

**“STUDIES ON PHYSICO-CHEMICAL EVALUATION
OF TAMARIND (*Tamarindus indica* L.) GENOTYPES
PREVAILING IN BASTAR REGION
OF CHHATTISGARH”**

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CERTIFICATE - I

This is to certify that the thesis entitled "STUDIES ON PHYSICO-CHEMICAL EVALUATION OF TAMARIND (*Tamarindus indica* L.) GENOTYPES PREVAILING IN BASTAR REGION OF CHHATTISARH" submitted in partial fulfilment of the requirements for the degree of "DOCTOR OF PHILOSOPHY IN AGRICULTURE (HORTICULTURE)" of the Indira Gandhi Agricultural University, Raipur (C.G.), is a record of the bonafide research work carried out by SHRI AMIT KUMAR SHUKLA under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

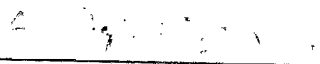
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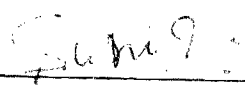

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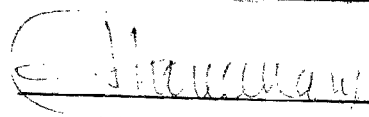
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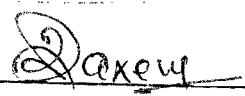
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This is to certify that the thesis entitled **STUDIES ON PHYSICO-CHEMICAL EVALUATION OF TAMARIND (*Tamarindus indica* L.) GENOTYPES PREVAILING IN BASTAR REGION OF CHHATTISGARH** submitted by **SHRI AMIT KUMAR SHUKLA** to the Indira Gandhi Agricultural University, Raipur (C.G.), in the partial fulfilment of the requirements for the degree of **Ph.D.** in the **Department of Horticulture** has been approved by the External Examiner and Student's Advisory Committee after oral examination.

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	Per cent
&	and
°B	Degree Brix
°C	Degree Celsius
CD	Critical difference
cm	Centimetre
df	Degree of freedom
<i>et al.</i>	And others/ co-workers
Fig.	Figure
<i>i.e.</i>	That is
g	Gram
Kg	Kilo gram
mg	Milligram
ml	Millilitre
mm	millimetre
NS	Non- significant
ppm	Part per million
RH	Relative humidity
SE _m ±	Standard error of mean
TSS	Total soluble solids
Vol	Volume
<i>viz.</i>	Namely/ in other words
Wt	Weight

Introduction

CHAPTER-I

INTRODUCTION

Tamarind (*Tamarindus indica* L.) is a hardy evergreen monotypic tree which belongs to the family 'Leguminosae' and sub-family Caesalpinaceae and has the chromosome number $2n=24$ (Anon, 1972; Purseglove, 1981). The name tamarind was derived from the Arabic word 'Tamar-E-Hind' meaning 'Date of India'. It is cultivated throughout the tropics and sub-tropics of the world and has become naturalized at many places.

Tamarind is an economically important tree of India as well as Chhattisgarh. In India, it is abundantly grown in Madhya Pradesh, Bihar, Andhra Pradesh, Tamil Nadu and Karnataka (Anon, 1993).

India is largest producer of tamarind in the world. As per the estimations, the total production was over 3 lakh tones in 1994-95 (Anon, 1997; George and Rao, 1997).

In India, tamarind is one of the most important common fruit trees and it is under cultivation for several centuries. Almost every part of it finds some use, but the most important is the fruit pulp which is the richest source of tartaric acid. It is being used in the manufacture of several products such as tamarind juice concentrate, pulp powder, pectin, pickle, chutneys, sauces, soups, jam, syrups, candy, tartaric acid, alcohol, refreshing tamarind drinks and tamarind kernel powder. The kernels contains a polysaccharide having very good sizing properties,

hence it is used in paper sizing, colour printing, textile industries, tanning of leather, and also glue for wood. It has been estimated that country earns more than Rs.50 crores annually from the export of various products of tamarind (Shankaracharya, 1998). Dry fruits are also exported to various countries viz., United States of America, Europe, Australia, Africa, Srilanka, Malaysia, Pakistan etc. The pulp possess some medicinal value and is used to cure dysentery. The pulp can withstand thermal processing and maintains the original flavour profile. The pulp in desiccated form, can be stored well for extended periods without refrigeration due to its high acid content, which acts as a natural preservative.

The proteins of tamarind seeds are reported to be of high biological value and compare well with properties of cereals, but meagre in utilization (Savur, 1956). Tamarind seeds are ground to make delicious feeds for livestock. The seeds also yield an amber coloured oil suitable for industrial use (Anon, 1976).

Tamarind is a hardy tree which grows well under warm climatic conditions of tropics and subtropics. It is drought tolerant and found growing in waste-land. Further, it also performs well in deep soils and tolerates poor or rocky terrain. In view of its ability to withstand heavy winds, it is preferred as a wind break. The tree is widely planted in avenues and it also provide a valuable timber.

Tamarind is short trunked tree, growing upto a height of 25 metres with dome shape crown. Seedlings of tamarind take more time to bear

promising genotypes of tamarind from naturally available genetic stock of the Bastar region of Chhattisgarh in respect of fruit quality, which will provide valuable information for further improvement of the crop. Therefore, the present studies were carried out with the following objectives:

1. To evaluate tamarind genotypes for better quality fruits.
2. To find out the physical and chemical composition of fruits in tamarind genotypes.
3. To find out the nutrient status of fruits and seeds of tamarind genotypes.
4. To find out the correlation among physical and biochemical characteristics of tamarind genotypes (fruits).

Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

Tamarind is an economically important multipurpose tree species, which is grown both as domesticated species in farmland and wild in forest lands. With increasing population pressure, demand for tamarind pulp has been increased considerably. This has necessitated to identify superior elite trees for monoculture plantations, without causing genetic erosion. Establishing plantations using genetically improved clones will help to maximize production per unit area and leads to indirect economic and social benefits.

Tree improvement through the application of genetic principles is basically directed towards modifying the heredity of tree populations, so that trees are able to meet the needs of the farmer. Tamarind is a highly cross-pollinated crop and significant improvement is possible by selecting the plus trees (desirable seedling trees) and further multiplication by clonal propagation. Wide variation for most of the attributes is observed in tamarind and there is much scope for identification of divergent types. Tamarind fruits can be processed in the variety of food products of commercial importance. The good quality of tamarind will fetch higher prices. Therefore, it is felt necessary to evaluate the physico-chemical characters of tamarind for the better quality fruits. The literature pertaining to studies in some horticultural crops including tamarind are reviewed here under the following main heads.

2.1 Selection of desirable clone from existing seedling trees

2.2 Variability studies

2.3 Physical characters of fruit

2.4 Chemical composition of fruit pulp

2.5 Mineral composition of fruit pulp and seeds

2.6 Correlation studies in tamarind

2.1 Selection of desirable clones from existing seedling trees

Selection of best individual from a native species is one of the most commonly used crop improvement methods. It is one of the easiest and most promising method of crop improvement (Singh, 1963). Tamarind is mostly grown as self sown plant or from seed of high yielding tamarind trees, which has resulted in wide variation among the seedling progenies. It is desirable to make proper selection of mother plants for the collection of seeds for planting purpose (Paulos, 1975). *Tamarindus indica* L. is a highly cross-pollinated tree and offers scope for selection of superior clones (Thimmaraju *et al.*, 1978). Such trees need to be further multiplied by vegetative means.

Bailey (1947) reported that seedling origin trees of tamarind show considerable variation in size of trees and quality of fruits. The heterozygous nature and natural cross pollination observed in most perennial fruit crops results in immense variation amongst the seedlings and gave wide scope for selection (Singh and Singh, 1958). The existing fruit plants of seedling origin, represented variations among the trees in respect to fruit size, shape, quality, season of bearing and fruit yielding

qualities. The heterozygous condition of trees had helped to select promising types in jackfruit plants (Guruprasad, 1981) and pummelo types (Narayanamurthy, 1982).

Shivanandam and Thimmaraju (1988) stated that fruit size can be the basis for preliminary evaluation of a large number of existing tamarind trees of seedling origin. Shivanandam (1980) observed that there is a good scope for the selection of promising types of tamarind by studying the existing variation among the seedling progenies with respect to quality and productivity.

2.2 Variability studies

Challapilli (1992) evaluated 24 tamarind trees of seedling origin and the significant variations were observed for fruit weight, pulp weight per fruit, seed weight etc.

Gangaprasad (1993) assessed the variability in tamarind across 282 genotypes from six districts of southern Karnataka. The variations for the characters like pod weight, number of seeds per pod, seed to pod ratio, pulp yield and tartaric acid content etc. were conspicuous.

Hanamashetti and Sulikeri (1997) evaluated 40 tamarind genotypes and noticed wide variability for all the characters studied. The variations observed for pod characteristics, tartaric acid etc. were significant.

Singh *et al.* (1997) studied the variation in fruit and seed characteristics by selecting one tree at Urigam of Dharmapuri district,

Tamil Nadu and two trees at the Institute of Forest Genetics and Tree Breeding, Forest Campus, Coimbatore.

Mastan *et al.* (1997) evaluated 52 tamarind trees in Chittoor and Anantapur districts of Andhra Pradesh and observed significant differences for the characters *i.e.*, fruit weight, veins weight, shell weight, seed weight, number of seeds per kg fruit.

