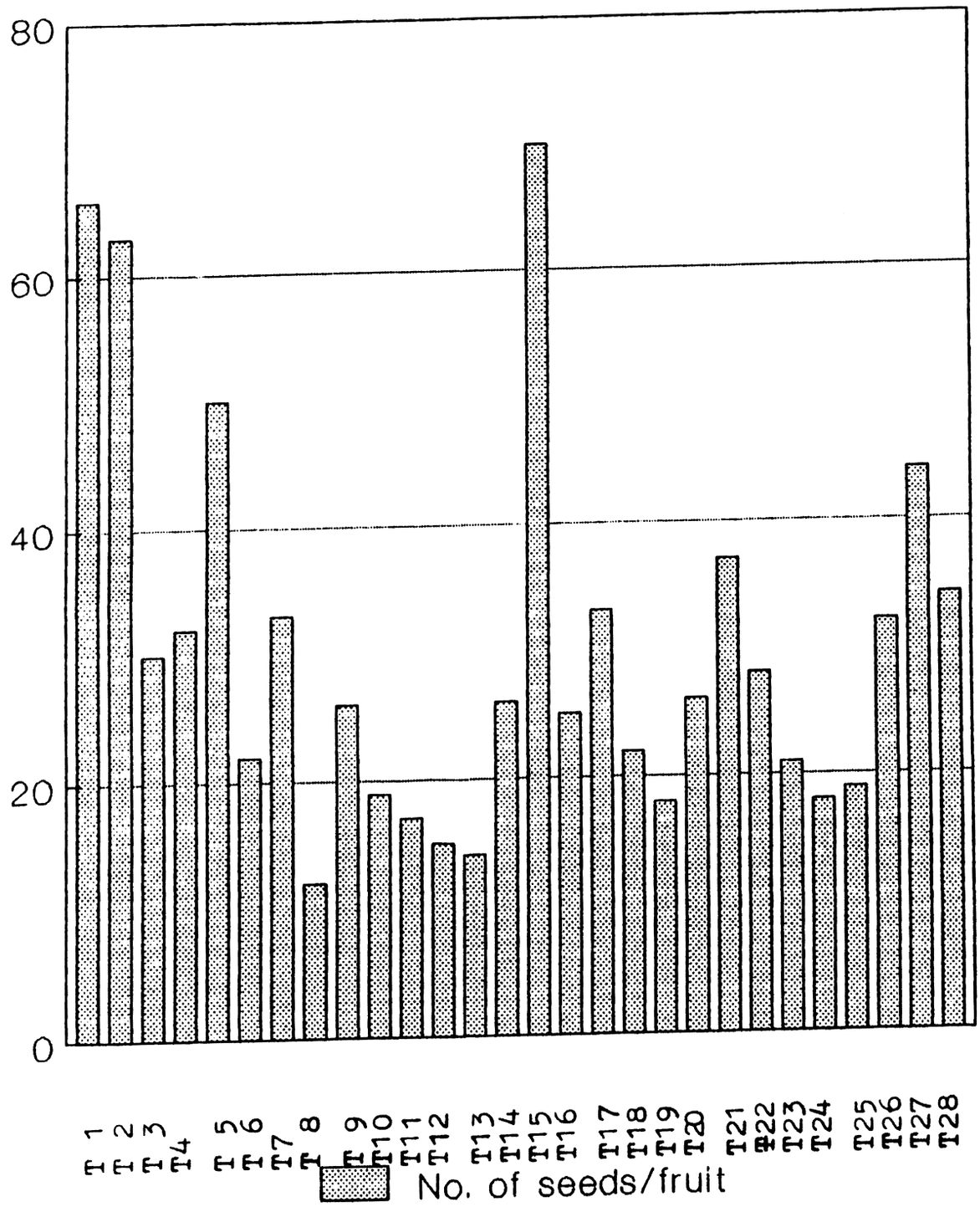
The data recorded on the number of seeds per fruit were statistically analysed and analysed data have been presented in table no-19 and illustrated graphically in Figure. 11

Table No.19 Average number of seeds per fruit of custard apple types.

Type No.	Number of seeds	Type No.	Number of seeds
T1	66	T15	70
T2	63	T16	25
T3	30	T17	33
T4	32	T18	22
T5	50	T19	18
T6	22	T20	26
T7	33	T21	37
T8	12	T22	28
T9	26	T23	21
T10	19	T24	18
T11	17	T25	19
T12	15	T26	32
T13	14	T27	44
T14	26	T28	34
SE (M) ± 2.9201 C.D (0.05) - 8.456 . Mean - 30.3571.			

The perusal of the data in table 19 revealed that there was a variation of 12.0 to 70.0 number of seeds per fruit in the types under observation with a mean of 30.357. The highest number of seeds (70) per fruit was recorded in T 15, closely followed by T1 (66) and T 2 (63) which were found to be at par with each other. Next to them the number of seeds per fruit

Fig-11 **Average number of seeds per fruit of custard apple types**



varied from 50 in T5 to 44 in T27. The lowest number of seeds was recorded (12). In T 8; T 13; T 12; T 11; T 19; T 24; T 10; and T 25 the number of seeds per fruit ranged between 14 to 19.

Weight of seeds per fruit

The analysed data relating to the weight of seeds per fruit has been presented in table no-20

The data revealed that there was a variation in seed weight from 4.2 to 25.9g with a mean of 10.50g. The maximum seed weight (25.9) was recorded in T 1 closely followed by T15 (25.1g) which were significantly different to rest of the types. This was followed by T2 which recorded 20.0 gram. The minimum weight of seeds per fruit was recorded in T8 (4.2 g.). In T12; T11; T13; T10; T24; T9; T23; T25; the weight of seeds per fruit were at par and their seed weight ranged between 5.0 to 7.2 grams.

Table No.20 Average weight of seeds per fruit of custard apple types.

Type No.	Weight of seeds (g)	Type No.	Weight of seeds(g)
T1	25.9	T15	25.1
T2	20.0	T16	10.53
T3	9.3	T17	11.6
T4	10.3	T18	10.9
T5	13.8	T19	9.1
T6	9.3	T20	9.89
T7	12.2	T21	10.8

T8	4.2	T22	8.1
T9	6.8	T23	7.0
T10	6.09	T24	6.2
T11	5.2	T25	7.2
T12	5	T26	9.6
T13	5.8	T27	13.7
T14	9.4	T28	11.2
SE (M) ± 1.0124	C.D. (0.05) = 2.931.		Mean = 10.5057 g

Summary of findings on physical characters of fruit types

Table No.-- 21 **Summary of findings on physical characters of custard apple fruit types.**

Character (S)	Low	High	Range	Mean	CV(%)
Fruit Weight(g)	110.0	370.0	260.0	192.5	30.923
Number of segments	15.0	215.0	160.0	99.35	29.296
Peel content(%)	22.85	76.9	54.05	47.99	28.407
Pulp content(%)	23.75	71.42	47.67	46.14	26.357
Seed Number	12.00	70.00	58.00	30.35	50.899
Seed Weight(g)	4.20	25.90	21.70	10.50	50.993

It was revealed from the summarized data on physical characters of custard apple fruit types (table-21) that highest Coefficient of variation was recorded in the characters as seed number per fruit and weight of seed per fruit (i.e.50.89 and 50.99). A cv of 30.92% in Fruit weight; 29.29% in no of segments; 28.4% in peel % and 26.35% in pulp percentage were recorded for different fruit types.

Chemical composition of fruit types:

Total soluble solid content

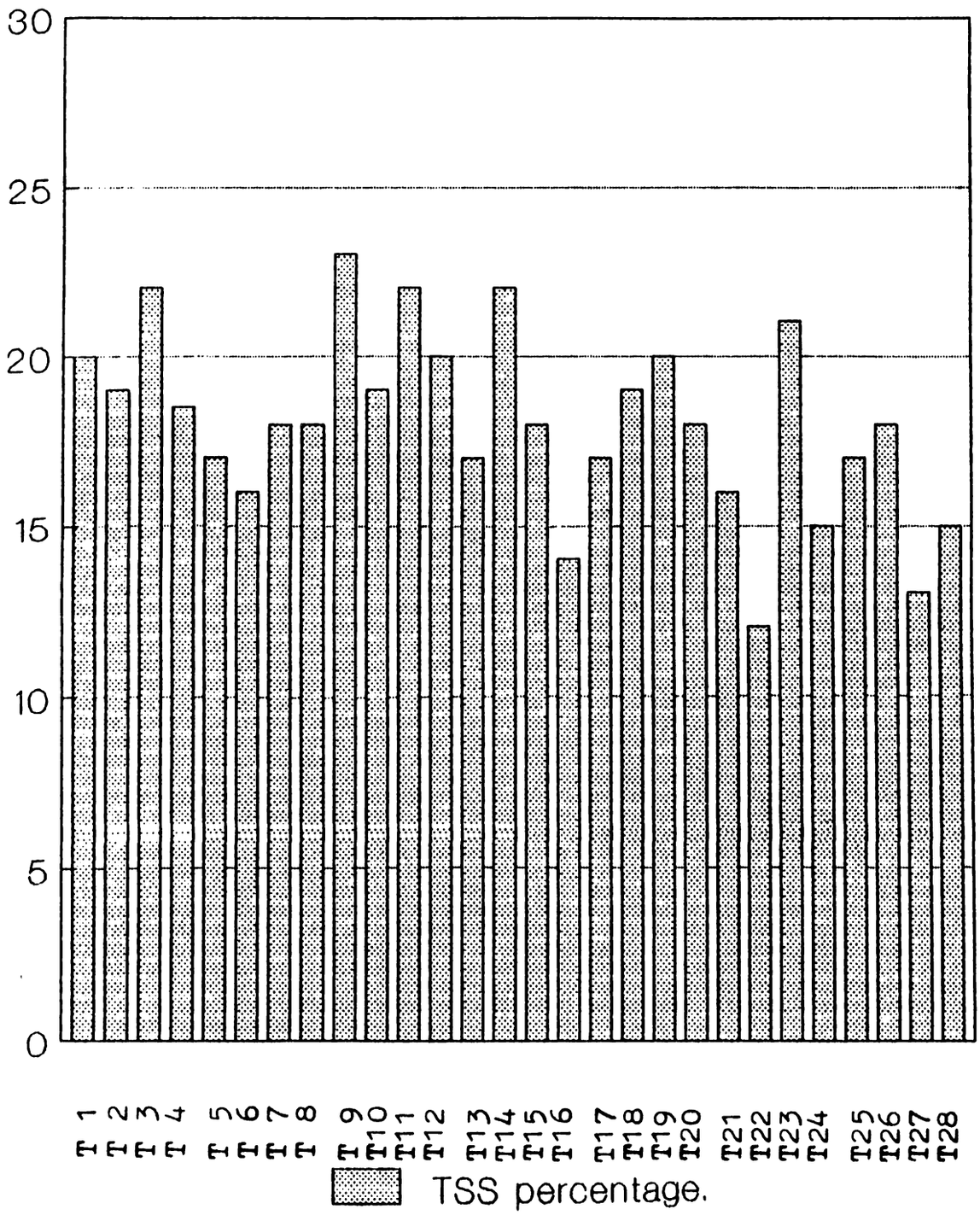
The data relating to the total soluble solid content of fruits were statistically analysed and the analysed data have been presented in table -22 and illustrated graphically in Figure. 12

It was observed that (table -22) the total soluble solid content of fruits varied from 12.0 to 23.0% with a mean of 18.01%. The highest T.S.S percentage (23.0%) was recorded in T9 which was at par with T3 (22%); T11(22%) and T14 (22%) and they were significantly superior to rest of the types. These were followed by T1 (20%) and T12 (20%). The lowest T.S.S (12%) was observed in T22 which was at par with T27 (13%).

Table No. 22 Total soluble solid content of custard apple fruits types.

Type No.	T.S.S. %	Type No.	T.S.S. %
T1.	20.0	T15	18.0
T2	19.0	T16	14.0
T3	22.0	T17	17.0
T4	18.5	T18	19.0
T5	17.0	T19	20.0
T6	18.0	T20	18.0
T7	18.0	T21	16.0
T8	18.0	T22	12.0
T9	23.0	T23	21.0
T10	19.0	T24	15.0
T11	22.0	T25	17.0
T12	20.0	T26	18.0
T13	17.0	T27	13.0
T14	22.0	T28	15.0
SE (M) ± 0.5198. C.D. (0.05) = 1.505 Mean = 18.0179.			

Fig. 12 **Total soluble solid content of different custard apple types.**



Titrable acidity

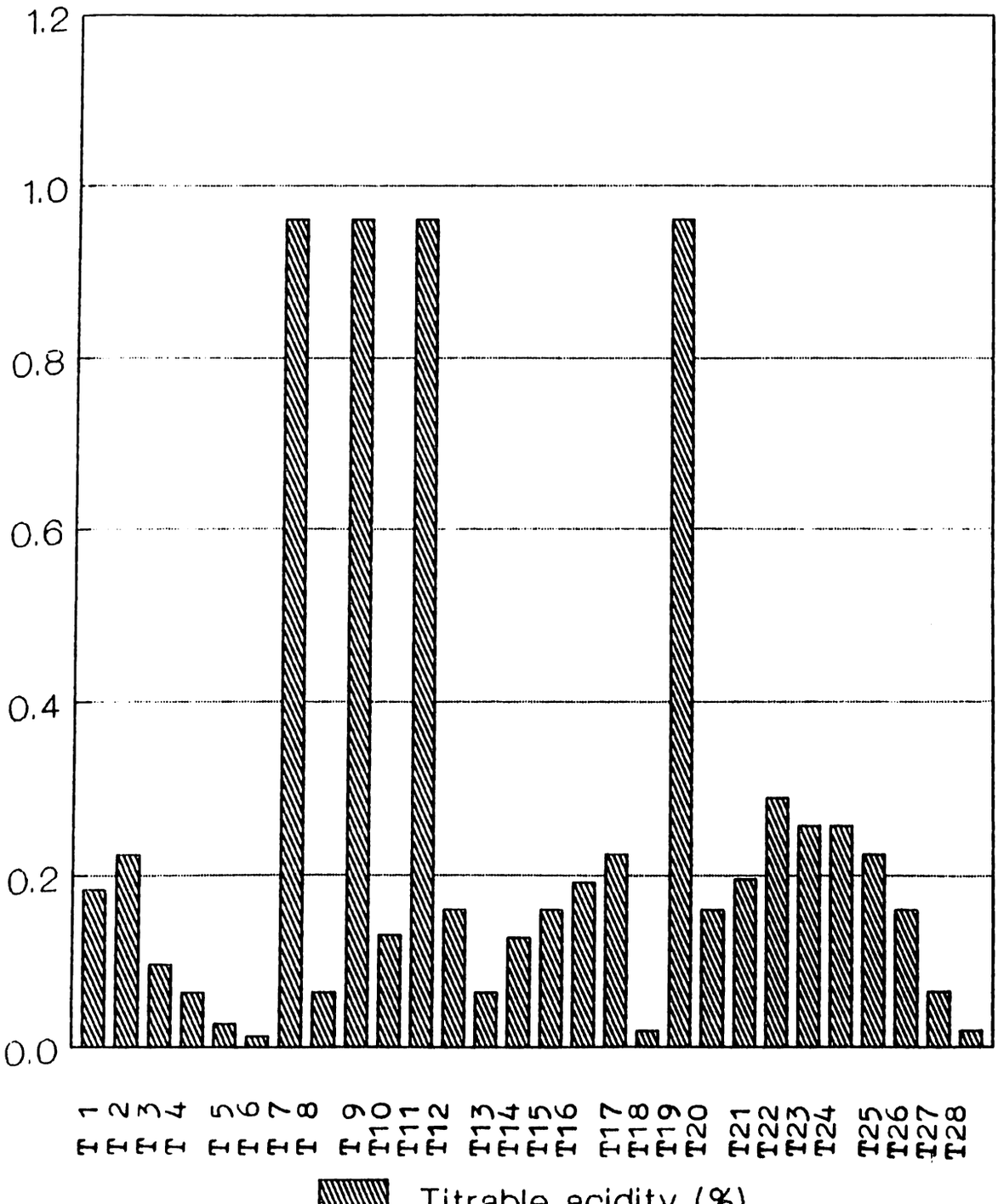
The data relating to titrable acidity content of fruits were statistically analysed and the analysed data has been presented in table - 23 & figure no. - 13 .