Jambulingam *et al.* (1997) studied the variation in natural seedling population of Tamarind in Tamil Nadu and they assessed the variability for fruit length and fruit weight. Keskar *et al.* (1989) studied various qualitative and quantitative parameters of 14 tamarind seedling types and noticed a wide variation for TSS, acidity, weight of fruit, pod size and pod shape.

2.3 Physical characters of fruit

2.3.1 Pod size

David (1907) reported that tamarind fruit is a large flat pod measuring four to six inches in length. Bailey (1947) recognized two types of tamarind, those with long pods named as East Indian variety and those with short pods named as West Indian variety. Seedlings show considerable variation in size and quality of fruits, which account for different types.

Tamarind pods measuring 7.5 to 20 cm length, 2.5 cm breadth and 1.0 cm thickness more or less constricted between the seeds and slightly curved were reported (Anon., 1972). Hernandez-Unzon and Lakshminarayana (1982) reported tamarind pods having curved shape

measuring 12 to 15 cm length. Shivanandam (1980) reported higher fruit length (16.35 cm) and fruit thickness (1.41 cm) in straight and bulged type and also higher breadth (2.60 cm) in curved and bulged type. Mowry *et al.* (1967) reported tamarind fruits ranging from 3 to 7 inch length and about 1 inch in breadth, having slightly curved shape. A variety known as Urigam has been a popular variety in Tamil Nadu and the tree is of dwarf stature with umbrella like branching and the pods are lengthy, fleshy compared to other varieties (Geetha, 1995).

Kokate (1988) conducted a survey at MPAU, Rahuri and located six promising tamarind types having larger sized fruits (22.5 cm length) with extra white endocarp membrane colour. Keskar *et al.* (1989) recorded average fruit length of 11.58 to 22.13 cm and an average fruit breadth of 2.40 to 5.50 cm in 14 different seedling types of Western Maharashtra.

Azhakiamanavalan and Vadivel (1997) reported the morphological traits of PKM-1. They registered a pod length of 16.70 cm and pod girth of 6.90 cm. There was also a considerable variation for pod length (6.61 cm in S-4 to 11.83 cm in NTI-32), pod width (1.67 cm in NTI-57 to 2.60 cm in NTI-19) and pod thickness (1.31 cm in NTI-70 to 1.70 cm in NTI-57) as reported by Hanamashetti and Sulikeri (1997). Singh *et al.* (1997) noticed variation for pod size ranging from 18 x 3 cm to 36.5 x 5 cm for Urigam variety in Dharmapuri district. Jambulingam *et al.* (1997) reported a wide variation for fruit length ranging from 10.41 cm to 13.32 cm and

fruit girth ranging from 2.0 cm to 4.25 cm among the five different seedling plants of tamarind in Tamil Nadu.

Benjamin and Seegobin (1999) found that mean values for width, thickness and length being 2.08, 0.93 and 12.96 cm, respectively. Tamarind fruit is about 3 to 7 inches long and 1 inch wide (Anon., 2000). Ilango and Vijayalakshmi (2002) reported pod length of tamarind 15.10 cm and width 2.90 cm.

2.3.2 Fruit weight

Hernandez-Unzon and Lakshminarayana (1982) described the ripe fruit of tamarind as indehiscent, with the weight ranging from 15 to 20 g. Kokate (1988) reported larger tamarind fruits weighing 35 to 42 g at Rahuri. Challapilli (1992) noticed a wide variation for fruit weight ranging from 7.74 to 25.2 g for different tamarind seedling types. Keskar *et al.* (1989) reported maximum fruit weight of 42.25 g and minimum of 20.83 g for different seedling types of Western Maharashtra. Hanamashetti and Sulikeri (1997) recorded wide variation for fruit weight ranging from 5.73 g (S-4) to 16.84 g (NTI-32). Jambulingam *et al.* (1997) reported mean fruit weight ranging from 15.70 to 18.66 g. Mastan *et al.* (1997) reported maximum fruit weight of 63.56 g and minimum of 16.40 g for different seedling populations of Anantapur and Chittoor districts of Andhra Pradesh. Benjamin and Seegobin (1999) found that mean value for fruit weight is 17.72 g.

2.3.3 Shell weight and per cent shell weight of fruit

David (1907) reported that tamarind fruit contain 11.1 per cent shell and fibre. Shivanandam (1980) reported higher shell weight (7.29 g) for fruits of curved and bulged type and lower shell weight (2.94 g) for fruits of curved and flattened type. Keskar *et al.* (1989) recorded wide variation for shell weight ranging from 6.52 to 20.83 per cent of fruit for seedling populations of Maharashtra.

Mastan *et al.* (1997) reported wide variation for shell weight ranging from 3.0 to 13.40 g. Rind to shell ratio varied from 0.83 : 1 to 3.80 : 1 in different seedling progenies of tamarind in Anantapur and Chittoor districts of Andhra Pradesh. Hanamashetti and Sulikeri (1997) recorded wide variation in shell weight ranging from 1.78 g (NTI-77) to 5.04 g (NTI-19) and per cent of shell weight ranging from 22.71 (NTI-32) to 42.04 (S-4). Azhakiamanavalan and Vadivel (1997) compared the shell weight of PKM-1 (260 g/kg of fruit) with local type (302 g/kg of fruit). The shell weight contributed to about 26 per cent in case of PKM-1 and 30.2 per cent in local type. Vennila (2000) reported that tamarind pod contains 15 to 25 per cent shell.

2.3.4 Fibre (vein) weight and fibre (vein) per cent

The fibre content in tamarind is 12 per cent (Winton and Winton, 1935 and Lewis *et al.*, 1954). Shivanandam (1980) reported that the fruits of curved and bulged types recorded higher fibre (vein) weight (1.46 g) and the least fibre (vein) weight (0.68 g) in straight and flattened type. Keskar *et al.* (1989) recorded wide variation in fibre (vein) content ranging

from 2.35 to 6.67 per cent. Azhakiamaavalan and Vadivel (1997) compared fiber (vein) content of PKM-1 having 30 g per kg of fruit (3.0%) with local type 38 g per kg of fruit (3.8%). Mastan *et al.* (1997) recorded wide range of variation in fibre (vein) weight ranging from 0.37 to 4.30 g for 52 different seedling populations of tamarind in Chittoor and Anantapur district of Andhra Pradesh. Vennila (2000) reported that tamarind pods contain 10 to 15 per cent fibre (vein). Prabhushankar *et al.* (2004) evaluated tamarind clones and reported that tamarind fruit contain fibre from 3.13 per cent in S-18 to 7.59 per cent in P-14.

2.3.5 Pulp weight and per cent pulp content

The pulp content in tamarind fruit is 55 per cent (David, 1907; Winton and Winton, 1935; Lewis *et al.*, 1954). Keskar *et al.* (1989) reported wide variation for pulp percentage ranging from 43.34 to 71.18 per cent. Challapilli (1992) reported wide variation for pulp weight ranging from 2.70 to 9.18 g per fruit and pulp percentage from 25.71 to 62.02. Azhakiamaavalan and Vadivel (1997) compared the pulp content of PKM-1 (39 per cent) with local type (28.0 per cent). Mastan *et al.* (1997) reported wide variation for pulp weight ranging from 6.89 to 40.90 g per fruit for different seedling populations of Chittoor and Anantapur districts of Andhra Pradesh. Hanamashetti and Sulikeri (1997) recorded wide variation for pulp weight per pod ranging from 1.47 g (NTI-77) to 5.68 g (NTI-32) and pulp content ranging from 21.11 (NTI-62) to 43.05 (NTI-19) per cent.

Shivanandam (1980) reported that the fruits of curved and bulged type had more pulp weight (17.03 g) and more percentage of pulp (49.36) than other types. As high as 72 per cent pulp content was recorded in tamarind fruits (Kokate, 1988). Grollier *et al.* (1998) reported that tamarind fruits contain about 30 per cent pulp. Benjamin and Seegobin (1999) found that mean weight for pulp is 8.23 g. Sivakumar (2000) reported that tamarind fruit contained 55 per cent pulp. Vennila (2000) reported that tamarind pod contained 40 to 55 per cent pulp.

Ilango and Vijayalakshmi (2002) reported that tamarind fruit contains 10.83 g pulp. Prabhushankar *et al.* (2004) evaluated tamarind clones and reported that tamarind fruit contains pulp from 64.25 per cent in Urigam to 23.98 per cent in P-10.

2.3.6 Seed character

David (1907) stated that the seeds vary in shape from tree to tree and some were possessing irregular outline like round, ovate or obtusely four sided. One hundred seeds recorded 75.88 g seed weight. Bailey (1947) recognized two types of tamarind *i.e.*, those with long pods containing seeds ranging from six to twelve in number named as East Indian variety and those with short pods containing seeds ranging from one to four in number named as West Indian variety.

According to Randhawa (1965), tamarind fruit contained three to twelve shining seeds. Cowen (1970) recorded one to ten seeds in tamarind fruit and the seeds were enclosed in fibrous pulp and the pod was more or less constricted between the seeds.

Eight to ten blackish brown hard shiny seeds are usually found in tamarind fruits. Haernandez-Unzon and Lakshminarayana (1982) stated that the number of seeds per pod seem to be a varietal character. It has been reported in tamarind fruit that the number of seeds ranged from three to twelve, the seeds were obvate-oblong and compressed with a shallow oblong pit on each side of the flat faces. It is reported that tamarind pod is composed of about 34 per cent seed (Anon., 1972; Parameshwar and Sadashivaiah, 1985; Kokate, 1988).

Shiavanandam (1980) reported higher seed weight (8.77 g) in curved and bulged type and least seed weight (5.85 g) in curved and flattened type and the fruits of straight and bulged type recorded higher number of seeds per fruit (9.29). Challapilli (1992) reported that the weight of seed in pod constituted 2.8 to 9.2 per cent of the pod weight. Hanamashetti and Sulikeri (1997) observed variation in number of seeds per pod from 3.0 (S-4) to 7.30 (NTI-62). The seed weight per pod was ranging from 1.86 g (NTI-70) to 5.33 g (NTI-75) and per cent of seed was ranging from 20.5 (NTI-19) to 36.85 (NTI-75). Mastan *et al.* (1997) reported a wide variation in number of seeds (517 to 1389) per kg of seeds and seed weight (4.4 g to 14.50 g) per fruit. Azhakiamaavalan and Vadivel (1997) recorded 320 g of seeds per kg of fruits and 9.70 seeds per pod in PKM-1 variety. Grollier *et al.* (1998) reported that tamarind fruits contain about 40% seeds and pod (fruits) containing about 10 brown seeds. Benjamin and Seegobin (1999) reported that number of seeds averaged 7 per fruit. Tamarind fruit contain about 34 per cent seed

(Anon., 2000). Whereas, Vannila (2000) reported that tamarind pod contained 25 to 35 per cent seeds.

Prabhushankar *et al.* (2004) evaluated 15 tamarind clones and reported that tamarind fruits contain seed weight from 11.42 per cent in urigam to 35.13 per cent in P-13.

2.4 Chemical composition of fruit pulp

The fruits of tamarind tree (*Tamarindus indica* L.) is the most acidic of all the fruits. The major acid present in the fruit is tartaric acid (14.18%), which is responsible for acidic taste (Lewis *et al.*, 1954; Lewis and Johar, 1956; Lewis *et al.*, 1957; Rao, 1959).

Iyengar (1938) reported that the green tamarind fruit is a better source of tartaric acid than the ripe one, although the later is more readily stored and available at all periods of the year. Unripe fruits contain free tartaric acid to the extent of over 16 per cent, while the ripe has nearly seven per cent. The total acidity of tamarind fruit consists mainly of tartaric acid (98%) with a small amount of mallic acid (2%) as reported by Lewis *et al.* (1961) and Lewis and Neelakantan (1964).

Heranandez-Unzon and Lakshminarayana (1982) reported that the ripe fruit contains 14 per cent tartaric acid and 12-15 per cent ascorbic acid. The ripening of tamarind fruit was not accompanied by a decrease in acid content unlike in other fruits (Lewis and Neelakantan, 1959). They also reported that the formation and breakdown of starch in a short period during the process of ripening and accumulation of 30-40 per cent reducing sugars imparted a sweet taste to the harvested fruits.

Duke (1981) estimated the approximate composition of the tamarind pod and dried pulp of tamarind fruit. Ripe fruit of tamarind is a rich source of protein (1.4-3.30%), total sugars (21.40-30.85%) besides tartaric acid (8.4-12.4%), whereas, the dried pulp composed of higher tartaric acid (8-18%) and total sugars (41.20%).

Shivanandam (1980) reported that the highest content of tartaric acid was recorded in tamarind fruits which are curved and bulged type (3.16%) followed by straight and bulged type (2.99%), whereas, the highest total soluble solid (TSS) content was recorded in fruits of straight and bulged type (14.40) and least TSS was recorded in curved and flattened type (12.6⁰B). The TSS content and acidity of ripe fruit varied from 15-55 per cent and 5.25 to 12.60 per cent respectively (Keskar *et al.*, 1989). Tamarind pulp contains small amount of vitamins, carotene, thiamine and nicotinic acid, the ascorbic acid content in tamarind is very small and varies from 2-20 mg/100g (Ishola *et al.*, 1990). They also reported that tamarind pulp contain 8-18 per cent tartaric acid, 25-45 per cent reducing sugar, proteins 2.00-8.79 per cent, crude fibre 2.20-18.30 per cent, non-reducing sugar 16.52 per cent, total sugar 41.20 per cent.

Challapilli (1992) observed a wide range of variation in tartaric acid from 8.94 to 14.98 per cent, Hanamanshetti and Sulikeri (1997) reported that the tartaric acid content ranged from 5.43 per cent (NTI-62) to 16.70 per cent (NTI-32) during evaluation of tamarind genotypes.

Azhakiamanavalan and Vadivel (1997) recorded a TSS of 9.10⁰B and acidity (tartaric acid) of 17.10 per cent in the variety PKM-1. Mastan

et al. (1997) reported tartaric acid ranging from 9.1 to 14.2 g per 100 g of fruit. Vennila (2000) reported that tartaric acid ranged from 8 to 18 per cent. Shankaracharya (1998) reported that tamarind pulp contains about 600 mg tannin/100 g. The only other organic acid reported in tamarind is oxalic acid. The chief amino acids present are proline and pipercolonic acid. He also reported that the fruit pulp is the richest natural source of tartaric acid (8-18%) and pulp also contains reducing sugar 25-45 per cent, it shows pH around 3.15 per cent, fat 0.5-2.53 per cent and protein 2-8.79 per cent.

Grojlie *et al.* (1998) reported that tamarind fruit is rich in reducing sugar and contains significant amount of organic acids, 98 per cent of which is tartaric acid. Benjamin and Seegobin (1999) determined mean values of total soluble solids ($^{\circ}$ Brix) and titratable acidity (%) are 9.35 and 13.73 respectively. Ravindran *et al.* (2002) reported that ripe tamarind pod contains water 17.8-35.8 per cent, protein 2-3 per cent, fat 0.6 per cent, carbohydrates 41.1-61.4 per cent, fibre 2-9 per cent, thiamine 0.33 mg, riboflavin 0.1 mg, niacin 1.0 mg and vitamin C 44 mg.

Prabhushankar *et al.* (2004) evaluated 15 tamarind clones, they reported that tamarind fruit pulp contains titratable acidity from 7.66 per cent in P-13 to 18.01 in PKM-1 and total soluble solids from 12.10 degree Brix in P-10 to 19.77 degree Brix in S-18.

2.5 Mineral composition of fruit pulp and seeds

The mineral content of tamarind pulp is calcium (81.0-466.0 mg/100g), phosphorus (86.0-190.0 mg/100g), magnesium (72.0

mg/100g), potassium (62.0-570 mg/100g), sodium (3.0-76.7 mg/100g), copper (21.8 mg/100g), iron (1.3-10.9 mg/100g), zinc (1.1 mg/100g), manganese (Nil) and the mineral content of tamarind seed is calcium (9.3-786.0 mg/100g), phosphorus (68.4-165.0 mg/100g), magnesium (17.5-118.3 mg/100g), potassium (272.8-610.0 mg/100g), sodium (19.2-28.8 mg/100g), copper (1.6-19.0 mg/100g), iron (6.5 mg/100g), zinc (2.8 mg/100g) and manganese (0.9 mg/100g) as reported by Ishola *et al.* (1990) and Bhattacharya *et al.* (1994).

Chouhan *et al.* (1991) mentioned in their report that tamarind contained P (0.19%), K (0.82%), Ca (0.52%), Mg (0.24%), Na (low) and S (0.03%). They also found that quantity of Fe, B, Cu, Zn Al, Sr, Ba and Mo were 48, 13, 14, 25, 32, 47, 4 and 1.02 ppm respectively. Ravindran *et al.* (2002) reported that ripe tamarind pulp contains calcium 34-94 mg, phosphorus 34-78 mg and iron 0.2-0.9 mg.

Parvez *et al.* (2003) analyzed mineral components of tamarind, the amount of Mg (25.6 to 30.2 mg) and Na (23.8 to 28.9 mg) were found to be highest, while the lowest amounts were recorded for Cu (0.8 to 1.2 mg) and Zn (0.8 to 0.9 mg).

2.6 Correlation studies in tamarind

Challapilli *et al.* (1995) evaluated fruits from 24 established tamarind trees which were compared for eight characters and found that fruit weight was positively and significantly associated with pulp, fibre and seed weight and fruit length and breadth.

Karale *et al.* (1999) studied the correlation analysis of several fruit parameters indicated that breeding for high pulp weight should focus on selection of high fruit weight and low seed weight and shell weight.

Birdar and Hanamashetti (2001) evaluated the correlation among different pod characters (pod length, pod width, pod thickness, pod weight pulp weight, shell weight, vein weight, number of seeds and seed weight) of 17 different tamarind genotypes. A Significant and positive correlation was observed among the various pod characteristics studied.

Materials and Methods

CHAPTER-III

MATERIAL AND METHODS

The present investigation entitled "Studies on physico-chemical evaluation of Tamarind (*Tamarindus indica* L.) genotypes prevailing in Bastar region of Chhattisgarh" was carried out for two consecutive years during 2004-05 and 2005-06, in the laboratory of Department of Horticulture and Soil Science, College of Agriculture and Dairy Chemistry laboratory (Dept. of Dairy chemistry, college of Dairy Technology) of the Indira Gandhi Agricultural university, Raipur (C.G.). The details of the technical programme *i.e.*, the experimental details, location, agro-climatic conditions and technique employed in the present investigation are described below:

3.1 Geographical situation

Jagdalpur (Bastar) is situated in southern part of Chhattisgarh at latitude 19.08° N, longitude 82.03° E and an altitude of 553 metres above the mean sea level under Bastar plateau.