Table No. 23 Percentage of Titrable acidity content of fruit types

Type No.	Titrable acidity	Type No.	Titrable acidity
T1	0.184	T15	0.160
T2	0.224	T16	0.192
T3	0.096	T17	0.224
T4	0.064	T18	0.018
T5	0.028	T19	0.96
T6	0.013	T20	0.160
T7	0.96	T21	0.196
T8	0.064	T22	0.288
T9	0.96	T23	0.256
T10	0.13	T24	0.256
T11	0.96	T25	0.224
T12	0.16	T26	0.16
T13	0.064	T27	0.064
T14	0.128	T28	0.018
SE (M) ± 0.0511 C.D. (0.05) = 0.148. Mean = 0.2266%			

The data presented in table no. 23 revealed that the percentage titrable acidity varied from 0.013% to 0.96% with a mean of 0.22%. The maximum percentage of acidity was recorded

Fig-13 **Percentage of titrable acidity of different custard apple types.**



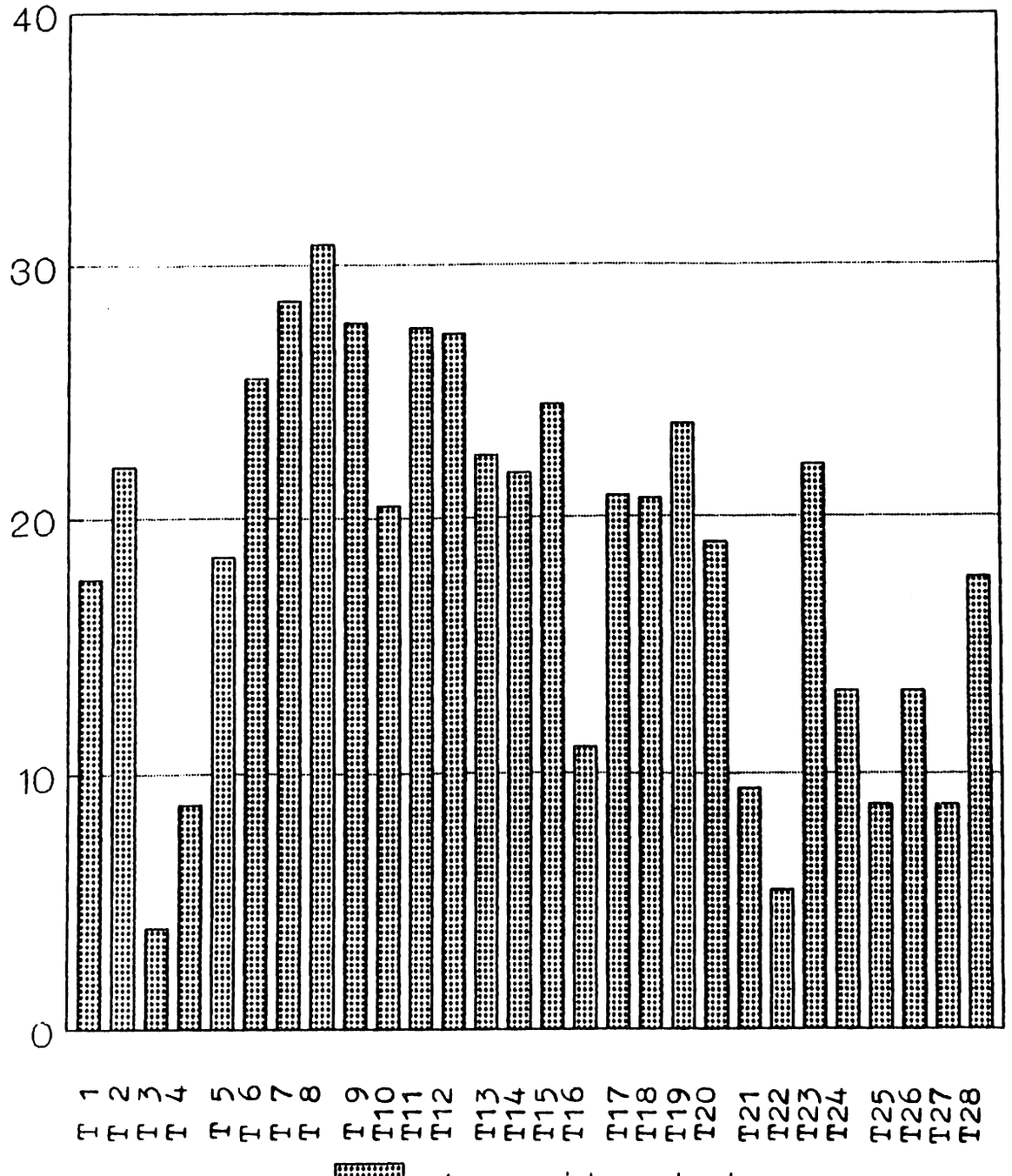
in the types T7; T9; T11; and T19; (i.e. 0.96%), which was followed by T22; T23; T24; T2; T17; T25; T21; T16; and T1 where the amount of acidity ranged from 0.184% to 0.288% and were statistically at par. The minimum acidity was recorded in T6 (0.013) which was at par with T18; T28; T5; T4; T8; T13; T27; T10; T14; T12; T15; T20; and T26; where amount of acidity varied from 0.018% to 0.16%.

Ascorbic acid (Vitamin -C) content of fruits.

The data relating to ascorbic acid content of fruit types has been presented in table -24and illustrated graphically in Figure. 14

The perusal of the data (table -) on ascorbic acid content of the fruits indicated that there was a variation from 4.0 to 30.8mg / 100g of ascorbic acid with a mean value of 18.6mg/per 100g. The maximum amount of ascorbic acid was recorded in T8 (30.8) which was at par with T7 (28.6); T9 (27.72); T11 (27.5); and T12 (27.28). This was followed by T6 ; T15 ; T13 ; and T14 where ascorbic acid content ranged from 21.72 to 25.52 mg/100g. The minimum quantity of ascorbic acid was observed in T3 (4.0) which was at par with T22 (5.48).

Fig-14 **Ascorbic acid content of different custard apple types.**



Unit : mg/100g. pulp.

Table No 24 Ascorbic acid content of custard apple fruit types.

Type No.	Ascorbic acid (mg/100g pulp)	Type No.	Ascorbic acid (mg/100g. Pulp)
T1	17.6	T15	24.47
T2	22.0	T16	11.0
T3	4.0	T17	20.8
T4	8.8	T18	20.67
T5	18.48	T19	23.67
T6	25.52	T20	18.97
T7	28.6	T21	9.38
T8	30.8	T22	5.48
T9	27.72	T23	22.0
T10	20.46	T24	13.2
T11	27.5	T25	8.8
T12	27.28	T26	13.2
T13	22.44	T27	8.8
T14	21.72	T28	17.6
SE (M) ± 1./4233 C.D. (0.05) = 4.121 Mean = 18.6057 mg/100g			

Total Sugar

Data relating to amount of total sugar present in fruit types were statistically analysed and the analysed data has been presented in table no - 25 and illustrated graphically in figure. 15

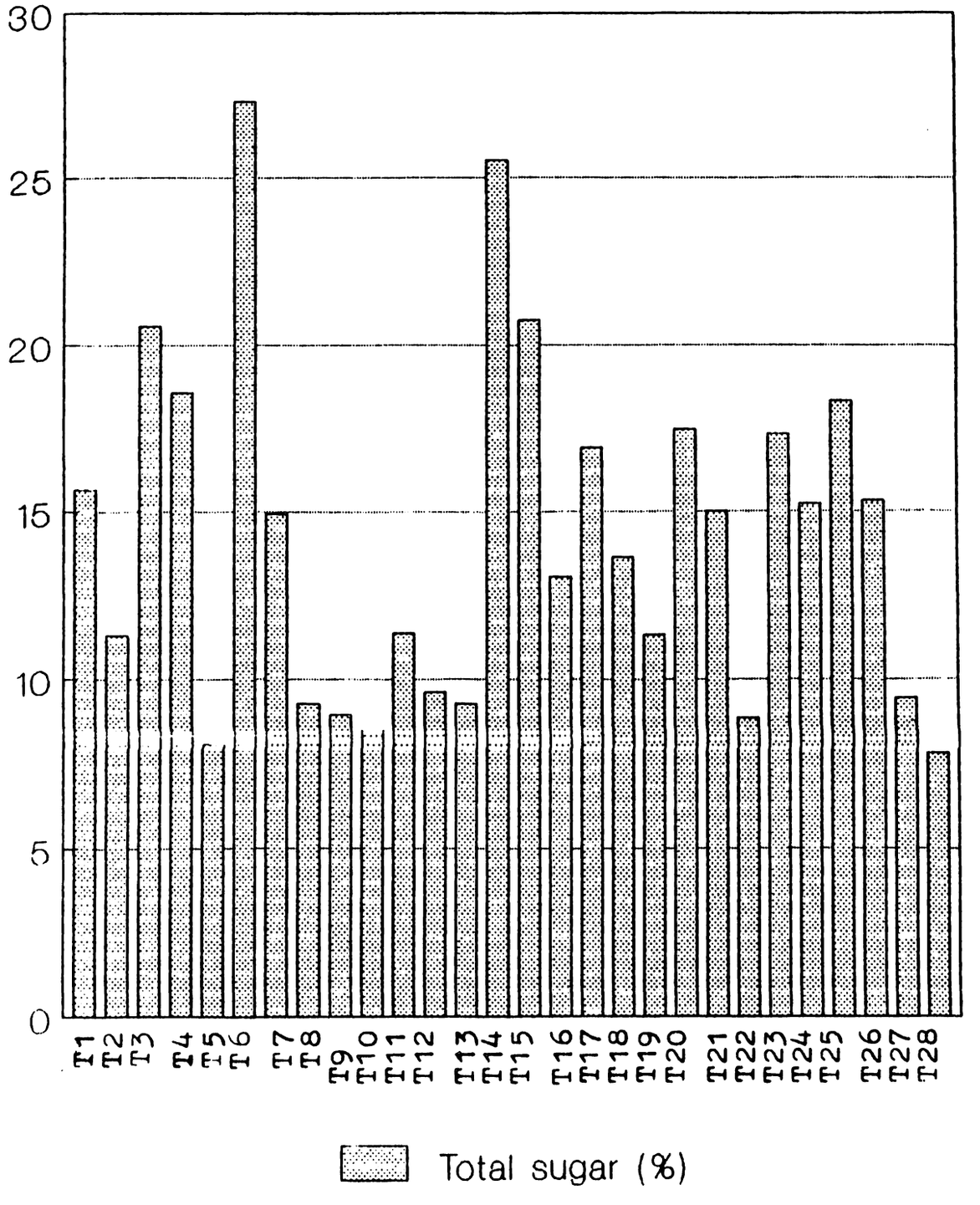
It was observed that (table no 25) there was a variation from 7.81% to 27.32% of total sugar with a mean value of 14.24 %. The maximum percentage of total sugar was recorded in T6

(27.32) which was at par with T14 (25.53%). This was followed by T15; T3; T4; and T25 where the total sugar content ranged from 18.2% to 20.73%. The Minimum percentage of total sugar was estimated in T 28 (7.81%) which was at par with T5; T10; T22; T9; T8; T13; T27; and T12 where the amount varied from 9.25 to 9.615 %.

Table No 25 Total sugar content of various custard apple types.

Type No.	Total Sugar(%)	Type No.	Total Sugar(%)
T1	15.625	T15	20.732
T2	11.286	T16	13.071
T3	20.576	T17	16.865
T4	18.518	T18	13.631
T5	8.064	T19	11.307
T6	17.32	T20	17.423
T7	14.92	T21	14.995
T8	9.25	T22	8.846
T9	8.928	T23	17.277
T10	8.474	T24	15.2
T11	11.363	T25	18.3
T12	9.615	T26	15.3
T13	9.25	T27	9.43
T14	25.53	T28	7.81
SE (M) ± 0.9884 C.D. (0.05) = 2.862. Mean = 14.2468%.			

Fig-15 **Total sugar content of different custard apple types.**



Reducing Sugar

The data on reducing sugar content of the fruit types were statistically analysed and the analysed data has been presented in tables .26

Table No - 26 The percentage reducing sugar content of the custard apple fruit types.

Type No.	Reducing sugar (%)	Type No.	Reducing sugar (%)
T1	13.93	T15	14.28
T2	5.26	T16	10.0
T3	12.82	T17	11.62
T4	9.43	T18	9.43
T5	6.04	T19	8.62
T6	16.66	T20	11.93
T7	13.15	T21	10.91
T8	6.02	T22	6.49
T9	6.57	T23	11.90
T10	5.56	T24	11.62
T11	7.24	T25	13.3
T12	6.49	T26	12.5
T13	8.62	T27	7.81
T14	21.73	T28	6.41
SE (M) ± 0.7300 C.D (0.05) = 2.113 Mean = 10.2285%			

The perusal of the data in the table no.26 revealed that the reducing sugar content of fruits varied from 5.26% to 21.739 % with a mean value of 10.22%. The maximum percentage

of reducing sugar (21.739%) was recorded in T14. Which was significantly superior to rest of the types. This was followed by T6 (16.66%). The minimum percentage of reducing sugar was found in T2 (5.26%) which was at par with T10; T8; T5; T12; T22; T9 and T11 where percentage reducing sugar varied from 5.56% to 7.246%.