Raipur is situated in the central part of Chhattisgarh at latitude 21.16° N, longitude 81.36° E and an altitude of 289.56 metres above the mean sea level under Chhattisgarh plains.

3.2 Climate

Bastar (Jagdalpur) district is characterized by high rainfall, comparatively lower temperature and high humidity. The mean

temperature ranges from 10-30°C and annual rainfall ranges from 1200-1600 mm.

Raipur comes under dry sub-humid to semi-arid agro-climatic region in rice zone of the state. The average rainfall of Chhattisgarh region is 1200-1400 mm. Most of the rains (about 85%) are received between the middle of June to the end of September and the rest during post monsoon and winter season. The maximum temperature during the summer months reaches as high as 42-45°C and the mercury drop to as low as 6-8°C during winter months. The atmospheric humidity is high during July to October.

3.3 Weather condition during experimentation

The meteorological observation during the investigation have been presented in Fig. 3.1, 3.2 and; Appendix 1 and 2. Weekly meteorological observations from April 2004 to March 2005 and April 2005 to March 2006 were recorded by the Department of Agrometeorology, S.G. College of Agriculture and Research Station, Jagdalpur (Bastar).

3.4 Experimental details

Design : R B D (Randomized Block Design)
Replication : Three
Crop : Tamarind (*Tamarindus indica* L.)
Number of Treatment : 16 genotypes of tamarind (fruit)

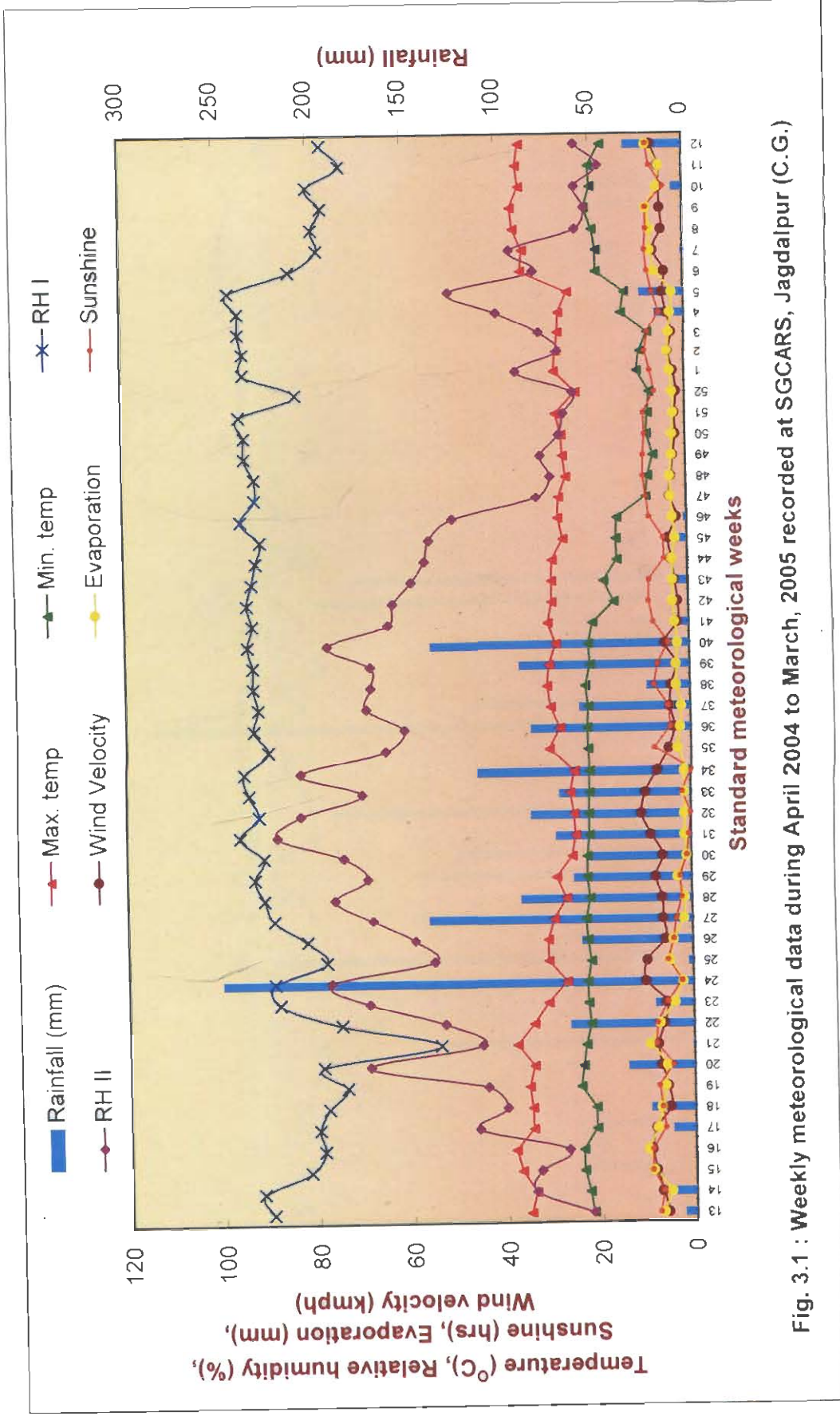


Fig. 3.1 : Weekly meteorological data during April 2004 to March, 2005 recorded at SGCARS, Jagdalpur (C.G.)

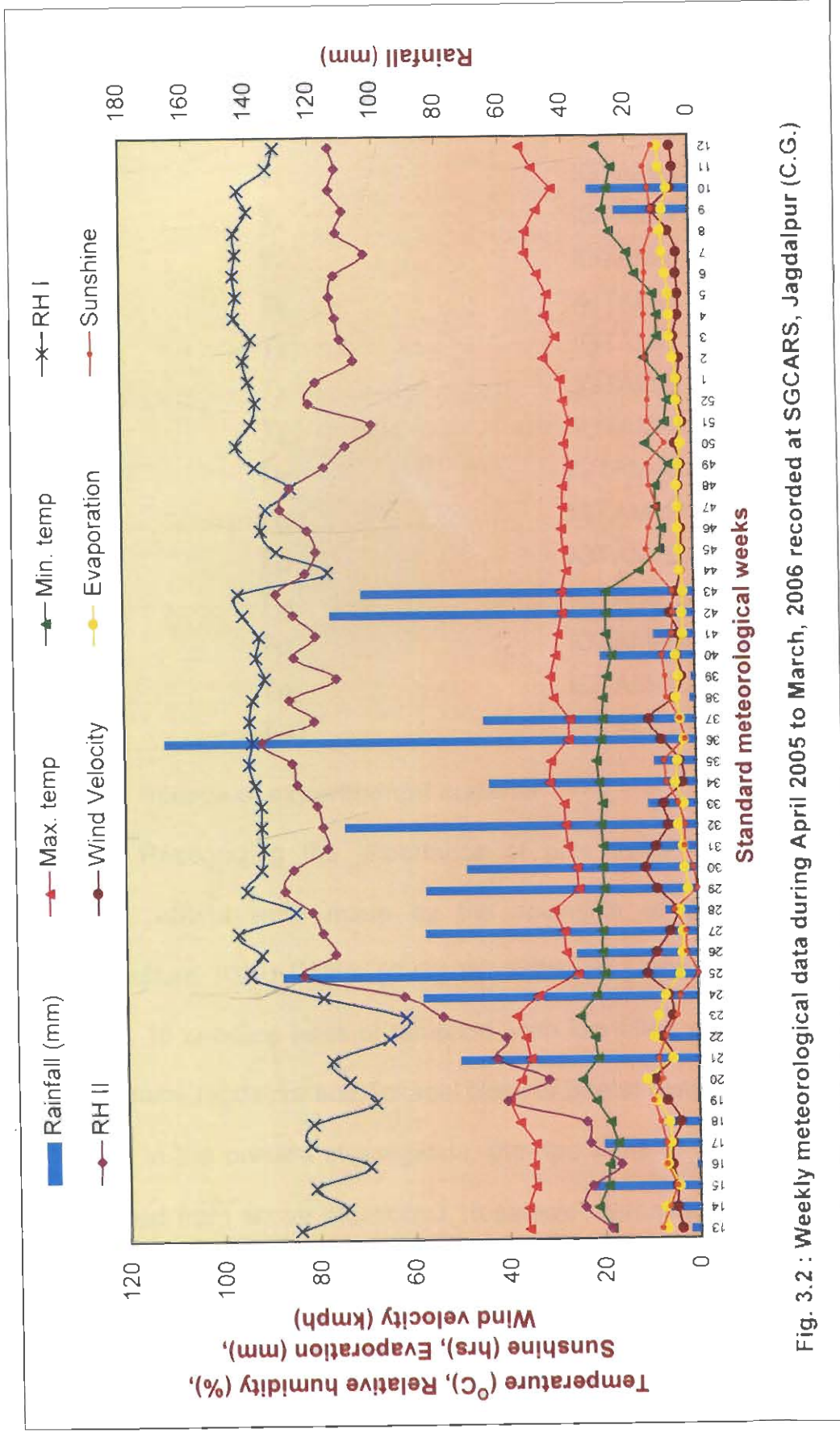


Fig. 3.2 : Weekly meteorological data during April 2005 to March, 2006 recorded at SGCARS, Jagdalpur (C.G.)