Summary of findings on chemical composition of fruits types.

Table No.27 Summary on chemical composition and yield of fruit types.

Character (s)	Low	High	Range	Mean	C.V (%)
T.S.S. (%)	12.00	23.00	11.0	18.017	15.264
Acidity (%)	0.013	0.96	0.947	0.226	119.237
Ascorbic acid (mg/100 g.)	4.00	30.8	26.8	18.605	40.478
Total Sugar (%)	7.81	27.32	19.51	14.246	36.711
Reducing sugar(%)	5.26	21.739	16.479	10.228	37.762
Yield (Kg/tree)	6.00	43.5	37.5	19.243	47.536

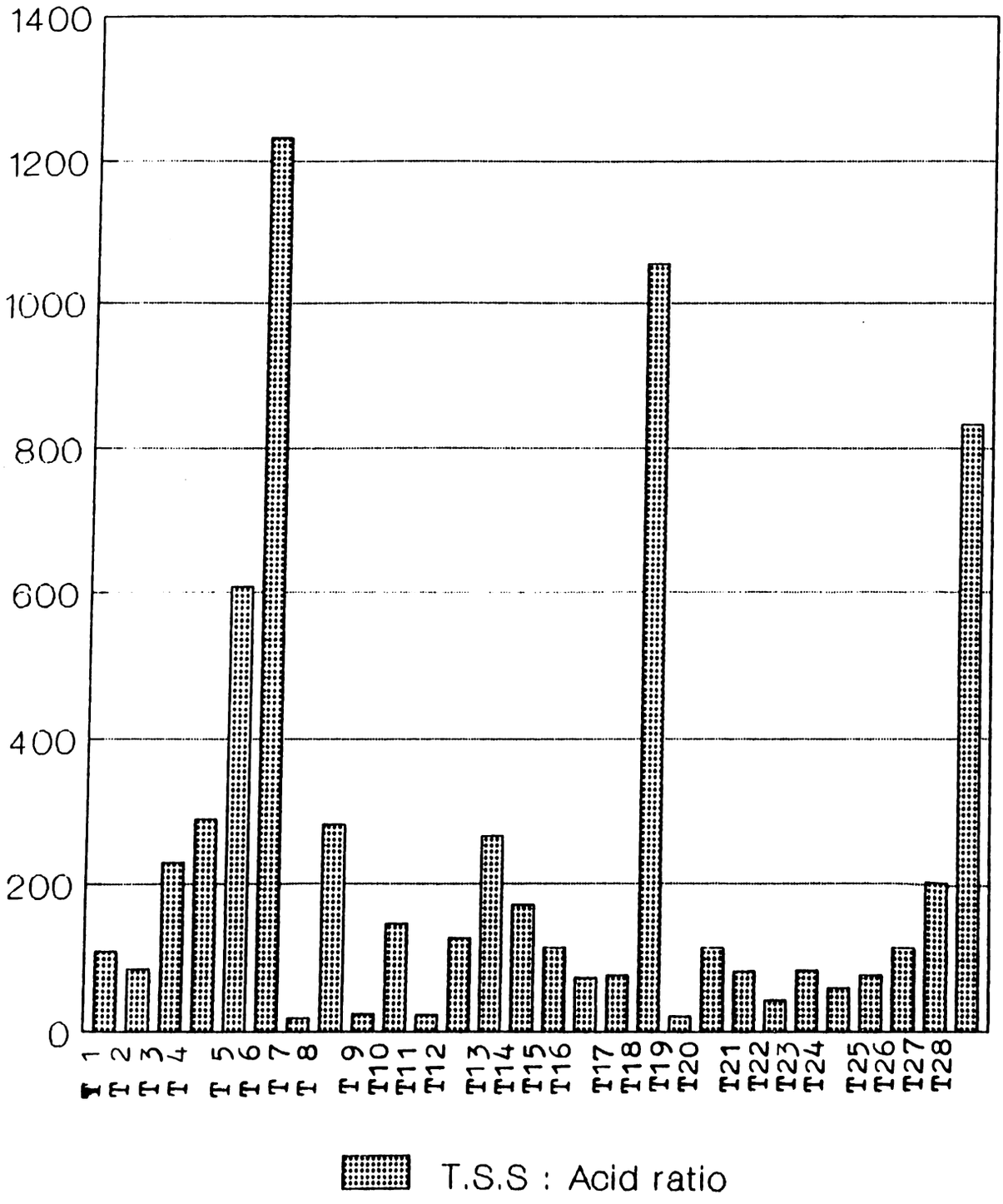
It was revealed from the summarised data on chemical composition of fruit types (table no-27) that there existed a highest cv % in titrable acidity of fruit types (i.e. 119.23%) followed by yield (47.53%); ascorbic acid (40.47%) Minimum cv % was observed in T.S.S (15.26%).

T.S.S : Acid ratio

Table No 28 **T.S.S : Acid ratio of fruit types**

Type No	T.S.S (%)	Acidity (%)	TSS:acid ratio
T 1	20.0	0.184	108.6
T 2	19.0	0.224	84.82
T 3	22.0	0.096	229.16
T 4	18.5	0.064	289.06
T 5	17.0	0.028	607.14
T 6	16.0	0.013	1230.75
T 7	18.0	0.96	18.75
T 8	18.0	0.064	281.25
T 9	23.0	0.96	23.95
T 10	19.0	0.13	146.15
T 11	22.0	0.96	22.91
T 12	20.0	0.16	125.0
T 13	17.0	0.064	265.62
T 14	22.0	0.128	171.87
T 15	18.0	0.160	112.5
T 16	14.0	0.192	72.91
T 17	17.0	0.224	75.89
T 18	19.0	0.018	1055.55
T 19	20.0	0.96	20.83
T 20	18.0	0.160	112.5
T 21	16.0	0.196	81.63

Fig-16 **T.S.S. : Acid ratio of different custard apple types.**



T 22	12.0	0.288	41.66
T 23	21.0	0.256	82.03
T 24	15.0	0.256	58.59
T 25	17.0	0.224	75.89
T 26	18.0	0.16	112.5
T 27	13.0	0.064	203.12
T 28	15.0	0.018	833.33

T. S. S. : Acid ratio of fruit types gives a good indication regarding the quality of the fruits. Higher the T. S. S.: acid ratio, better is the quality.

The data relating to T.S.S : acid ratio in table no - 28, revealed that highest was observed in T 6 (1230.75) followed by T 18 (1055.55) and T 28 (833.33).

Index Score analysis

When different fruit types were subjected to index score analysis on the basis of different physical characters chemical composition and yield criteria then following results were obtained.

Physical characters

Results of index score analysis of physical characters of fruit types has been presented in table No.- 29

The perusal of the data (Table No.- 29) revealed that highest score was obtained by T-3 (i.e. 14.0) followed by T-14, T-23 (i.e. T3.0) and T-8, T-11, T-12, T-20, T-25 (i.e. 12.0). But lowest score was obtained by T-5 and T-7 (i.e. 7.0).

Observations recorded on physio-chemical composition of fruit types were subjected to index score analysis and following results were obtained.

Table - 29 Index score analysis of physical characters of custard apple types.

Types	Fresh weight(g) score	Peel % score	Pulp % score	Seed no. score	Seed wt. score	Total score
T1	3	3	3	1	1	11
T2	2	3	3	1	1	10
T3	2	3	3	3	3	14
T4	1	2	2	2	3	10
T5	1	1	1	2	2	7
T6	2	2	1	3	3	11
T7	1	1	1	2	2	7
T8	2	2	2	3	3	12
T9	1	2	2	3	3	11
T10	1	2	2	3	3	11
T11	2	2	2	3	3	12
T12	1	3	2	3	3	12
T13	1	1	1	3	3	9

T14	3	2	2	3	3	13
T15	2	3	3	1	1	10
T16	1	1	2	3	3	10
T17	1	2	2	2	2	9
T18	1	1	2	3	3	10
T19	1	2	1	3	3	10
T20	1	2	3	3	3	12
T21	1	3	1	2	3	10
T22	1	1	2	3	3	10
T23	1	3	3	3	3	13
T24	1	1	2	3	3	10
T25	1	2	3	3	3	12
T26	2	2	1	2	3	10
T27	2	2	2	2	2	10
T28	2	3	2	2	2	11

The perusal of the data (Table No.- 29) revealed that highest score was obtained by in T - 14 (i.e. 14.0) followed by T-6 (i.e. 13.0) and T-1, T-15, T-23, (i.e. 12.0). Lowest score was obtained by T-27 (i.e. 5.0).

Chemical Composition

Results of index score analysis on chemical composition of fruit types has been presented in Table No.- 36

Table No - 30 **Index score analysis of chemical composition of fruit types and yield.**

Type	T.S.S. score	Acidity score	Ascorbic acid score	Total sugar score	Red sugar score	Total score
T1	3	3	2	2	2	12
T2	2	3	2	1	1	9
T3	3	3	1	2	2	11
T4	2	3	1	2	1	9
T5	2	3	2	1	1	9
T6	2	3	3	3	2	13
T7	2	1	3	2	2	10
T8	2	3	3	1	1	10
T9	3	1	3	1	1	9
T10	2	3	2	1	1	9
T11	3	1	3	1	1	9
T12	3	3	3	1	1	11
T13	2	3	3	1	1	10
T14	3	3	2	3	3	14
T15	2	3	3	2	2	12
T16	1	3	1	1	1	7
T17	2	3	2	2	2	11
T18	2	3	2	1	1	9
T19	3	1	3	1	1	9
T20	2	3	2	2	2	11
T21	2	3	1	2	2	10
T22	1	3	1	1	1	7

T23	3	3	2	2	2	11
T24	2	1	2	2	2	9
T25	2	1	1	2	2	8
T26	2	1	2	1	2	8
T27	1	1	1	1	1	5
T28	1	1	2	1	1	6

The perusal of the data (Table No.- 30) revealed that highest score was obtained in T-14 (i.e. 14.0) followed by T-6 (i.e. 13) and T-1, T-5, T-23 (i.e. 12.0). Lowest score was obtained by T-27 (i.e. 5.0).

Yield of custard apple types

Data on yield of custard apple types were subjected to index score analysis and results are presented in Table No.- 31

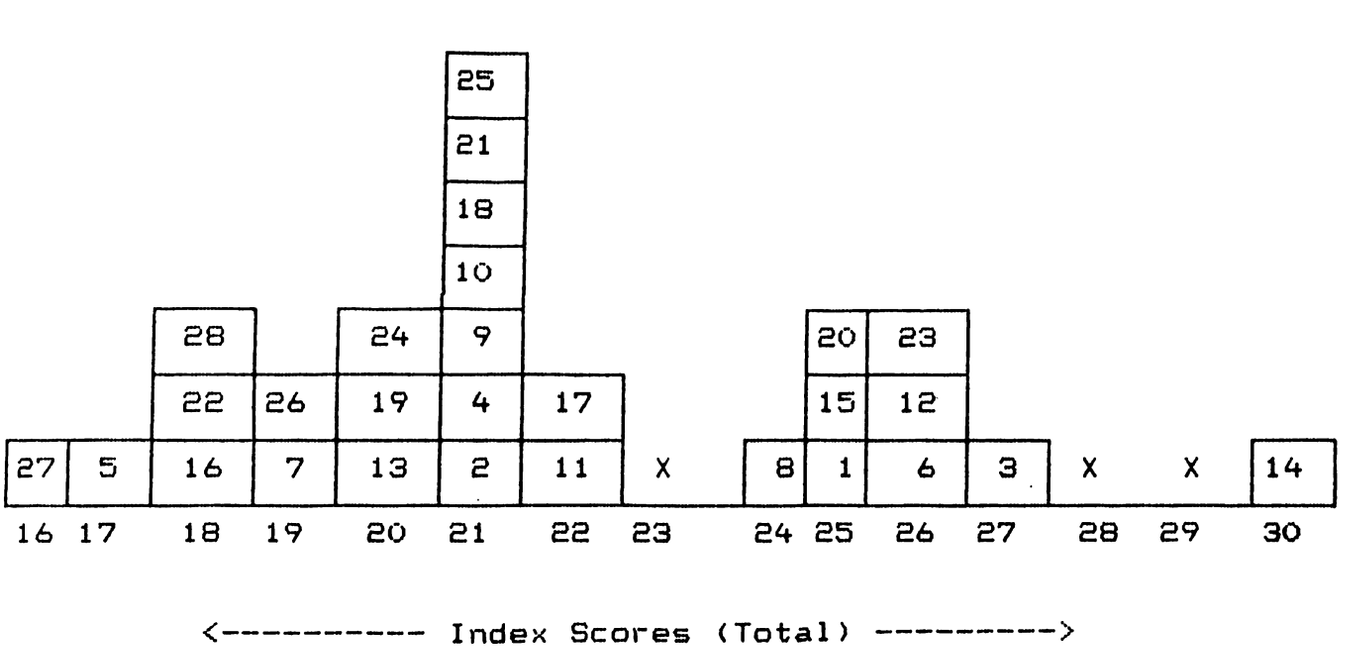
Perusal of the data in Table No.31 revealed that highest scoring types were T-12, T-14, and T-15 (is 3.0) followed by T-1, T-2, T-3, T-6, T-7, T-8, T-17, T-18 and T-20 (is 2.0).

Table No.- 31 Custard apple types with their total score by index score technique.

Type No.	Source	Score			Total score
		Physical characters	Chemical composition	Yield	
T1	Keonjhar type-I	11	12	2	25
T2	Udala type-I	10	9	2	21
T3	Khireitangi type-I	14	11	2	27

T4	Baripada type-I	10	9	2	21
T5	Bainda type-I	7	9	1	17
T6	Bainda type-II	11	13	2	26
T7	BBSR type-I	7	10	2	19
T8	Keonjhar type-II	12	10	2	24
T9	BBSR type-II	11	9	1	21
T10	BBSR type-III	11	9	1	21
T11	Berhampur type-I	12	9	1	22
T12	Remuna type-I	12	11	3	26
T13	Pudamari type-I	9	10	1	20
T14	Paralakhemundi type-I	13	14	3	30
T15	Baghajhar type-I	10	12	3	25
T16	Chikiti type-I	10	7	1	18
T17	Chhatrapur type-I	9	11	2	22
T18	BBSR type-IV	10	9	1	21
T19	BBSR type-V	10	9	1	20
T20	Puri type-I	12	11	2	25
T21	Baramunda type-I	10	10	1	21
T22	Nayapalli type-I	10	7	1	18
T23	BBSR type-VI	13	12	1	26
T24	OUAT type-I	10	9	1	[illegible]
T25	OUAT type-II	12	8	1	21
T26	BBSR type-VII	10	8	1	19
T27	Raniguda type-I	10	5	1	16
T28	BBSR type-VIII	11	6	1	18

Figure No. 17 Index score analysis results.



Perusal of the data in table relating to index score analysis on physical characters, chemical composition of fruit types with yield per tree revealed that highest scoring type was T - 14 (i.e. 30.0), followed by T-3 (i.e. 27.0) and T-6, T - 12, and T - 23 (i.e. 26.0).

It was observed that average score of the various types was 21.78. Hence, the types securing scores above the mean were : T - 1, T - 3, T - 6, T - 7, T - 11, T -12, T - 14, T - 15, T - 17, T - 20, and T - 23.

Metroglyph analysis -

The 28 types of custard apple were classified into four groups following metroglyphic analysis (figure - 18). These groups were characterised as

Gr - I = High pulp % & High fruit weight

Gr - II = High pulp % & Low fruit weight

Gr - III = Low pulp % & High fruit weight

Gr - IV = Low pulp % & Low fruit weight

Among the four groups Gr - I is the most desirable type and Gr - IV is the most undesirable type, whereas the other two groups (Gr - II & III) are desirable types with respect to either one of the important character.

On the basis of the distribution of different types in the scattered diagram with fresh weight and pulp % as two variables, different types can be grouped as follows -

Fig-18.

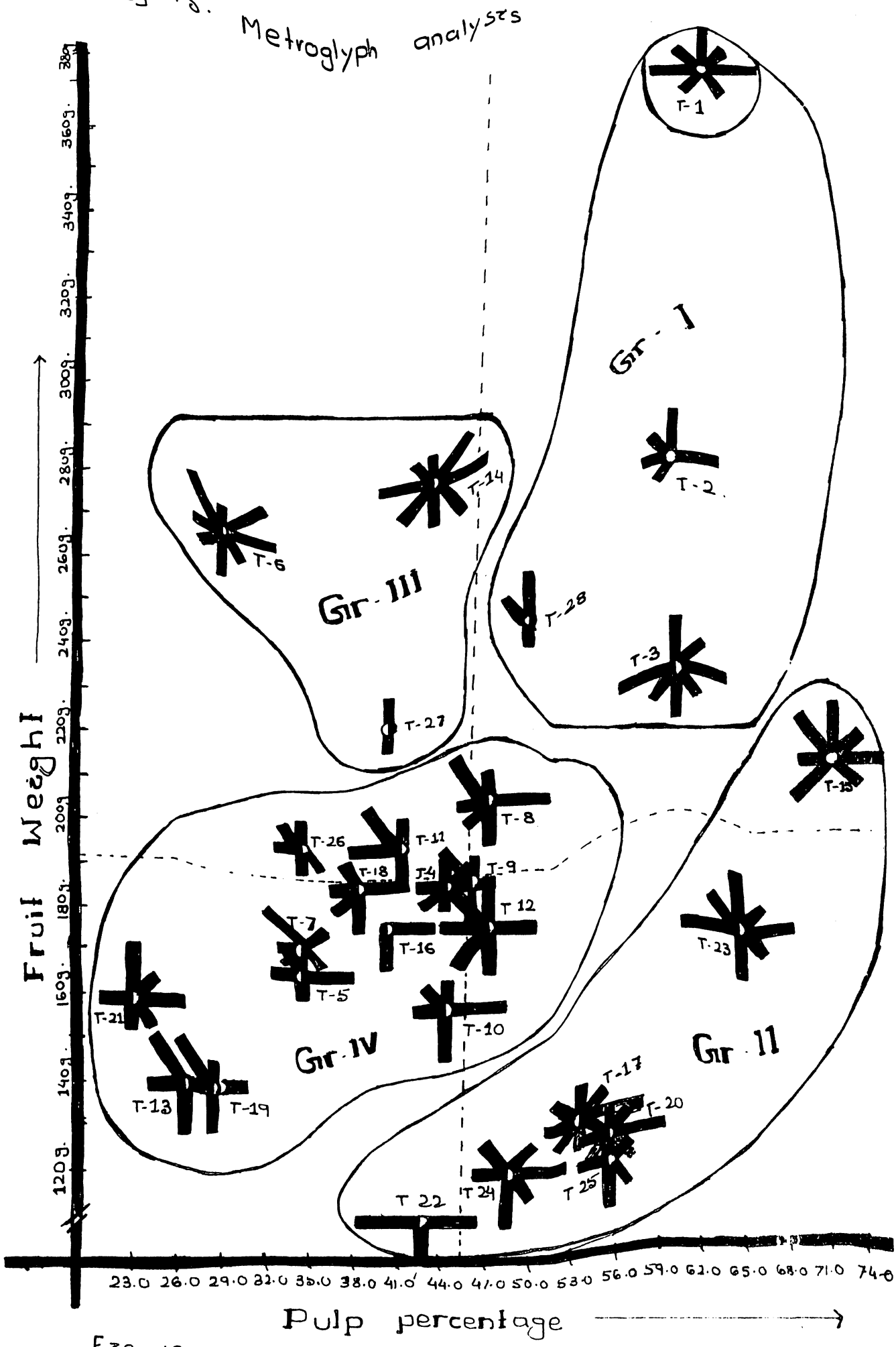

Metroglyph analysis
Fruit Weight
Pulp percentage
Gr. I
Gr. II
Gr. III
Gr. IV
T-1
T-2
T-3
T-5
T-6
T-7
T-8
T-9
T-10
T-11
T-12
T-13
T-14
T-15
T-16
T-17
T-18
T-19
T-20
T-21
T-22
T-23
T-24
T-25
T-26
T-27
T-28
380
360
340
320
300
280
260
240
220
200
180
160
140
120
23.0 26.0 29.0 32.0 35.0 38.0 41.0 44.0 47.0 50.0 53.0 56.0 59.0 62.0 65.0 68.0 71.0 74.0

Fig-18.

Table No.- 32 Grouping of different custard apple types on the basis of group mean performance.

Groups	Characteristics	Group mean		Types	No.of types
		Pulp%	Fresh wt		
I	High pulp% & high fruit weight	59.31	280g.	1,2,3 and 28	4
II	High pulp% & low fruit weight	56.727	140.71g	15,17,20 22,23,24 and 25.	7
III	Low pulp% & high fruit weight.	38.72	265.0g	6,14 and 27	3
IV	Low pulp% & Low fruit weight.	38.70	177.85g	4,5,7,8, 9,10,11, 12,13,16, 18,19,21, and 26.	14
	Grand Mean	46.142	192.50g.		

Here * type(s) - 1,2,3,and 28 were found most desirable with high pulp% and high fruit weight,

* type(s) - 15,17,20,22,23,24,and 25 were found desirable with high fruit weight,

Further type(s)- 6,14,27, were found desirable with high pulp%

Where as type(s)-4,5,7,8,9,10,11,12,13,16,18,19,21,and 26 were found on desirable.

Numerical classification

In order to make the numerical classification of collected types, they were subjected to numerical taxonomic analysis (Sneath and Sokal, 1973) based on 12 characters. Then the S_{ij} values were calculated for the purpose presented in

table - 33. A dendrogram (figure - 19) was constructed based on S_{ab} values following UPGMA strategy. At 60 phenon level of the dendrogram 8 clusters were distinguished. The details of cluster composition has been presented in table - 34

Table no - 34 Composition of cluster obtained by numerical classification.

Cluster	Composition of Cluster.	Size of cluster	No of desirable types.	No of undesirable type
I	T-1, T-2,T-15 T-16,T-22,T-24,T-25 T-27 and T-28	9 types	8	1
II	T-17,T-20, and T-23	3 types	3	-
III	T-5	1 type	-	1
IV	T-7,T-8,T-9,T-10, T-11,T-12,T-13 and T-19	8 types	-	8
V	T-18	1 type	-	1
VI	T-3 and T-4	2 types	1	1
VII	T-6 and T - 14	2 types		-
VIII	T-21 and T-26	2 types	-	2

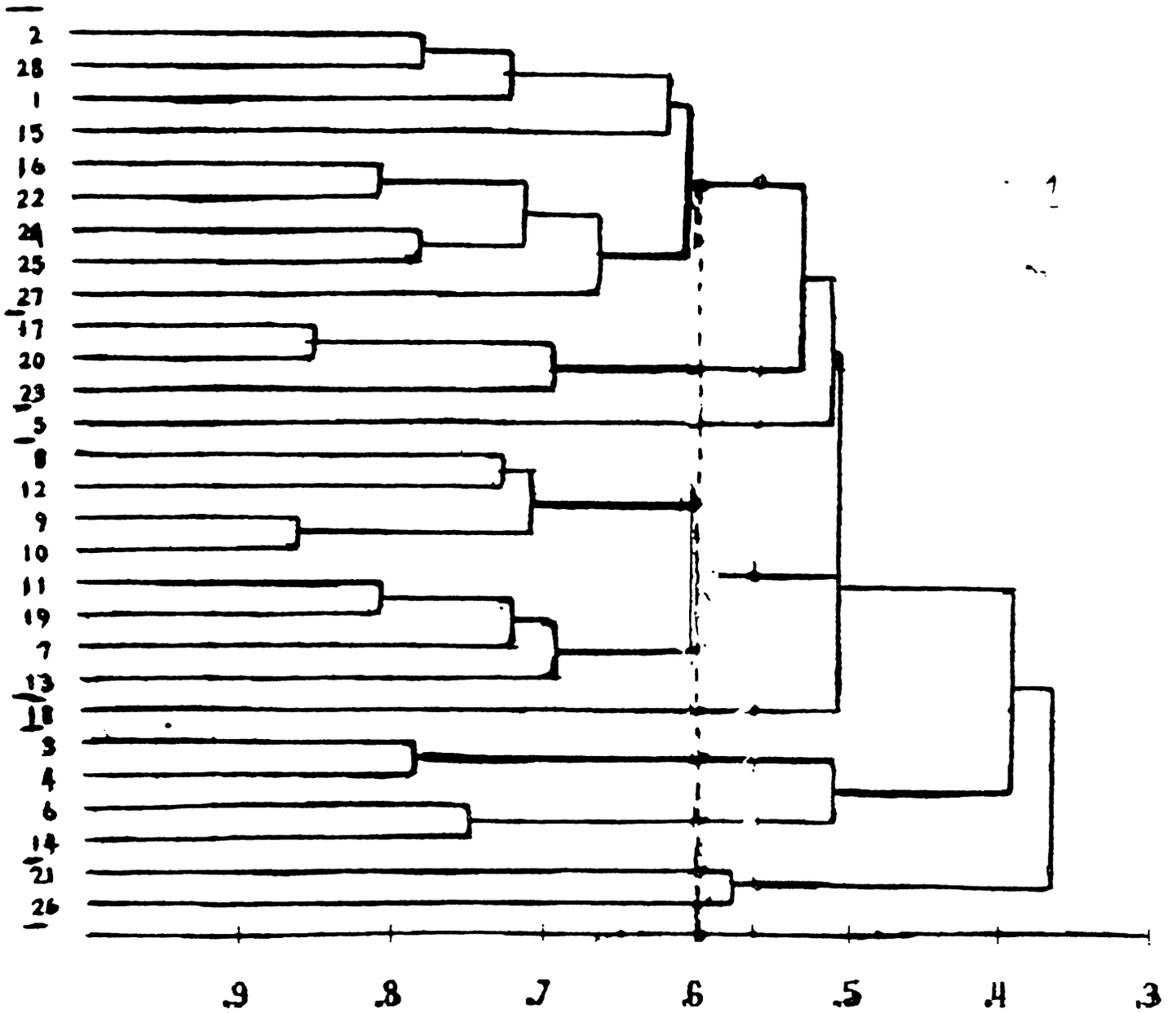
It was found that, cluster - 1, cluster - 3, and cluster -7 were those containing all the desirable types except T - 16. But cluster - III, IV, V, & VIII were completely undesirable. Cluster - VI contained T - 4 the undesirable type and T - 3 the desirable one.