Treatment details :

Treatments		Notation of Genotypes
T ₁	:	IGTAM-1
T ₂	:	IGTAM-2
T ₃	:	IGTAM-3
T ₄	:	IGTAM-4
T ₅	:	IGTAM-5
T ₆	:	IGTAM-6
T ₇	:	IGTAM-7
T ₈	:	IGTAM-8
T ₉	:	IGTAM-9
T ₁₀	:	IGTAM-10
T ₁₁	:	IGTAM-11
T ₁₂	:	IGTAM-12
T ₁₃	:	IGTAM-13
T ₁₄	:	IGTAM-14
T ₁₅	:	IGTAM-15
T ₁₆	:	IGTAM-16

3.5 Source of experimental material

Recognizing the importance of plus trees (desirable seedling trees), efforts were made by the scientists of the Department of Horticulture, IGAU Raipur (C.G.) to identify plus trees. In the last seven years, 16 seedling trees of tamarind were identified and documented by them from Jagdalpur and Tokapal block of Bastar district (C.G.).

In the present investigation, the ripe fruits of tamarind has been obtained from above mentioned 16 selected tamarind genotypes during Feb-March 2004-05 and Feb-March 2005-06. The list of plus trees and their locations are given in Table 3.1.

3.6 Observations recorded

The observations were recorded on the ripe fruits collected from the plus trees and replicated thrice. The methods used for the estimation of various physical, chemical and mineral components of the fruits of 16 tamarind genotypes are given in following sub-heads:

3.6.1 Physical characters

3.6.1.1 Fruit weight

The weight of fruit was measured by the weighing each pod separately and value was recorded as the weight of per fruit and expressed in gram.

3.6.1.2 Fruit length

The length of each pod was measured from the tip of the pod to the base of the pod with the help of a thread and expressed in cm.

3.6.1.3 Fruit width

The width of each fruit was measured by using vernier calipers and the reading was recorded in cm.

3.6.1.4 Thickness of fruit

Vernier calipers was used to measure the thickness of fruit and the reading was expressed in centimetres.

3.6.1.5 Shell weight per fruit

After removal of outer cover of the fruit, weight of the shell was recorded and expressed in gram.

3.6.1.6 Pulp weight per fruit

Immediately after removal of shell, Vein (fibre) and seeds from the fruit, pulp weight was recorded and expressed in gram.

3.6.1.7 Seed weight per fruit

Seed weight was recorded after separation of seeds from the pulp and expressed in gram.

3.6.1.8 Vein (fibre) weight per fruit

The weight of vein was recorded after separating veins from the pulp and expressed in gram.

3.6.1.9 Number of seeds per fruit

The seeds separated from the pods and were recorded as number of seeds per fruit.

3.6.1.10 Pulp per cent

Pulp per cent was calculated by dividing weight of pulp by weight of fruit and multiplied by 100. This was expressed as pulp per cent per fruit.

3.6.1.11 Shell per cent

Shell per cent was calculated by dividing weight of shell by weight of fruit and multiplied by 100 and expressed as shell per cent per fruit.

3.6.1.12 Vein per cent

Vein per cent was calculated by dividing the weight of vein over weight of fruit and multiplied by 100. This was expressed as vein per cent per fruit.

3.6.1.13 Seed per cent

Seed per cent was calculated by dividing weight of seed by weight of fruit and multiplied by 100. This was expressed as seed per cent per fruit.

3.6.2 Chemical characters

3.6.2.1 Total soluble solids (TSS)

The total soluble solids were determined by using portable hand refractometer. The 5 g pulp of fruit was mashed with 5 ml of distilled water to make into juice. A few drops of extracted juice was placed on refractometer and the reading recorded were expressed in degree Brix.

3.6.2.2 Titratable acidity

Acidity of tamarind pulp was calculated by titrating the diluted pulp against the standard N/10 NaOH solution using phenolphthalein as an indicator and expressed as anhydrous acetic acid w/w (Ranganna, 1986).

3.6.2.3 pH of pulp

The of pH each sample of tamarind was recorded with the help of u-365 pH meter.

3.6.2.4 Ascorbic acid

A known weight of finely chopped flesh was properly blended with 15 ml 3 per cent metaphosphoric acid in pestle mortar. After macerating, the contents were transferred into 100 ml volumetric flask and volume was made upto the mark with 3 per cent metaphosphoric acid. A known volume of aliquot of the filtrate was titrated against 2, 6-Dichlorophenyl-indophenol dye solution to a pink end point, which persisted for 15 seconds (Ranganna, 1986).

3.6.2.5 Total sugar

Total sugar was determined as per "Lane and Eynon" method (Ranganna, 1986). The clear extract of tamarind pulp about 50 ml was

taken in a 250 ml conical flask, 5 g of citric acid and 50 ml distilled water was added and boiled gently for 10 minutes to complete the inversion of sucrose, then cooled. This solution was transferred to another 250 ml conical flask and neutralized with 1N NaOH using phenolphthalein as an indicator. The volume was made upto 250 ml by adding distilled water. This aliquot was titrated against 10 ml of mixed Fehling's solution using "Methylene blue" as an indicator. It was then boiled for 2 minutes. Two drops of methylene blue were added and further titration was completed within a minute. The end point was indicated by decolourization of indicator. Percentage of total sugar was calculated by using the following formula:

$$\text{Total sugar (\% invert sugar)} = \frac{\text{Factor for Fehling's solution} \times \text{Dilution} \times 100}{\text{Titre value (ml)} \times \text{weight of sample taken} \times 1000}$$

3.6.2.6 Reducing sugar

The extract was taken and titrated against 10 ml of mixed Fehling's solution using methylene blue as an indicator according to the "Lane and Eynon" method (Ranganna, 1986). It was then boiled for two minutes, 2-3 drops of methylene blue indicator were added and the titration was completed within a minute. The end point was identified when the decolourization of indicator occurred. Percentage of reducing sugar was calculated and expressed in terms of percentage, by using the following formula:

$$\text{Reducing sugar(\%)} = \frac{\text{Factor for Fehling's solution} \times \text{dilution} \times 100}{\text{Titre value (ml) wt. or vol of sample taken} \times 1000}$$

3.6.2.7 Non-reducing sugar

Non-reducing sugar was calculated by deducting the quantity of reducing sugar from total sugar and multiplied by factor 0.95 and the results were expressed as per cent of non-reducing sugar (Ranganna, 1986).

$$\text{Non-reducing sugar(\%)} = (\text{Total sugar} - \text{reducing sugar}) \times 0.95$$

3.6.2.8 Protein per cent

Pulp protein was determined by Kjeldahl method (Jackson, 1958) by digesting 0.2 gm of fruit pulp sample in 10 ml diacid containing conc. H₂SO₄ and perchloric acid in 5:1 ratio and catalyst mixture of sodium sulphide and copper sulphate followed by distillation and titration. The obtained value of nitrogen was multiplied with the factor 6.25 to get pulp protein per cent.

3.6.2.9 Crude fibre per cent

Crude fibre refers to the residue of a food that is insoluble after successive boiling with dilute acid (1.25% H₂SO₄) and alkali (1.25% NaOH) by Weende's method with the help of fibre pulp and using muffle furnace at 550° C temperature for 4-6 hours. The crude fibre content of pulp was determined as Ranganna (1986).

3.6.3 Minerals of pulp and seed

3.6.3.1 Iron, manganese, copper and zinc

Lindsay and Norvell (1978) developed a method using DTPA (Diethylene Triamine Penta Acetic Acid) for the extraction of available Fe, Mn, Cu and Zn.

3.6.3.2 Potassium and Sodium

Potassium (K) and sodium (Na) was determined by flame photometer method as described by Chapman and Pratt (1961).

3.6.3.3 Phosphorus

The total phosphorus was determined by using spectrophotometer (Olsen *et al.*, 1954) and Vanado molybdate yellow reagent procedure. In this procedure 0.5 g sample was digested in 10 ml diacid (HNO_3 and HClO_4 9:4) and then using yellow reagent (Ammonium molybdate + Ammonium meta vanadate + nitric acid) in aliquots.

3.6.3.4 Calcium

Calcium was determined by oxalatory method as described by Chapman (1928).

3.6.3.5 Magnesium

Magnesium was determined by thiazole yellow method as described by Young and Gill (1951).

3.7 Statistical analysis

The data obtained from various characters under study were analysed by the method of analysis of variance as described by Gomez and Gomez (1984).

3.8 Correlation analysis

Correlation coefficient was carried out as per the method suggested by Miller *et al.* (1958).