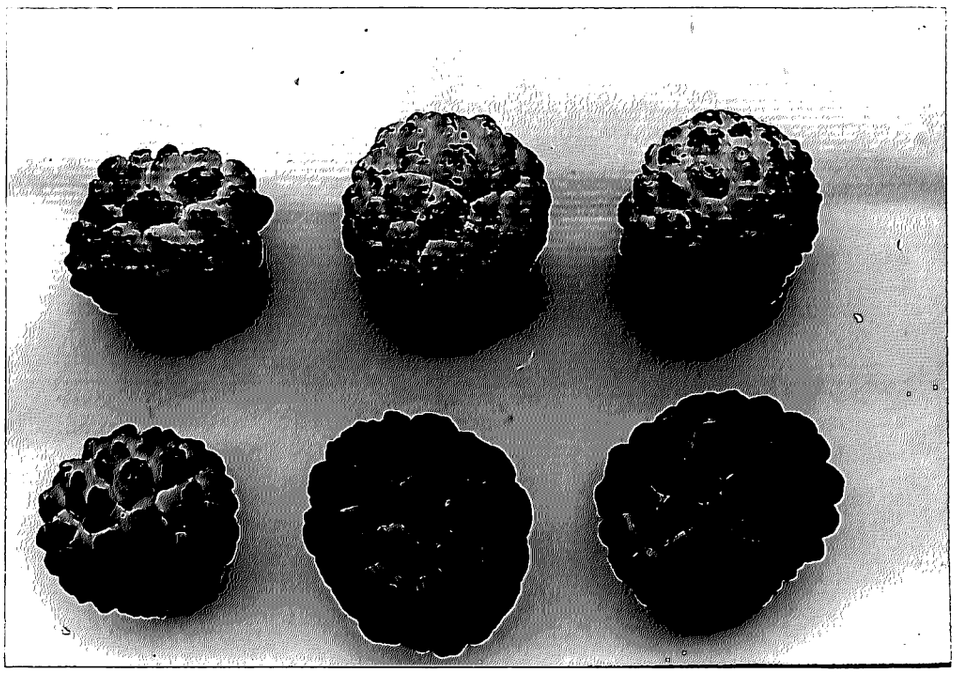
Table No. 33 Similarity Co-efficient Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	-	0.744	0.675	0.617	0.55	0.556	0.517	0.516	0.451	0.523	0.473	0.571	0.429	0.588	0.783	0.557	0.648	0.6	0.488	0.637	0.587	0.43	0.64	0.521	0.57	0.63	0.558	0.618
2	-	-	0.716	0.704	0.714	0.625	0.607	0.702	0.624	0.704	0.639	0.736	0.589	0.63	0.785	0.662	0.74	0.723	0.64	0.706	0.664	0.592	0.709	0.597	0.625	0.669	0.694	0.774
3	-	-	-	0.849	0.624	0.722	0.634	0.682	0.632	0.684	0.648	0.72	0.595	0.769	0.709	0.739	0.783	0.746	0.639	0.803	0.736	0.657	0.788	0.695	0.794	0.804	0.701	0.737
4	-	-	-	-	0.775	0.765	0.733	0.746	0.707	0.807	0.7	0.764	0.733	0.738	0.685	0.86	0.663	0.862	0.726	0.861	0.836	0.765	0.772	0.785	0.851	0.885	0.809	0.801
5	-	-	-	-	-	0.668	0.748	0.774	0.706	0.83	0.684	0.72	0.832	0.575	0.609	0.808	0.779	0.831	0.718	0.762	0.775	0.758	0.675	0.733	0.675	0.793	0.824	0.822
6	-	-	-	-	-	-	0.7	0.725	0.607	0.687	0.623	0.697	0.702	0.817	0.658	0.715	0.763	0.76	0.682	0.751	0.721	0.593	0.689	0.674	0.694	0.763	0.649	0.708
7	-	-	-	-	-	-	-	0.701	0.767	0.687	0.774	0.686	0.71	0.614	0.609	0.739	0.794	0.774	0.797	0.736	0.713	0.626	0.678	0.699	0.651	0.771	0.63	0.637
8	-	-	-	-	-	-	-	-	0.799	0.882	0.804	0.888	0.817	0.652	0.612	0.764	0.776	0.822	0.748	0.783	0.688	0.725	0.743	0.746	0.722	0.775	0.739	0.805
9	-	-	-	-	-	-	-	-	-	0.826	0.908	0.787	0.739	0.615	0.513	0.702	0.708	0.731	0.846	0.722	0.651	0.697	0.749	0.676	0.652	0.715	0.657	0.716
10	-	-	-	-	-	-	-	-	-	-	0.802	0.854	0.868	0.662	0.574	0.892	0.806	0.843	0.893	0.833	0.762	0.805	0.82	0.809	0.784	0.815	0.772	0.819
11	-	-	-	-	-	-	-	-	-	-	-	0.789	0.739	0.614	0.56	0.737	0.689	0.789	0.856	0.693	0.643	0.688	0.732	0.72	0.683	0.746	0.685	0.697
12	-	-	-	-	-	-	-	-	-	-	-	-	0.764	0.718	0.653	0.733	0.769	0.783	0.778	0.773	0.703	0.691	0.788	0.716	0.697	0.731	0.67	0.777
13	-	-	-	-	-	-	-	-	-	-	-	-	-	0.577	0.512	0.784	0.754	0.82	0.793	0.763	0.76	0.763	0.741	0.806	0.737	0.771	0.74	0.737
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.648	0.647	0.72	0.7	0.621	0.732	0.624	0.533	0.707	0.607	0.643	0.705	0.573	0.649
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.591	0.727	0.626	0.545	0.715	0.636	0.474	0.706	0.557	0.619	0.66	0.575	0.632
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.82	0.881	0.733	0.821	0.843	0.85	0.737	0.875	0.81	0.875	0.856	0.814
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.827	0.746	0.923	0.813	0	0.825	0.824	0.841	0.844	0.731	0.786
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.773	0.825	0.769	0.736	0.767	0.801	0.758	0.865	0.783	0.797
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.779	0.759	0.686	0.766	0.709	0.692	0.759	0.643	0.701
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.816	0.738	0.874	0.827	0.867	0.858	0.709	0.790
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.759	0.778	0.790	0.790	0.868	0.784	0.793
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.675	0.849	0.802	0.767	0.845	0.773
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.786	0.818	0.785	0.644	0.735
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.895	0.838	0.770	0.757
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.844	0.751	0.729
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.819	0.866
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.844
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

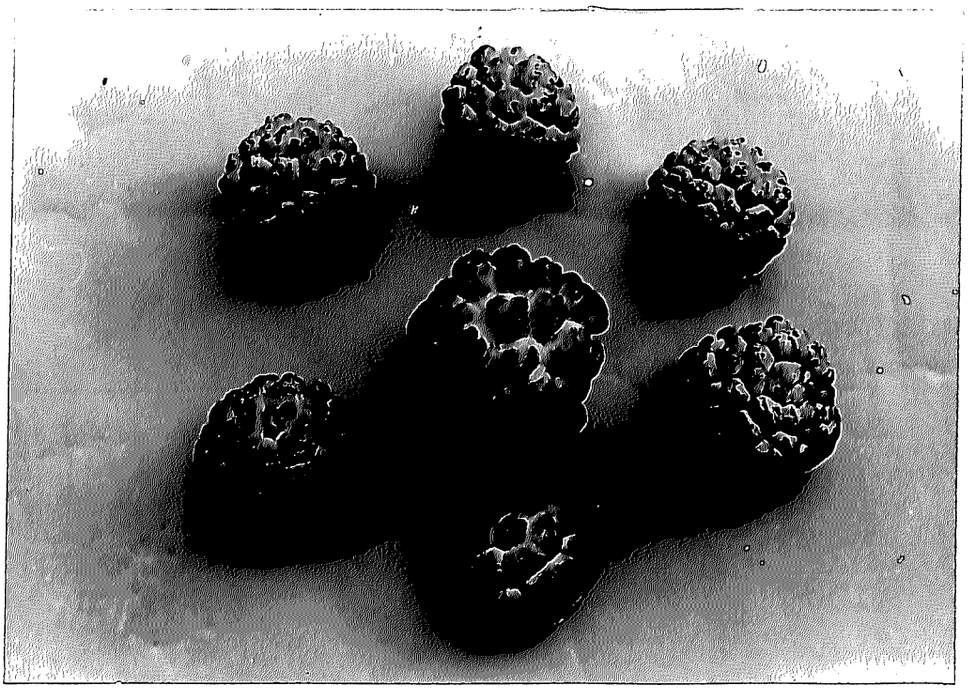
Fig-19

SINGLE LINKAGE DENDROGRAM

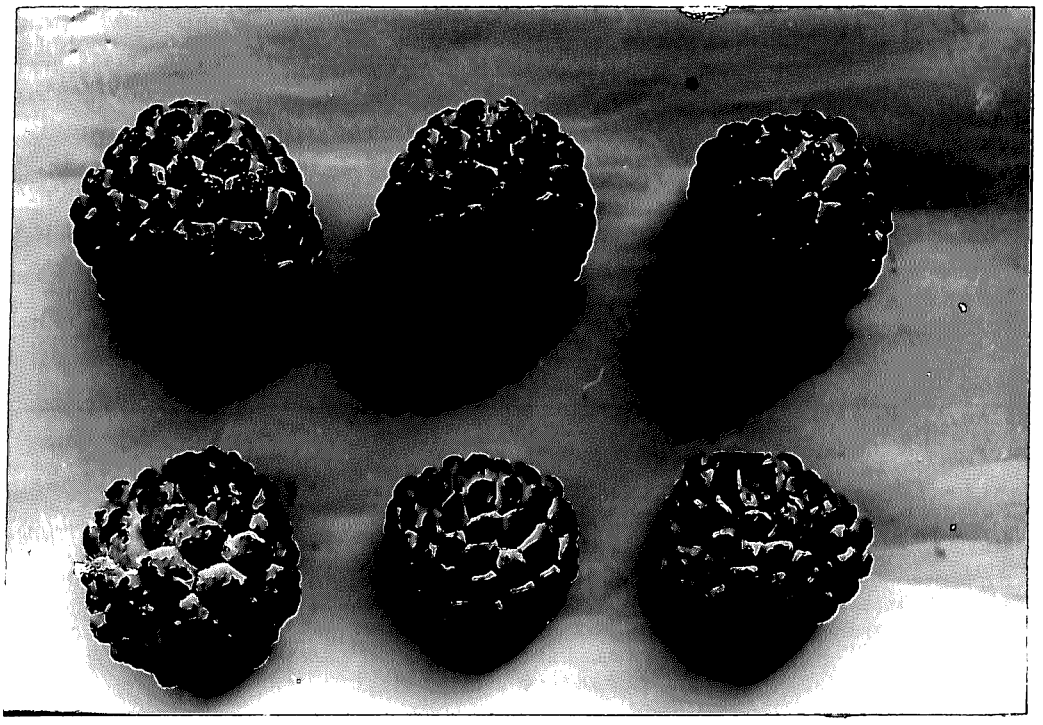




T - 21; T - 6; T - 18;
T - 22; T - 3; T - 14



T - 16; T - 20; T - 19;
T - 28
T - 17; -



T - 2; T - 8; T - 27;
T - 9; T - 11; T - 4

Correlation and character association

The data relating to the correlation studies on various characters of custard apple have been presented in table no - Perusal of the data (Table No. -35) revealed that

* The fruit weight was significantly and positively correlated with number of segments (r=0.62), seed number (r=0.550) and yield (r=0.6092) at 1% level of significance.

* But the fruit weight was significantly but negatively correlated with percentage of peel of the fruit (r= -0.4232) at 5% level of significance.

* Number of segments per fruit was significantly and positively correlated with seed number (r=0.4691) and seed weight (r = 0.5582) of fruits.

* Percentage of peel per fruit was negatively, but significantly correlated with pulp content (r= -0.5832), seed number (r = - 0.3796), seed weight (r = -0.3956) and yield (r = - 0.3768).

* Pulp content of the fruits was positively but significantly correlated with number of seeds (r=0.4030).

Table No. - 35 **CORRELATION MATRIX**

	1	2	3	4	5	6	7	8	9	10	11	12
1	-	0.6277**	-0.4232*	0.2271	0.4999**	0.5500**	0.2824	-0.2114	0.1625	0.2666	0.2911	0.6092**
2	-	-	-0.2550	0.3541	0.4691*	0.5582**	0.0119	-0.0135	-0.2539	0.0987	0.1527	0.1730
3	-	-	-	-0.5382**	-0.3796*	-0.3956*	-0.3208	0.1746	0.0053	-0.3033	-0.1925	-0.3768*
4	-	-	-	-	0.4030*	0.4135*	0.2512	-0.1997	-0.0327	0.1994	0.1139	0.2015
5.	-	-	-	-	-	0.9531**	-0.0733	-0.1428	-0.1315	0.0943	0.0953	0.2838
6.	-	-	-	-	-	-	-0.0567	-0.0862	-0.0587	0.1878	0.2125	0.3542
7.	-	-	-	-	-	-	-	-0.2134	-0.4634*	0.1964	0.1634	0.4799**
8.	-	-	-	-	-	-	-	-	0.2878	-0.0919	-0.0167	-0.0518
9.	-	-	-	-	-	-	-	-	-	-0.0966	-0.0681	0.3635
10.	-	-	-	-	-	-	-	-	-	-	0.9076**	0.4755*
11.	-	-	-	-	-	-	-	-	-	-	-	0.4442*
12.	-	-	-	-	-	-	-	-	-	-	-	-

* No. of seeds per fruit was significantly and positively correlated with weight of seeds (r = 0.9531).

* Total soluble solid content of the fruit was significantly and positively correlated with ascorbic acid content of fruit (r = 0.4634) and yield of fruits (r = 0.4799)

Total sugar content of fruit was significantly and positively correlated with reducing sugar content (r=0.9076) and yield (r = 4755).

Reducing sugar content was significantly and positively correlated with total yield of the plants (r=0.4442).

CHAPTER - V

DISCUSSION

Discussion

PART - I

The experimental findings which has been presented in the previous chapter has elucidated different aspects of floral biology of green and red types of custard apple. The relevant findings have been discussed here in detail.

Vegetative growth in relation to flowering

The development of flower buds were observed in the new flushes that appeared after complete shedding of the leaves. The new vegetative flushes were of mixed type containing flower buds in the extra axillary position. However few buds were also found to develop in the older branches. This was noticed in both green and red types of Annona squamosa. The buds were seen in clusters of 2 to 5 in mixed vegetative flushes, but in older branches only one bud appeared at one place. These findings corroborate with the observation of Naik (1949); Hays (1957) ; Thakur and Singh (1965) and Nalwadi et. al (1965).

Duration of flowering

The flower buds commenced to develop from last week of March during 1995 but from last week of February during 1996 in green types. But in red types flower bud initiatuon commenced from 2nd week of March and 2nd week of February during the Year (S) 1995 and 1996 respectively. There was

cessation of flowering in 2nd week of September during the Year 1995 and in 3rd week of September during 1996 in green type, where as in red type the flowering was over in 2nd week of July and 1st week of August in the respective years.

Thus, duration of flowering was five and half months in green type and about four months in red type during 1995. In 1996, the duration of flowering was about seven months in green type but five and half months in red type. These findings are similar to the studies conducted by Thakur and Singh (1965) under Delhi condition and also kumar and Singh (1977) under sabour condition. However, a shorter duration of flowering was observed by Nalwadi et. al (1975) under Dharwar condition. This variation is probably due to differences in the climatic condition in different areas. In the year, 1996 the duration of flowering was prolonged in both green and red types because of favourable climatic condition.

Pattern of flowering

The flowering in custard apple is a continuous process following a distinct phasic pattern in both the types also in both the years. In green type, there were three flushes with three peaks as mentioned in the earlier chapter. Where as in red type though number of flushes is same in both the years but peak period is different probably because of differences in the meteorological condition during the period of study in both the years and also might be due to difference in types.

Here in both the types, intensity of flowering was high at the first peak period which then decreased gradually. This finding corroborates with that of Thakur and Singh (1965), Who recorded two flushes of flowering.

Flower bud development

It took 30 to 35 days in green type and 28 to 32 days in red type of custard apple for complete bud development. The corresponding average period of the above types were 31.85 days and 29.5 days respectively. These results are similar to the findings of Thakur and Singh (1965) who observed a duration of 32 days under Delhi condition, and the findings on duration of 30.8 days reported by Nalwadi et. al (1995) under Dharwar condition. According to Kumar and Singh (1977) a duration of 35 days for bud development was observed under Sabour condition. These variations in duration of bud development might be due to difference in climatic condition of the places and also due to differences in types.

The process of flower bud development was found to occur in 5 broad phases which is more or less similar to 8 phases reported by Thakur and Singh (1965). These 5 different phases had a duration of 4 days ; 2 days ; 20 to 24 days ; 2 to 3 days and 2 days (i.e.total 30 to 35 days) in green type, where as 3 days ; 2 days ; 20 to 22 days ; 2 to 3 days and 1 to 2 days (i.e. total 28 to 32 days) in red type. Finally buds attained bright lustrous green colour and sage green colour in the respective types.

Flower morphology

It was observed that in both the types flowers were solitary, axillary with 2 to 5 no. of flower per cluster. This finding corroborates with that of Thakur and Singh (1965) and Nalwadi et. al (1975). Colour of the fully opened flower was bright lustorous, green in green type but, sage green colour in red type.

This finding is similar to the findings of Thakur and Singh (1965). Flower is simple, regular, complete and trimerous with 3 tepals and numerous stamens and carpels arranged spirally over the receptable, with a superior ovary. These findings corroborate with that reported by Bailey (1949).

Anthesis

The time taken from initiation to completion of anthesis was found to vary from 34 to 38 hours but on an average the period for completion of anthesis was 36.13 hrs. and 36.5 hrs. respectively in green and red types. This is more or less similar to the findings of Thakur and Singh (1965) who reported few hours to about twenty four hours for completion of anthsis under Delhi condition. The difference in the time taken for completion of anthesis might be due to difference in climatic condition.

The time of completion of anthesis varied between 2.30 am to 6.30am with maximum percentage of flowers opened

(i.e.55.57% and 48.42%) between 5.30am to 6.30am in green and red types respectively. Minimum percentage of flowers opened between 2.30am to 3.30am (6%) in both the types. Similarly kumar et. al (1977) reported that anthesis took place between 5.30pm to 5.30am. Singh (1965) recorded the rate of anthesis at an interval of three hours and found maximum anthesis to occur between 5.30am to 8.30am under Delhi condition. According to Nalwadi et. al (1975) anthesis continued from 6am to 6pm with its peak at 6am under Dharwar condition. All these differences in the time of anthesis are possibly due to variation in climatic condition. In the present study conducted at Bhubaneswar the maximum percenrtage of flowers were found to open under low temperature and high humidity conditions. These findings corroborate with the views expressed by Venkatratnam (1959) ; Thakur and Singh (1965) and Nalwadi et. al (1975).

Anther dehiscence

The dehiscence of anthers commenced with the appearance of a longitudinal slit at the point of attachment of anthers with the pollen sac which proceeded towards the two ends. These findings corroborate with the findings of Thakur and Singh (1965).

The anther dehiscence was found to commence from 4.30pm and continued upto about 6.30pm. The maximum dehiscence was between 5.30pm to 6pm. Similarly, Thakur and Singh (1965)

reported that dehiscence of anthers took place from 5.30 am to 5.30pm with maximum at 2.30pm under Delhi condition.

Also, Kumar and Singh (1977) reported that maximum anthers dehisced, between 11.30am to 2.30pm. But Nalwadi et. al (1975) reported that anthers dehisced between 12pm to 4am with a peak at 2am. These variations in the time of anther dehiscence might be due to variation in climatic condition.

Pollen Studies

Pollen Morphology

The shape of the pollens was found to be round to oval with light yellow colour. This Corroborates with the findings of Thakur and Singh (1965) and Nalwadi et. al (1975). The pollen diameter was found to range between 53.15 µ to 53.8 µ in green type and between 47.81 µ to 48.26 µ in red type with an average diameter of 53.49 µ and 48.09 µ in green and red types respectively. These findings on pollens of green type corroborates with the findings of Nalwadi et. al (1975). The findings related to the pollens of red type corroborates with that of Thkur and Singh (1965).

Pollen Viability

The viability of pollens was found to vary from 42.3% to 93.33% in green type and 45.1% to 93.9% in red type with an average of 68.12% and 65.81% viable pollens in green and red type respectively. These findings are more or less similar to

that of Nalwadi et. al (1975) for green type and to that of Thakur and Singh (1965) in red type.

Duration of stigmatic secreations

The secreations from stigma commenced one day prior to anthesis and reached its peak at the time of anthesis, which later on dried up after two to three hours of anthesis. This corroborates with the findings of Thakur and Singh (1965).

Pollination and fruit set

The data presented in the previous chapter indicate that there was only 0.75% fruit set under cotrolled pollination and 3.33% set fruit under natural pollination. Thus, a total of 4.08% fruit set was observed in Annona squamosa, which is very low. Therefore it may be presumed to be a cross pollinated crop having barriers in self pollination due to protogynous condition and lack of coincidence in the time of anther dehiscence and the period of stigmatic receptivity. These views corroborate with the findings of Thakur and Singh (1965); Nalwadi et. al (1975).

PART - II

The experimental results on the study of yield and qualitative characters of 28 custard apple types have been presented in the previous chapter. The relevant findings and the significance of results of study on 28 types with regard to their variation in yield, fruit weight, number of segments, peel content; pulp content; seed number and seed weight alongwith T.S.S.; acidity; ascorbic acid; sugar content of fruit types have been discussed in this chapter. Along with the study of these characters, correlation and character association study also has been conducted. Then the fruit types were subjected to index score and metroglyph analysis and numerical classification to find out probable superior types among them. Since the fruit types are of seedling origin the variation observed will offer a good scope for crop improvement by selection. (Venkat ratnam et. al, 1967). Hence this discussion ultimately will give a brief idea regarding superior types available in different parts of Orissa on which further improvement work can be done.

Yield

The results presented (Table -) indicate that there is a significant variation in yield among different types

and the highest yield (43.5Kg/tree) was recorded in T-14 (Paralakhemundi type - 1). Since the fruit types were of seedling origin some types were found to be at par with each other. Moreover, the range of variation between the highest yield (43.5Kg/tree) to lowest yield (6Kg/tree) was found to be very high.

In working on this line, Managave (1982) reported maximum yield of 46.75 Kg/tree. But Shete et. al (1991) from Rahuri reported a lesser variation in yield (i.e., 4.2 Kg to 8.7 Kg/tree). Jagtap and Kokate (1991) recorded a greater variation in yield (i.e. 40.3Kg to 50.98 Kg/tree) at Pemigri region in Maharastra. These differences might be due to difference in agroclimatic condition; and differences in the inherent characters of the custard apple types.

Fruit weight

The results indicate that there is a significant variation in fruit weight among the custard apple types. The maximum fruit weight of 370gm was recorded in T-1 (Keonjhar type - I). Since custard apple types are of seedling origin, some of the types were found to be at par with each other. Moreover, the range of variation between lowest fruit weight (110gm) in T-22 (Nayapalli type - I) to highest fruit weight (370gm) was found to be very high. This is even higher than the variation reported by Kumar

(1994) i.e. 90.0 gm to 231.0gm from the samples collected from different places of Orissa. Singh et. al (1993) & Shete et. al (1991) recorded a variation in fruit weight from 60.45 to 150.53gm and 151 to 207gm respectively, which is still lower than that has been observed now. But Jagtap and Kokate (1991) and Managave (1982) recorded maximum fruit weight upto 515.0gm and 322.41gm respectively. These differences might be due to variation in agroclimatic condition under which the crop has bee grown and the inherent character of the plant type. The results of present study in respect of variations in fruit weight are in general agreement with the reports of Rao & Muthuswamy (1957) and Keskar et. al (1988)

Number of segments per fruit

The number of segments per fruit under different types varied from 55 (lowest) in T-13 (Podamari type - I) to 215 (highest) in T - 1 (Keonjhar type - 1) and some of them were found to be at par with each other. But earlier Kumar (1994) reported a variation from 68.5 to 100.5 from the fruit samples collected at Bhubaneswar and some other places of Orissa. This difference is probably due to coverage of more no. of places of Orissa state under the present study. Than Kumor (1994) Singh et. al (1977) have also reported an average of 90.8 number of areoles (segments) per custard

apple fruit.

Less no. of segments is desirable in custard apple fruit but it has been observed after correlation and character association studies in the present investigation that number of segments is proportional to fruit weight and number of seeds.

Hence fruit types with medium no. of segments have been considered as superior types in the present study. They are T-14 (94); T-3 (115); T - 6 (90); T-12 (92) and T-23 (75).

Peel Percentage

The peel percentage of custard apple fruit types under study varied from 22.85 (lowest) in T-15 (Baghajhar type-I) to 76.9% (Highest) in T-7 (BBSR type-I) and many fruit samples were found to be at par. Similar reports on peel percentage of custard apple fruits varying from 30.07% to 56.52% was reported by kumar (1994) at and around Bhubaneswar but singh et. al (1993) recorded a variation from 35.84% to 61.19% under Kanpur condition. Also shete et.al (1991) from Rahuri have reported percentage of non edible portion to vary from 25.4 to 59.17%. Since peel content represents the non edible portion of the fruit, weightage is given to fruits with lesser peel content and more edible portion. Hence possible types coming under this category are T-15 (Baghajar type-I);

T-1 (Keonjhar type-I); T-23 (BBSR type-4); T-2 (Udala type-I); T-28 (BBSR-6); T-12 (Remuna type-I); T-3 (Khireitangi type-I); T-14 (Paralakhemundi type-I); and T-6 (Bainda type-2).

Pulp Content

The pulp content of the fruits indicate the edible portion of the fruit and it is specifically important for this dessert fruit because, if the percentage of pulp is more the fruit type is considered to be superior. In the present study, analysis of fruit types showed a variation in pulp content from 23.75% in T-21 (Baramunda type-I) to 71.42% in T-15 (Baghajhar type-I). Similar results have been reported by Kumar (1994) and shete et.al (1991) with a variation from 39.71% to 65.21% and 40.83% to 74.6% respectively. But Jagtap and kokate (1991) have observed higher percentage of pulp which varied from 70.8 to 82.42%. These variations are probably due to differences in the types/varieties grown under different agroclimatic conditions.

Since higher pulp content is a desirable criteria for selection of varieties fruit types; T-15 (Baghajhar type-I) and T-23 (BBSR-4) with higher pulp content of 71.42% and 65.41% respectiviely may be considered for selection.

Number of seeds per fruit

It was revealed from this study that the number of seeds per fruit varied between 12.0 (lowest) in T - 8 (Keonjhar type - 2) and 70.0 (highest) in T - 15 (Baghajhar type - 1). In between these two extremes many fruit samples were found to be at par with regards to seed number. Singh et. al (1993) have recorded similarly great variation in seed content which ranged from 29.67 to 93.0 seeds per fruit. But Kumar (1994) reported a variation from 10.0 to 54.75 seeds per fruit. Similar variation was also reported by shete et. al (1991) (is 22 to 72). Less number of seeds from Sabour and Naiu, 1949 (20 to 38) no. of seeds/fruit is a desirable character for selection of better types and consumers prefer to take custard apple fruits with less number of seeds, as reported by (shete et. al 1991). However, it is evident from the study on correlation and character association that number of seeds is significantly but positively correlated with fruit weight; pulp content of fruits but negatively correlated with peel content of fruits. Hence, in the light of the above discussions, the types with medium no. of seeds per fruit should be considered as superior types. In the present study, the following types were found to fulfill our requirement as mentioned in the above discussion. They are as follows

T 3 (Khireitangi type 1), T 6 (Bainda type 2), T 9 (BBSR type 2), T 14 (Paralakhemundi type 1), T 16 (Chikiti type 1), T 18 (BBSR type 4), T 20 (Puri type 1), T 22 (Nayapalli type 1), T 23 (BBSR type 6),

Weight of seeds per fruit

The weight of seeds per fruit was found to vary from 4.2 g. (lowest) in T 8 (Keonjhar type 2) to 25.9 g. (highest) in T 1 (Keonjhar type 1) closely followed by T - 15 (Baghajhar type 1). Generally seeds seed is considered to be desirable in this dessert fruit, less weight of seeds per fruit is also a desirable character for commercial use. But as indicated from the correlation and character association study that seed weight is significantly but positively correlated with weight of fruit and its pulp content significantly but negatively correlated with peel content of the fruits. Hence, types with low to medium weight of seeds per fruit are considered superior. Accordingly the following types may be considered for selection.

T - 3 (Khireitangi type - 1), T - 4 (Baripada type - 1), T - 6 (Bainda type - 2), T - 9 (BBSR type - 2), T - 10 (BBSR type - 3), T - 14 (Paralakhemundi type - 1), T - 19 (BBSR type - 5), T - 20 (Puri type 1), T - 24 (OUAT type 1), T - 26 (BBSR type 1),

Coefficient of variation for physical character (s)

The results of analysis on the physical characters of fruit types revealed that highest C. V. was observed in the characters like seed number and seed weight. Also n the desirable characters like fruit weight and pulp percentage the coefficient of variation was high.

Chemical composition of fruits

Total Soluble Solid (T. S. S) content

Among the qualitative characters, the T. S. S percentage of fruits gives a good indication of its quality and fruits with higher T. S. S are prefered. In the present study, the T. S. S. content of fruits varied from 12.0 % (lowest) in T - 22 (Nayapalli type 1) to 23.0% (highest) in T - 9 (BBSR type 2).

As already stated, the custard apple types under study were of seedling origin having inherent variation in T. S. S. content and the present findings may be viewed in that context. However, many fruit samples e.g. T - 3 (Khireitangi type 1), T - 11 (Berhampur type 1), T - 14 (Paralakhemundi type 1) were at par with the type-22 recording highest T. S. S. percent. The results are similar to the earlier findings by Kumar (1994) who recorded a variation in T. S. S. percent from 17.5% to 26.5% from fruits collected in and

around Bhubaneswar. Similarly, Singh et. al (1993) have reported a variation in T. S.S. percent of fruits from 8.3% to 20.27% at Kanpur. However, Shete et. al have reported a variation in T. S. S. from 17.7 to 28.0%, where as Choudhry et. al (1985) have recorded a T. S. S. range from 21.1 to 21.9%. In the present study the following types: T - 3 (Khireitangi type - 1), T -11)Berhampur type - 1) T - 14 (Paralakhemundi type - 1) T - 22 (Nayapalli type - 1) were found to be superior types. So far as T. S. S. content of fruits is concerned. These types may be considered for selection as superior types.

Titrable acidity

Titrable acidity of fruits is considered to be an important component of flavor, when present in moderate quantities. Fruits of higher acidity are generally not preferable so far as the last of this dessert fruit is concerned.

The percentage of titrable acidity of various fruit types under study should a wide rage of variation from 0.013% (lowest) in T - 6 (Bainda type II) to 0.96% (highest) in T - 7 (BBSR type I) T - 9 (BBSR type II) T - 11 (Berhampur type I) T - 19 (BBSR type V) similarly. stahle (1953) have reported a wide variation in acidity of custard

apple fruits which vary from 0.26 to 0.65%. However, fruits having low acidity range has been reported by Kumar, 1994 (0.092 to 0.216%) Pai, 1993 (0.077 to 0.27%) and Jagtap and Kokate, 1991 ((0.127 to 0.142%)

While taking up selection of superior types fruits with low & moderate acidity may be given weightage.

Ascorbi acid

The results presented on ascorbic acid content of custard apple fruits indicate that there was significant variation in the ascorbic acid content among the fruit types and the higher ascorbic acid content of fruits (30.8 mg/100g.) was recorded under T - 8 (Keonjhar type II), which was at par with T - 7 (BBSR type I), T - 9 (BBSR type II), T -11 (Berhampur type 1), T -12 (Remuna type I) . Moreover the range of variation between lowest ascorbic acid content (4 mg./100g.) in T - 3 to highest ascorbic acid content was found to be very high. The results are similar to the findings of Kumar (1994) who observed a range of variation from 9.9 to 25.3 mg/100g. Moreover, in studying the development and pysicochemical properties of custard apple fruits, Singh et. al (1985) have recorded that the ascorbic acid content of custard apple fruits varied from 0.74 to 1.03 mg/100g. pulp.