Experimental Findings

CHAPTER-IV

EXPERIMENTAL FINDINGS

The experimental finding of the present investigation have been given under the following heads:

- 4.1 Physical characters
- 4.2 Chemical characters
- 4.3 Mineral content of pulp
- 4.4 Mineral content of seed
- 4.5 Correlation studies

4.1 Physical characters

4.1.1 Fruit length

Data recorded on fruit length are presented in Table 4.1 and Fig. 4.1. It is observed that fruit length in different genotypes included in this study varied from 10.47 cm (IGTAM-5) to 22.10 cm (IGTAM-16) during 1st year (2004-05), 10.46 cm (IGTAM-5) to 22.15 cm (IGTAM-16) during 2nd year (2005-06) and 10.47 cm (IGTAM-5) to 22.13 cm (IGTAM-16) in case of pooled data (mean of both the years). Significant differences were observed among the genotypes in respect of fruit length during both the years as well as in pooled data.

During 1st year (2004-05), the highest fruit length was observed in IGTAM-16 (22.10 cm) which was found remarkably better than other genotypes studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-14 (21.36 cm), IGTAM-15 (20.28 cm) and IGTAM-1

(18.08 cm). The lowest fruit length was recorded in IGTAM-5 (10.47 cm) which was found significantly lower than all the treatments except IGTAM-6 (10.86 cm).

During 2nd year (2005-06), the highest fruit length was observed in IGTAM-16 (22.15 cm) which was found superior than all the genotypes studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-14 (21.39 cm), IGTAM-15 (20.48 cm) and IGTAM-9 (18.18 cm). The lowest fruit length was recorded in IGTAM-5 (10.45 cm).

In case of pooled data, highest fruit length was observed in IGTAM-16 (22.13 cm) which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-14 (21.37 cm), IGTAM-15 (20.38 cm) and IGTAM-9 (18.13 cm). The lowest fruit length was observed in IGTAM-5 (10.47 cm), which was found significantly lower than all the treatments except IGTAM-6 (10.86 cm).

Thus, the data recorded on fruit length clearly show that longest fruit was observed in IGTAM-16 and shortest fruit in IGTAM-5 in case of 1st year and 2nd year of the study as well as in pooled data.

4.1.2 Fruit width

Data recorded on fruit width in different genotypes included in this study are presented in Table 4.1 and Fig. 4.1.

The range of variation for this character was from 3.12 cm (IGTAM-3) to 4.40 cm (IGTAM-10) during 1st year (2004-05), 3.06 cm (IGTAM-3) to 4.40 cm (IGTAM-10) during 2nd year (2005-06) and 3.09 cm

(IGTAM-3) to 4.40 cm (IGTAM-10) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of fruit width during both the years as well as in pooled data.

During 1st year (2004-05), the maximum fruit width was observed in IGTAM-10 (4.40 cm) which was found better than all the genotypes studied in this investigation. This genotype (IGTAM-10) was followed by IGTAM-5 (3.85 cm), IGTAM-12 (3.70 cm) and IGTAM-14 (3.70 cm). The minimum fruit width was recorded in IGTAM-3 (3.12 cm).

During 2nd year (2005-06), the maximum fruit width was observed in IGTAM-10 (4.40 cm) which was found better than all the genotypes studied and it was followed by IGTAM-12 (3.91 cm), IGTAM-5 (3.83 cm) and IGTAM-14 (3.69). The minimum fruit width was recorded in IGTAM-3 (2.97 cm).

In case of pooled data, the maximum fruit width was observed in IGTAM-10 (4.40 cm) which was found better than all the genotypes studied in this investigation and was followed by IGTAM-12 (3.88 cm), IGTAM-5 (3.84 cm) and IGTAM-14 (3.70 cm). The minimum fruit width was recorded in IGTAM-3 (3.09 cm).

Thus, the data recorded on fruit width clearly indicate that highest fruit width was observed in IGTAM-10 while lowest fruit width was observed in IGTAM-3 in case of both the years of the study as well as in pooled data.

4.1.3 Fruit thickness

Data recorded on fruit thickness are presented in Table 4.1 and Fig. 4.1. It is observed that fruit thickness in different genotypes included in this study varied from 1.24 cm (IGTAM-7) to 2.17 cm (IGTAM-11) during 1st year (2004-05), 1.25 cm (IGTAM-7) to 2.11 cm (IGTAM-11) during 2nd year (2005-06) and 1.25 cm (IGTAM-7) to 2.14 cm (IGTAM-11) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of fruit thickness during both the years as well as in pooled data.

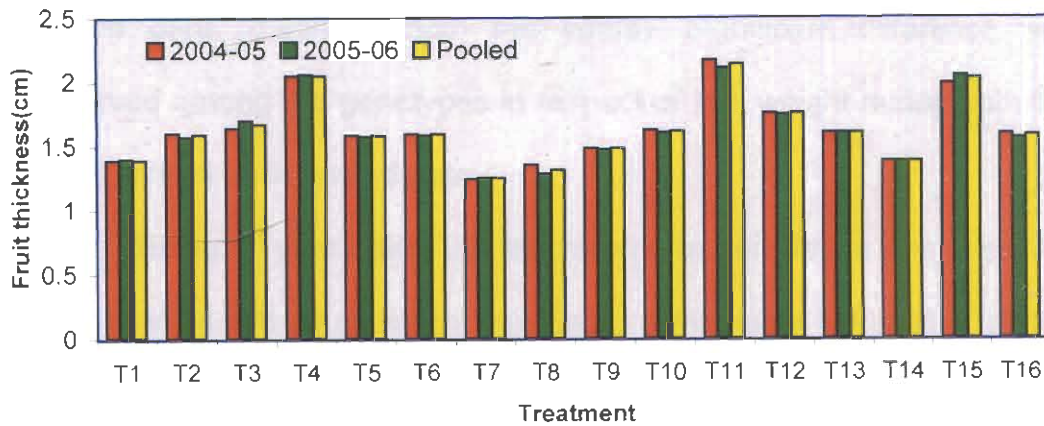
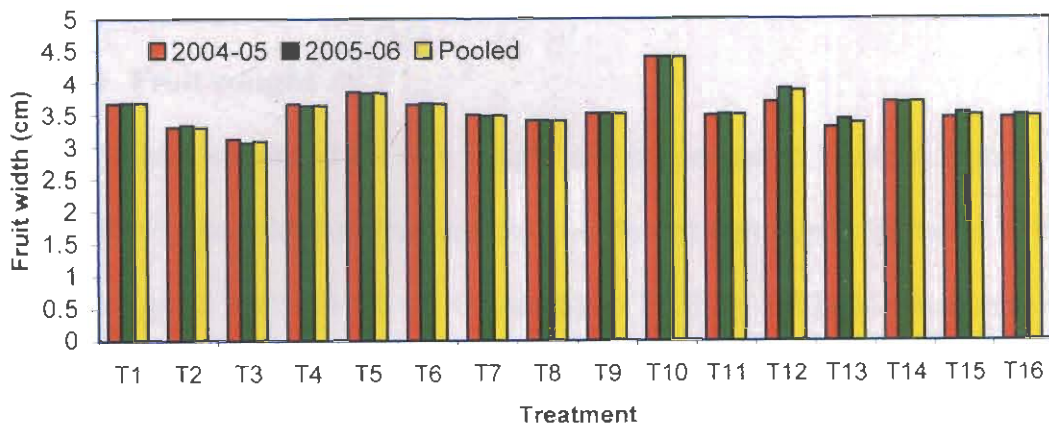
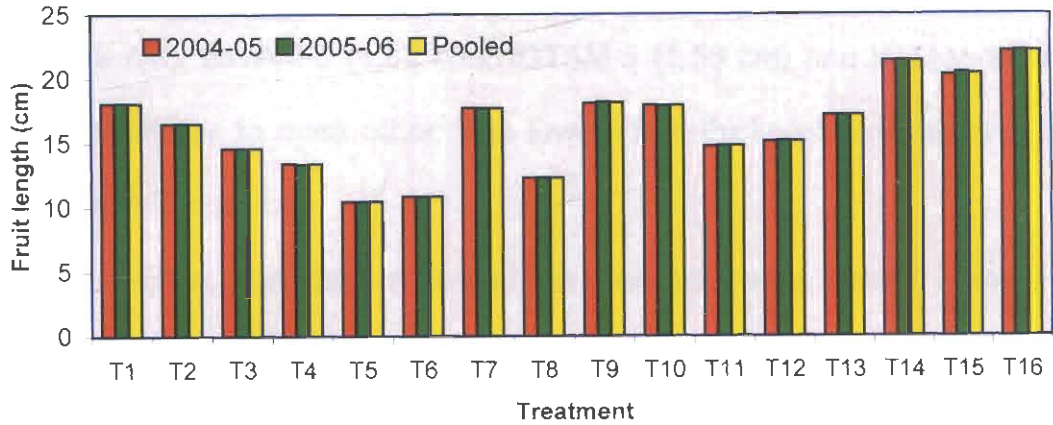
During 1st year (2004-05), the highest fruit thickness was observed in IGTAM-11 (2.17 cm) which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-11) was followed by IGTAM-4 (2.05 cm), IGTAM-15 (1.99 cm) and IGTAM-12 (1.76 cm). The lowest fruit thickness was recorded in IGTAM-7 (1.24 cm).

During 2nd year (2005-06), the highest fruit thickness was observed in IGTAM-11 (2.11 cm) which was found at par with IGTAM-4 (2.06 cm) and IGTAM-15 (2.05 cm) followed by IGTAM-12 (1.75 cm) and IGTAM-3 (1.70 cm). The lowest fruit thickness was observed in IGTAM-7 (1.25 cm), which was found significantly lower than all the treatments except IGTAM-8 (1.28 cm).