Since higher content of ascorbic acid in fruits is a desirable character, types with higher ascorbic acid may be preferred of for selection.

Total and reducing sugar

The total sugar percentage of this dessert fruit is an important character to select desirable types. Also it gives an indication of its suitability for preparation of preserved products. In this experiment, the total sugar percentage of the fruit was found to vary from 7.81% (lowest) in T - 28 to 27.32% (highest) in T - 6 (Bainda type II) which was at par with T - 14 (Paralakhemundi type I). Similarly Kumar (1994) recorded a variation from 7.14% to 14.28%. Like wise stahle (1953) have observed the total sugar content of fruits to vary from 12.4 to 16.6%.

The above discussion indicate that T - 6 (Bainda type II) and T - 14 (Paralakhemundi type I) are superior types so far as total sugar of fruits are concerned.

The reducing sugar content of fruits was found to vary from 5.26% (lowest) in T - 2 (Udala type I) to 21.73% (highest) in T - 14 (Paralakhemundi type I) This is similar to the findings of Jagatap & Kokate (1991) and Majumdar (1977) who recorded a range of variation from 23.8 to 24.94% and 9.92 to 19.31% respectively. It is evident from the

above discussion that T - 14 (Paralakhemundi type I) may be considered as a superior type suitable for selection.

Coefficient of variation for chemical composition yield of fruit types

The results on chemical composition of different custard apple types revealed that highest C. V. was observed in the character of titrable acidity followed by yield/plant. there was also high coefficient of variation for other character as ascorbic acid content of fruits.

Index score analysis

Index score analysis of the types based on 11 characters indicated that 11 types were found to secure higher score than average. They were T -1, T - 3, T - 6, T-7, T-11, T-12, T-14, T- 15, T- 17, T- 20 and T - 23 which were supposed to be superior types with desirable characters.

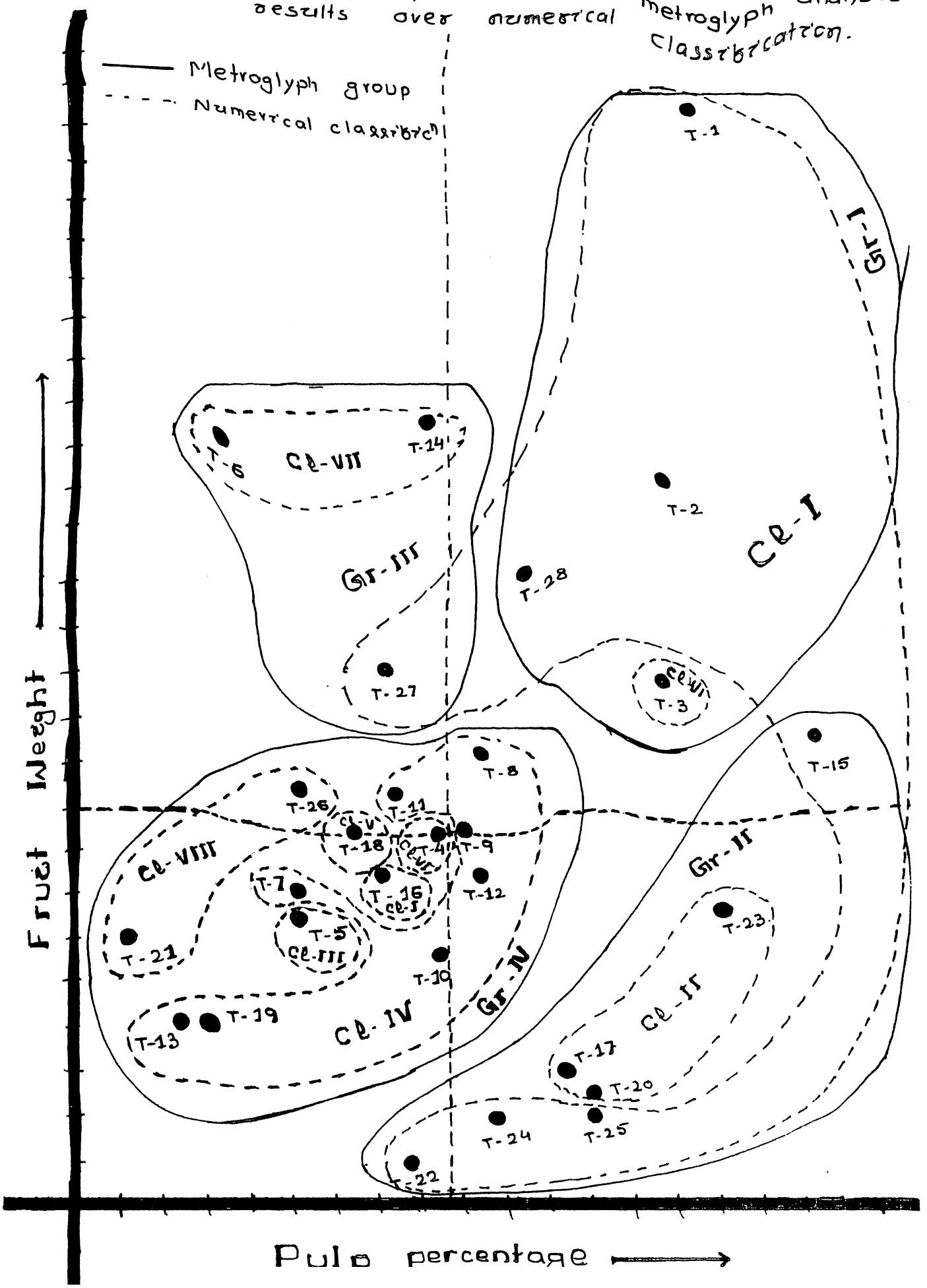
Metroglyph analysis and numerical classification

After metroglyphic analysis of different fruit types it was observed that type - 1, 2,3 and 28 were the best types with high percentage of pulp and also high fruit weight. But type -15,17,20,22,23,24, and 25 were considered good with regard to high fruit weight and type (s) - 6,14, and 27 considered good with respect to high pulp %. More over types

- 4,5,7,8,9,11,12,13,16,18,19,21, and 26 found to be undesirable as they contained low pulp as well as low fruit weight. Here, those types included in gr - II and gr - III are of great importance w.r.t. their supposed breeding value. They can be utilised to transfer that particular superior character they poses. After numerical classification of 28 types it was observed that cluster - I contained 8 desirable types (T-1,T-2,T-15,T-22,T-24,T-25,T-27,T-28) with a undesirable type (T-16). Hence this cluster can be considered most desirable. Cluster - II and Cluster - VII were found to be important because types included in those two groups do poses high fruit weight and high pulp% respectively. The cluster II and VII included types T-17,T-20,T-23 and types T-6, T-14 respectively. But cluster - III,IV, V & VIII were found to contain all the undesirable types like T-5, T-8, T-9, T-10, T-11, T-12, T-13, T-18, T - 19, T-21, and T-26.

But the cluster VI was of mixed nature which contained T-3 (a desirable type) and T-4 (a undesirable type). Hence it is observed that the 28 fruit types have been categorised to 4 groups in metroglyph analysis but they are placed into 8 clusters because only 2 characters (i.e. fruits weight and pulp%) are taken into consideration in metroglyph analysis compared to 12 characters in numerical

Fig- 20. Superimposition of results over numerical metroglyph analysis classification.



classification.

Although, there are 8 clusters and the desirable type are found to have more similarity among themselves and ar confined to cluster - I,II,and VII. Similarly, undesirabl types are confined to Cluster III,IV,V, and VIII. Hence there is a greater dissimilarity among undesirable types an also between desirable and undesirable types. (Fig - 20)

So, types included in cluster - I,II,and VII are foun to be superior types (i.e. T-1, T-2, T-3, T-6, T-14, T-15, T-16, T-17, T-20, T-22, T-23, T-24, T-25, T-27, T-28). Thi analytical result coincides with the result of metroglyp analysis except T-16 probably because of difference in no. of characters under consideration.

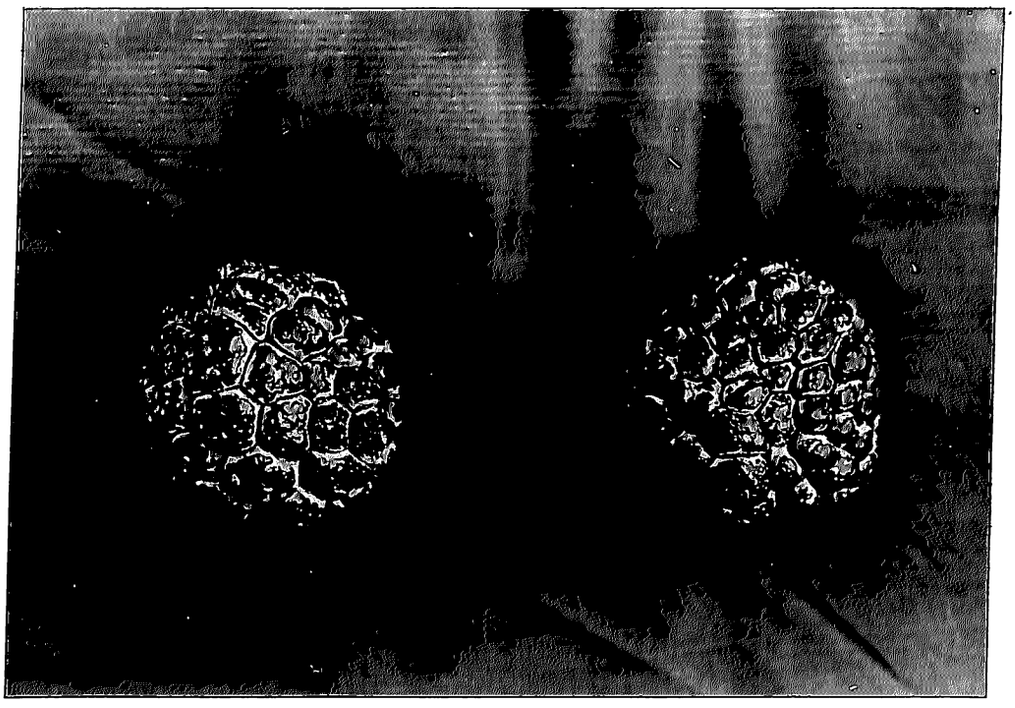
However, when index score analysis is taken intc consideration along with metroglyph analysis and numerical classification results, the following types were found to be the best ones as T - 1 (Keonjhar type - I) T - 3 (Khireitangi type - I), T- 6 (Bainda type - II) T - 14 (Paralakhemundi type - I), T - 15 (Baghajhar type - I) T - 17 (Chhatrapur type - I), T - 20 (Puri type -I) and T - 23 (BBSR type - VI).

Correlation and character assosiation studies

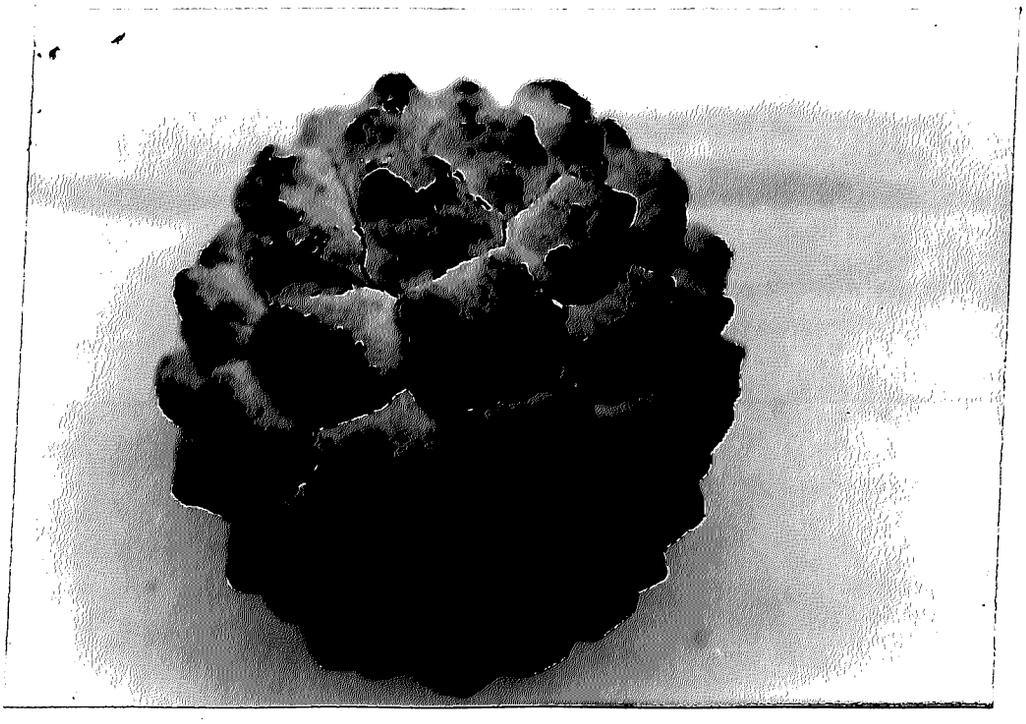
This study is aimed to give certain guidelines for selecting fruits based on physical characters, chemical

compositions and yield of custard apple.

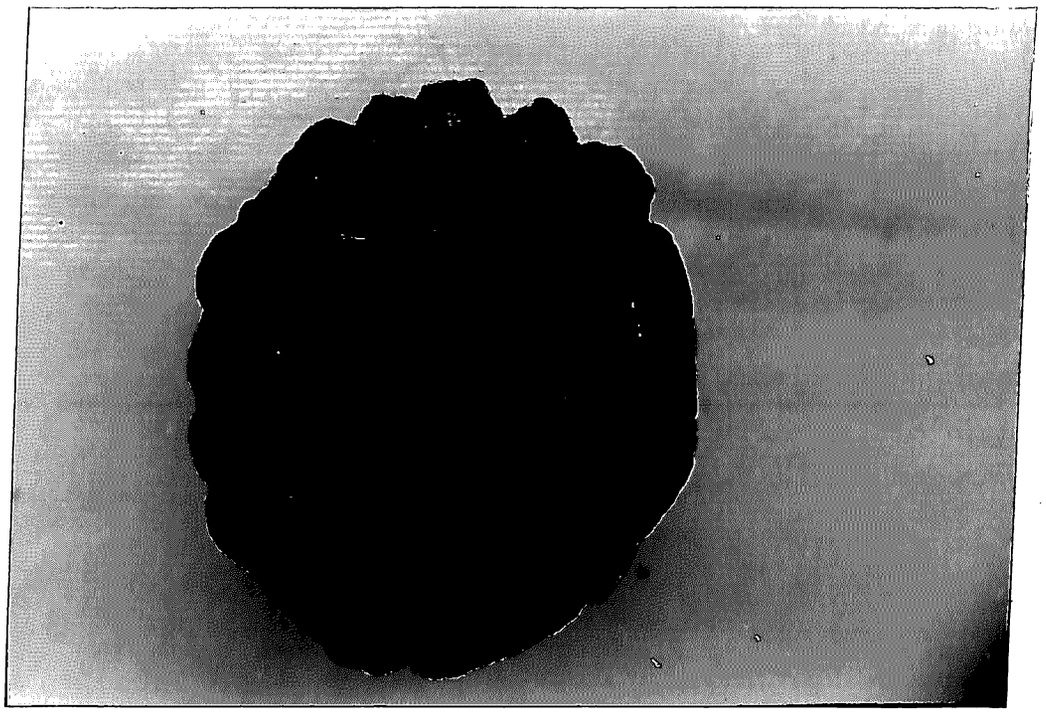
The correlation studies have indicated that, the fruit weight is significantly and positively correlated with num,ber of seeds (r= + 0.4999); seed weight (r = +0.5500) and yield 9r = +0.6092) at 1% level of significance. (It is also positively correlated with pulp content (r = + 0.2271), T. S. S. (r = +0.2824) and total sugar (r = +0.2666). This significant, high 'r' value indicates that there is strong evidence of high correlation among the characters.