In case of pooled data, highest fruit thickness was observed in IGTAM-11 (2.14 cm) which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-11) was followed by IGTAM-4 (2.05 cm), IGTAM-15 (2.03 cm) and IGTAM-12

Table 4.1 : Variability exhibited for length, width and fruit thickness of different Tamarind genotypes

Treatments	Fruit length (cm)		Fruit width (cm)		Fruit thickness(cm)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	18.08	18.10	3.67	3.68	1.39	1.40
IGTAM-2	16.50	16.53	3.30	3.33	1.60	1.57
IGTAM-3	14.59	14.59	3.12	3.06	1.64	1.70
IGTAM-4	13.42	13.35	3.66	3.63	2.05	2.06
IGTAM-5	10.47	10.46	3.85	3.83	1.58	1.57
IGTAM-6	10.86	10.86	3.65	3.67	1.59	1.58
IGTAM-7	17.72	17.70	3.49	3.47	1.24	1.25
IGTAM-8	12.30	12.32	3.40	3.40	1.35	1.28
IGTAM-9	18.08	18.18	3.51	3.51	1.48	1.47
IGTAM-10	17.94	17.88	4.40	4.40	1.62	1.60
IGTAM-11	14.75	14.80	3.49	3.51	2.17	2.11
IGTAM-12	15.12	15.17	3.70	3.91	1.76	1.75
IGTAM-13	17.15	17.16	3.30	3.43	1.60	1.60
IGTAM-14	21.36	21.39	3.70	3.69	1.38	1.38
IGTAM-15	20.28	20.48	3.45	3.53	1.99	2.05
IGTAM-16	22.10	22.15	3.45	3.49	1.59	1.56
SE(m)±	0.1501	0.1081	0.0426	0.0329	0.0165	0.0299
CD(5%)	0.43	0.31	0.12	0.09	0.05	0.09
Pooled	18.09	18.09	3.69	3.69	1.39	1.39
Pooled	16.51	16.51	3.30	3.30	1.60	1.59
Pooled	14.59	14.59	3.09	3.09	1.64	1.67
Pooled	13.39	13.39	3.64	3.64	2.05	2.05
Pooled	10.47	10.47	3.84	3.84	1.58	1.58
Pooled	10.86	10.86	3.66	3.66	1.59	1.59
Pooled	17.71	17.71	3.48	3.48	1.24	1.25
Pooled	12.31	12.31	3.40	3.40	1.35	1.31
Pooled	18.13	18.13	3.51	3.51	1.48	1.48
Pooled	17.91	17.91	4.40	4.40	1.62	1.61
Pooled	14.78	14.78	3.49	3.51	2.17	2.14
Pooled	15.15	15.15	3.70	3.88	1.76	1.76
Pooled	17.16	17.16	3.30	3.37	1.60	1.60
Pooled	21.37	21.37	3.70	3.70	1.38	1.38
Pooled	20.38	20.38	3.45	3.49	1.99	2.03
Pooled	22.13	22.13	3.45	3.47	1.59	1.58
Pooled	0.1014	0.1014	0.0426	0.0322	0.0165	0.0165
Pooled	0.29	0.29	0.12	0.09	0.05	0.05



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.1 : Variability exhibited for length, width and fruit thickness of different Tamarind genotypes

During 1st year (2004-05), the maximum pulp weight recorded in IGTAM-14 (17.73 g) which was found superior than all the genotypes of the present study and it was followed by IGTAM-10 (17.17 g), IGTAM-13 (16.37 g) and IGTAM-1 (14.32 g). The minimum pulp weight was observed in IGTAM-5 (6.48 g).

During 2nd year (2005-06), the higher pulp weight was recorded in IGTAM-14 (17.70 g) which was found superior than all the genotypes of the present study and was followed by IGTAM-10 (17.18 g), IGTAM-13 (16.29 g) and IGTAM-1 (14.42 g). The minimum pulp weight was recorded in IGTAM-5 (6.40 g).

In case of pooled data, highest pulp weight was observed in IGTAM-14 (17.72 g) which was found remarkably better than all the genotypes studied in this investigation. This genotypes (IGTAM-14) was followed by IGTAM-10 (17.17 g), IGTAM-13 (16.33 g) and IGTAM-1 (14.32 g). The lowest pulp weight was observed in IGTAM-5 (6.44 g).

Thus, the data obtained on pulp weight clearly reveal that highest pulp was observed in IGTAM-14 and lowest pulp weight was recorded in IGTAM-5 in both the years as well as in pooled data.

4.1.6 Seed weight

Data in respect of seed weight are presented in Table 4.2 and Fig. 4.2.

A perusal of data indicates that seed weight in different genotypes included in this study varied from 3.78 g (IGTAM-5) to 9.74 g (IGTAM-16) during 1st year (2004-05), 4.16 g (IGTAM-5) to 9.71 g (IGTAM-16) during

2nd year (2005-06) and 3.97 g (IGTAM-5) to 9.73 g (IGTAM-16) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of seed weight during both the years as well as in pooled mean basis.

During 1st year (2004-05), the highest seed weight was observed in IGTAM-16 (9.74 g) which was found higher than the other genotypes studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-14 (9.28 g), IGTAM-15 (8.33 g) and IGTAM-7 (8.07 g). The lowest seed weight was recorded in IGTAM-5 (3.78 g).

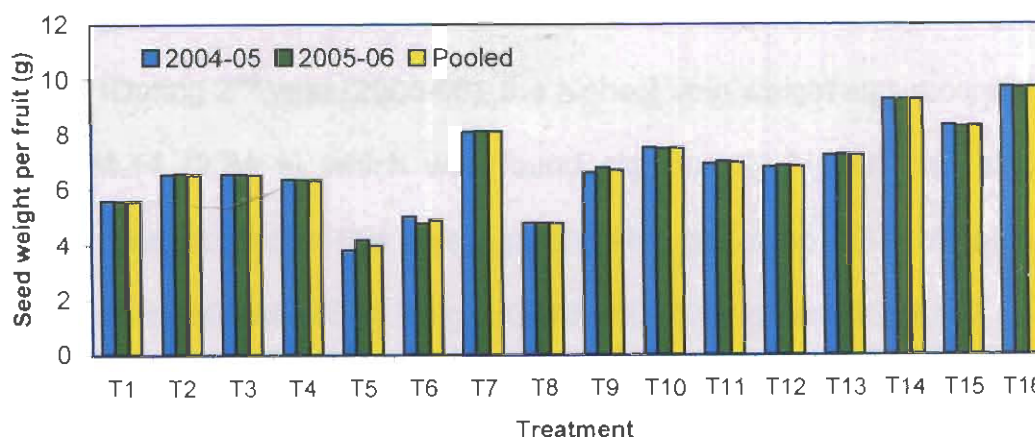
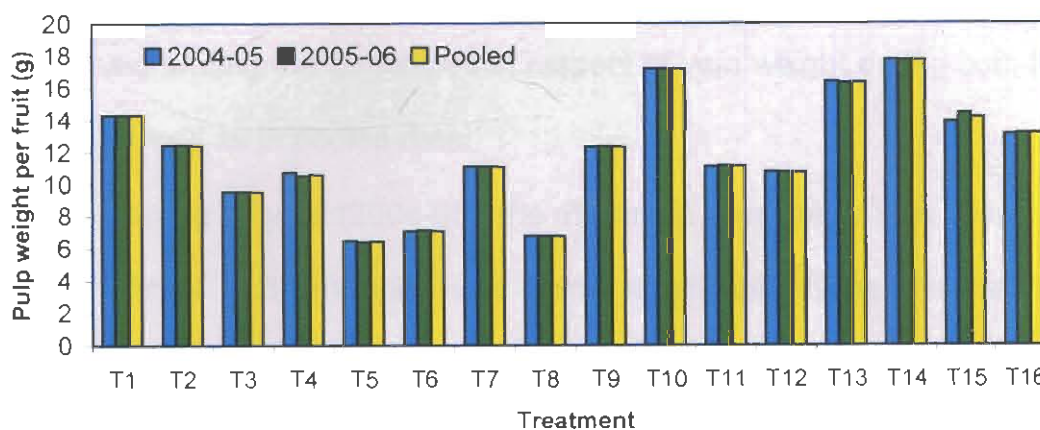
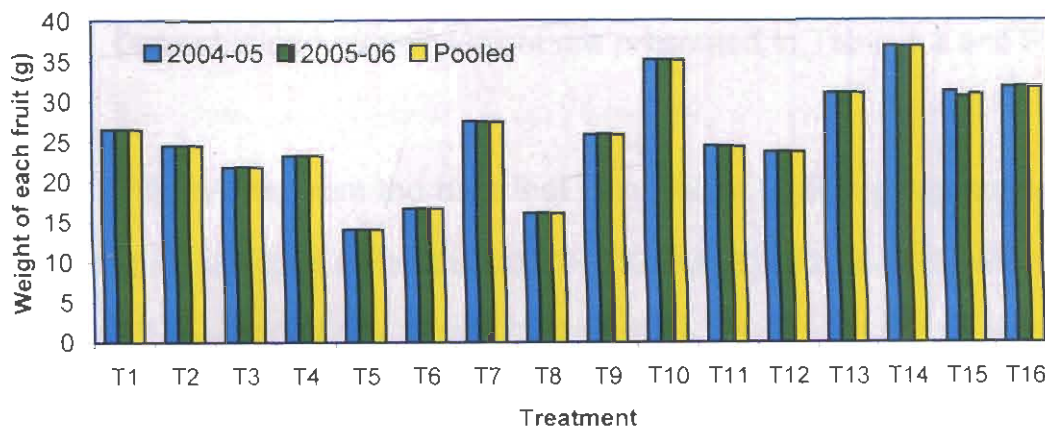
During 2nd year (2005-06), the maximum seed weight was observed in IGTAM-16 (9.71 g) which was found higher than all the other genotypes study in this investigation. This genotype (IGTAM-16) was followed by IGTAM-14 (9.28 g), IGTAM-15 (8.28 g) and IGTAM-7 (8.09 g). The minimum seed weight was observed in IGTAM-5 (4.16 g).