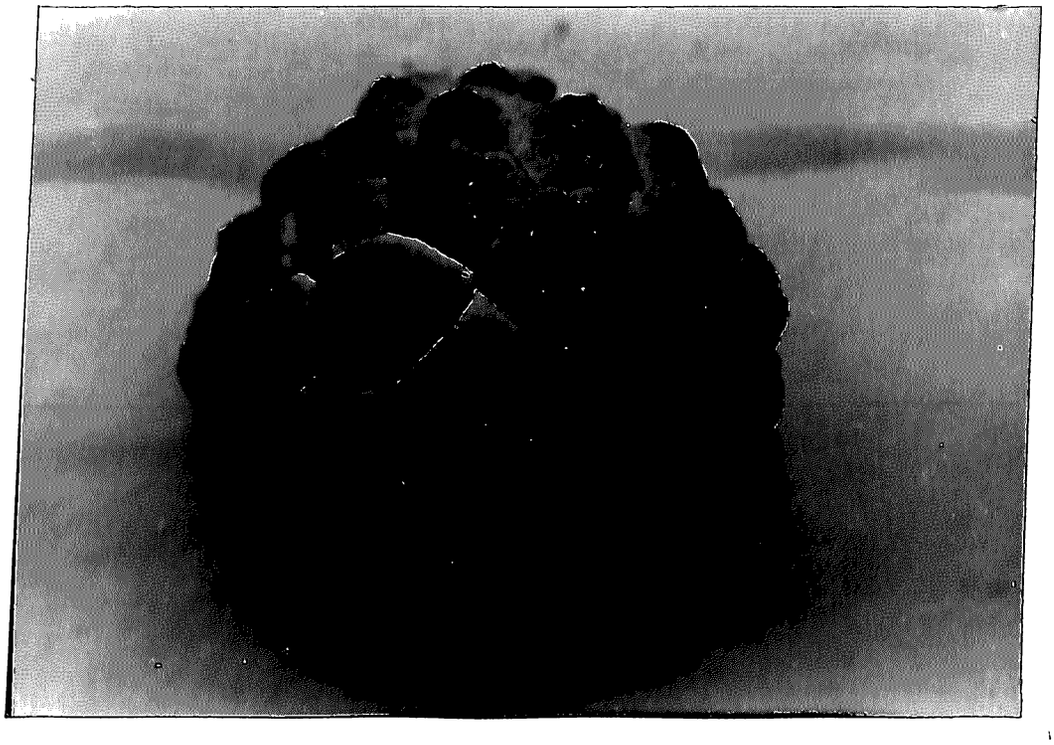
T – 24, T – 25



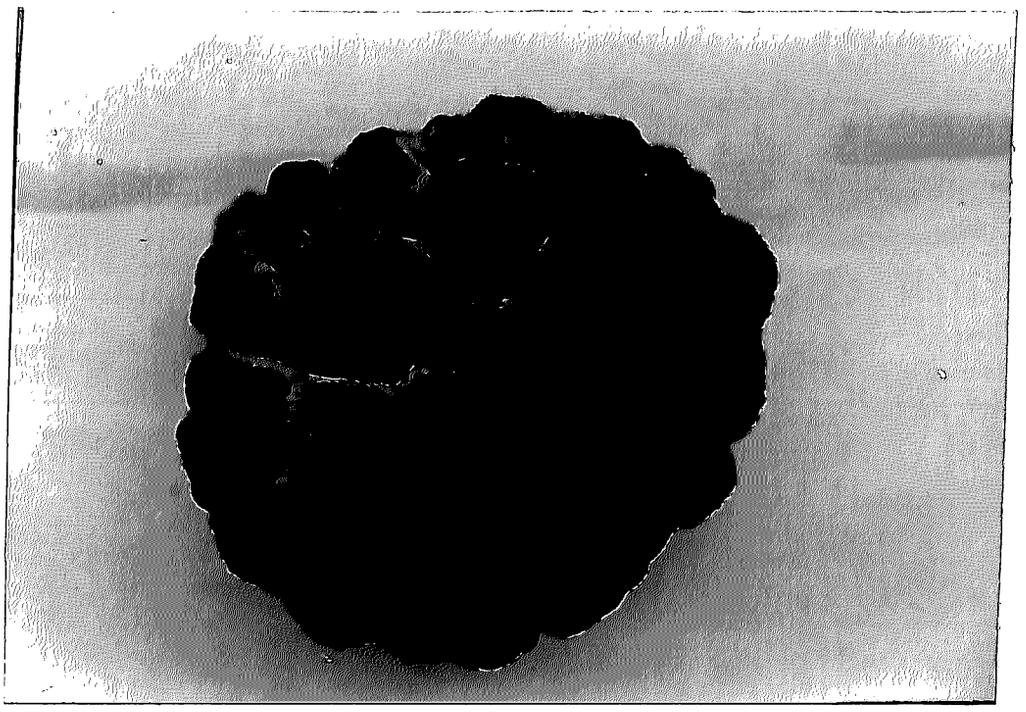
T – 1 (Keonjhar type – I)



T - 3 (Khireitangi type - I)



T - 6 (Bainda type - II)



T - 14 (Paralakhemundi type - I)

CHAPTER - VI

SUMMARY

Summary

The investigation entitled "Studies on floral biology and quality characters of different custard apple (**Annona squamosa**) types" was conducted in the Department of Horticulture, Orissa University of Agriculture and Technology, Bhubaneswar during 1995 and 1996. The investigation consisted of two parts (Part I and Part II)

Part I

This study on the floral biology of custard apple (green and red type) was carried out in the Horticultural research station, O.U.A.T. and in the gardens of residential quarters in the Bhubaneswar city during the month (S) of February to September, 1995 and again repeated in next year (i.e. February to September, 1996). The objective was to collect information on various aspects of floral biology, like vegetative growth in relation to flowering; duration and pattern of flowering; flower bud development; flower morphology; anthesis; anther dehiscence. duration of stigmatic secretion, pollination and fruit set, which will help to undertake crop improvement in custard apple.

Salient findings of the investigation are as follows :

The vegetative flushes containing rudimentary flower buds in the extra axillary position of the newly developed shoots were mostly found to develop after the complete shedding of

leaves. Also the flower buds were borne in clusters of two to five.

* Flowering duration was found to be five and half month to seven months in green type attaining three peaks during the whole period. But in red type, flowering duration was found to vary from four to five and half months with two peak periods.

* It was observed that flower buds pass through five stages of development in an average period of 31.85 days in green type and 29.5 days in red type.

* The flowers were complete regular, trimerous, with 3 tepals, numerous stamens and carpel with a convex receptacle.

* The time of anthesis in both the green and red types was found to occur between 2.30 am to 6,30 am attaining peak between 5.30 am to 6.30 am.

* Anther dehiscence started at about 4.30 pm and continued upto 6.30 pm with maximum no of anthers dehiscing between 5.30 pm to 6 pm.

* Round to oval pollens were found to posess light yellow

colour in green type and erythrite red colour in red type. The average diameter of pollens were found to vary between 53.15 and 53.8 in green type and between 47.81 to 48.26 in red type.

* The average pollen viability was found to be 68.12% in green type and 65.81% in red type.

* The stigmatic secretions started from one day prior to anthesis and continued up to 2-3 hours after anthesis indicating the receptive condition of stigma. The time of anther dehiscence did not coincide with stigma receptivity as the latter occurred much earlier indicating protogyny.

* There was only 3.33% fruit set under natural pollination and 0.75% fruit set under controlled self pollination.

Part II

The investigation regrading the "Study of quality characters of custard apple types was carried out in the post-harvest laboratory of the Department of horticulture during September - December, 1995. With an objective to find out superior types with desirable physical characters; chemical composition and yield per plant, in total 28 types of custard apple fruits collected from different localities of the state were utilised for the study. The following data were recorded i.e., yield; fruit weight, peel content, pulp content; no of seeds and its weight; T.S.S, titrable acidity, total sugar and reducing sugar content of various types of custard apple fruit. Data were subjected to index score analysis; metroglyphic analysis and numerical taxonomic classification to find out superior types.

The trial was conducted following a completely Randomized Design with 28 treatments (types) replicated five times.

The salient findings of the trial were as follows :

* Highest yield (43.5kg/tree) was recorded in T-14 lowest yield (6kg/tree) was recorded in T-25 which was at par with T-22, T-27, T-13.
* The maximum fruit weight of 370g. was recorded in T-1 followed by T-14, T-2 and T-6 with a range of fruit weight varying from 275g. to 290g. minimum fruit weight of 110g. was recorded in T-22.

* Maximim no. of segments per fruit (i.e. 215) was recorded in T -1 and minimum number of segments (i.e. 55) was recorded in T - 13.

* Lowest peel % (22.85) was recorded in T - 15 which was at par with T - 1 wth 28.7% peel content. The highest peel content was recorded in T - 7 (i.e. 76.9%).

* Maximum pulp content (71.42%) was recorded in T - 15 which was at par with T - 23. Minimum Pulp content (23.75%) was recorded in T -21.

* Maximum number of seeds per fruit (70) was recorded in T - 15 which was at par with T - 1 and T - 2 with 66 & 63 seeds respectively. Minimum number of seeds was recorded in T - 8 i.e 12 numbers which was at par with T - 13, T - 12, T - 11, T - 19, T - 24, T - 10 and T - 25.

* The maximum weight of seeds per fruit (i.e. 25.9 g.) was recorded in T - 1. The minimum weight of seeds was recorded in T - 8, which was at par with T - 12, T -11, T - 13, T - 10, T - 24, T - 9, T - 23 & T - 25.

* The highest T. S. S (23.0%) was recorded in T - 9, which was at par with T - 3, T - 11, T - 14. Lowest T. S. S.

(22%) was recorded in T - 22 which was at par with T - 27.

* The maximum amount of acidity (i.e. 0.96%) was recorded in T - 7, T - 9, T - 11, 7 T - 19 and minimum acidity was recorded in T - 6.

* The maximum amount of ascorbic acid (30.8 mg./100 g.) was recorded in T - 8, which was at par with T - 7, T - 9, T - 11 and T - 12 (27.28 to 28.6 mg./100 g.). But minimum quatity of ascorbic acid was recorded in T - 3 (4.0 mg./100 g.).

* The maximum percentage of total sugar was recorded in T - 6 (27.32%) which was at par with T - 14 (25.53%). But the minimum percentage of total sugar was estimated in T - 28 (7.81%).

* The maximum percentage of reducing sugar (21.74%) was recorded in T - 14 and minimum of 5.26% was recorded in T - 2.

* It was observed that type 6 recorded highest T. S. S. acid ratio of (1230.75) followed by T-18 (1055.55) & T - 28 (833.33)

* Type - 1,3,6,11,12,14,15,17,20 & 23 were found to high scoring types obtained by index score analysis.

* Type - 1,2,3,6,14,15,17,20,22,23,24,25,27 & 28 were found superior by metroglyph analysis.

* Type - 1, 2, 3, 6, 14, 15, 16, 17, 20, 22, 23, 24, 25, 27, & 28 were found to be superior by numerical taxonomic classification.

* The following types were found to be superior as observed after index scoring, metroglyph and numerical classification i.e. T - 1 (Keonjhar type - I); T - 3 (Khireitangi type - I); T - 6 (Bainda type - 2); T - 14 (Paralakhemundi type - I); T - 15 (Baghajhar type - I); T - 17 (Chhatrapur type - 1); T - 20 (Puri type - I); T - 23 (BBSR type - 6).

* The character, fruit weight has got significant positive correlation with number of segments, no. of seed, seed weight and yield but has significant negative correlation with peel %. Pulp % [illegible] significant correlation with seed number and seed weight. T. S. S % has got positively significant correlation with ascorbic acid content of fruits.

CHAPTER - VII

CONCLUSION

Conclusion

Part - I

The present study on the floral biology of custard apple (green and red types) in the Bhubaneswar city revealed the most crucial informations which would help the future workers to undertake crop improvement programme in this crop.

It was revealed from this study that flowering commenced after shedding of leaves from the plant between end of February and 2nd week of March depending upon the existing climatic condition at that time. Time of anthesis was found to occur between 2.30 a.m. to 6.30 a.m. attaining a peak between 5.30 a.m. to 6.30 a.m. Anthers were found to dehisce from 4.30 p.m. upto 6.30 p.m. with a peakbetween 5.30 to 6 p.m. But stigmas turned non-receptive by the time anthers dehisce, resulting in protogynous condition which is supposed to be a major cause of low fruitset in this crop.

So, self pollination and natural pollination should be avoided giving preference to artificial pollination in this crop of Annona squamosa to improve the percentage of fruitset ~~in this crop~~ which will increase its production as well as productivity.

Part - II

The present study on the study of the quality characters of different custard apple types from different parts of the state when subjected to Index scoring technique; Metroglyph analysis and Numerical classification then 8 types were found to be superior with the desirable characters compared to rest other types. The above mentioned superior types are T-1 (Keonjhar type - I); T-3 (Khireitangi type - I) T-6 (Bainda type -II); T- 14 (Paralakhemundi type - I); T- 15 (Baghajhar type -I); T - 17 (Chhatrapur type -I); T-20 (Puri type -I) ; and T -23 (BBSR type - VI).

Hence , above findings give an indication of existance of greater amount of variation. Hence, Orissa is supposed to be a good source of germ plasm of custard apple which will create a suitable condition for the future research workers to select or to develop new varieties of this crop. . So more attempt should be made to collect and preserve those superior types by maintaining vegetatively with standardised propagation techniques.

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