In case of pooled data, highest seed weight was recorded in IGTAM-16 (9.73 g) which was found higher than all the other genotypes studied. This genotype (IGTAM-16) was followed by IGTAM-14 (9.28 g), IGTAM-15 (8.31 g) and IGTAM-7 (8.08 g). The lowest seed weight was observed in IGTAM-5 (3.97 g).

Thus, the data gathered on seed weight clearly show that highest seed weight was observed in IGTAM-16 while lowest seed weight in IGTAM-5 in case of 1st year and 2nd year of the study as well as in pooled mean basis.

Table 4.2 : Fruit weight, pulp weight and seed weight of different Tamarind genotypes

Treatments	Weight of each fruit (g)		Pulp weight per fruit (g)		Seed weight per fruit (g)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	26.53	26.53	14.32	14.32	5.56	5.56
IGTAM-2	24.50	24.49	12.41	12.44	6.51	6.54
IGTAM-3	21.79	21.86	9.52	9.52	6.52	6.52
IGTAM-4	23.23	23.28	10.72	10.49	6.34	6.32
IGTAM-5	14.11	14.12	6.48	6.40	3.78	4.16
IGTAM-6	16.70	16.74	7.07	7.13	4.99	4.75
IGTAM-7	27.58	27.53	11.08	11.08	8.07	8.09
IGTAM-8	16.12	16.16	6.78	6.78	4.77	4.77
IGTAM-9	25.91	25.98	12.30	12.33	6.59	6.77
IGTAM-10	35.16	35.16	17.17	17.18	7.49	7.45
IGTAM-11	24.49	24.47	11.10	11.16	6.91	6.99
IGTAM-12	23.73	23.77	10.77	10.76	6.79	6.83
IGTAM-13	31.06	31.09	16.37	16.29	7.21	7.24
IGTAM-14	36.89	36.83	17.73	17.70	9.28	9.28
IGTAM-15	31.27	30.64	13.89	14.42	8.33	8.28
IGTAM-16	31.80	31.87	13.11	13.16	9.74	9.71
SE(m) [±]	0.1501	0.1402	0.086	0.0512	0.0398	0.0473
CD(5%)	0.43	0.40	0.25	0.15	0.12	0.14



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.2 : Fruit weight, pulp weight and seed weight of different Tamarind genotypes

4.1.7 Vein weight

Data obtained on vein weight are presented in Table 4.3 and Fig. 4.3.

It is evident from the data that vein weight in different genotypes included in this study varied from 0.47 g (IGTAM-5) to 2.36 g (IGTAM-14) during 1st year (2004-05), 0.48 g (IGTAM-5) to 2.34 g (IGTAM-14) during 2nd year (2005-06) and 0.48 g (IGTAM-5) to 2.35 g (IGTAM-14) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of vein weight during both the years as well as in pooled data.

During 1st year (2004-05), the maximum vein weight was observed in IGTAM-14 (2.36 g) which was found significantly higher than all the other genotypes studied in this investigation. This genotype (IGTAM-14) was followed by IGTAM-16 (1.72 g), IGTAM-10 (1.61 g) and IGTAM-7 (1.46 g). The minimum vein weight was observed in IGTAM-5 (0.47 g).

During 2nd year (2005-06), the highest vein weight was recorded in IGTAM-14 (2.34 g) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-14) was followed by IGTAM-16 (1.72 g), IGTAM-10 (1.61 g) and IGTAM-7 (1.46 g). The lowest vein weight was recorded in IGTAM-5 (0.48 g).

In case of pooled data, highest vein weight was observed in IGTAM-14 (2.35 g) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-14) was

followed by IGTAM-16 (1.72 g), IGTAM-10 (1.61 g) and IGTAM-7 (1.46 g). The lowest vein weight was observed in IGTAM-5 (0.48 g).

Thus, the data obtained on vein weight clearly show that maximum vein weight was observed in IGTAM-14 and minimum vein weight was observed in IGTAM-5 in case of both the years as well as in pooled data

4.1.8 Shell weight

Data regarding shell weight are presented in Table 4.3 and Fig. 4.3.

Data revealed that shell weight in different genotypes included in this study varied from 3.47 g (IGTAM-5) to 8.99 g (IGTAM-10) during 1st year (2004-05), 3.55 g (IGTAM-5) to 8.95 g (IGTAM-10) during 2nd year (2005-06) and 3.51 g (IGTAM-5) to 8.97 g. (IGTAM-10) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of shell weight during both the years as well as in pooled data.

During 1st year (2004-05), the maximum shell weight was observed in IGTAM-10 (8.99 g) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-10) was followed by IGTAM-14 (7.55 g), IGTAM-16 (7.35 g) and IGTAM-7 (6.95 g). The minimum shell weight was recorded in IGTAM-5 (3.47 g).

During 2nd year (2005-06), the maximum shell weight was recorded in IGTAM-10 (8.95 g) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-10)

was followed by IGTAM-14 (7.54 g), IGTAM-16 (7.36 g) and IGTAM-7 (6.93 g). The minimum shell weight was observed in IGTAM-5 (3.55 g).

In case of pooled data, highest shell weight was recorded on IGTAM-10 (8.97 g) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-10) was followed by IGTAM-14 (7.54 g), IGTAM-16 (7.36 g) and IGTAM-7 (6.94 g). The lowest shell weight was observed in IGTAM-5 (3.51 g).

Thus, the data revealed that maximum shell weight was recorded in IGTAM-10 and minimum shell weight in IGTAM-5 in case of 1st year and 2nd year of the study as well as in pooled data.

4.1.9 Number of seeds

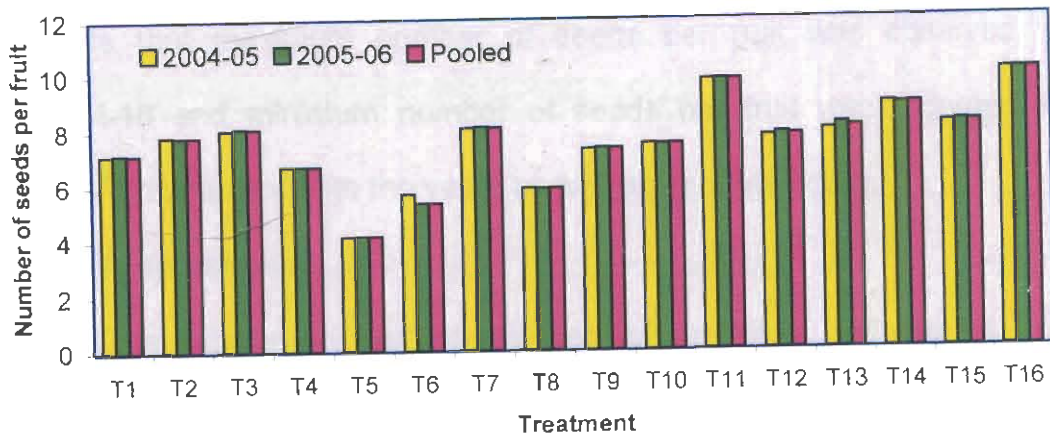
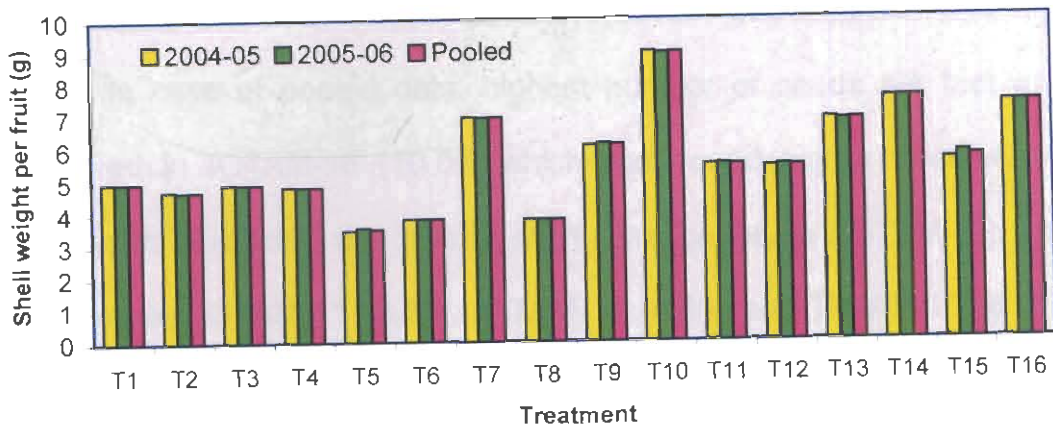
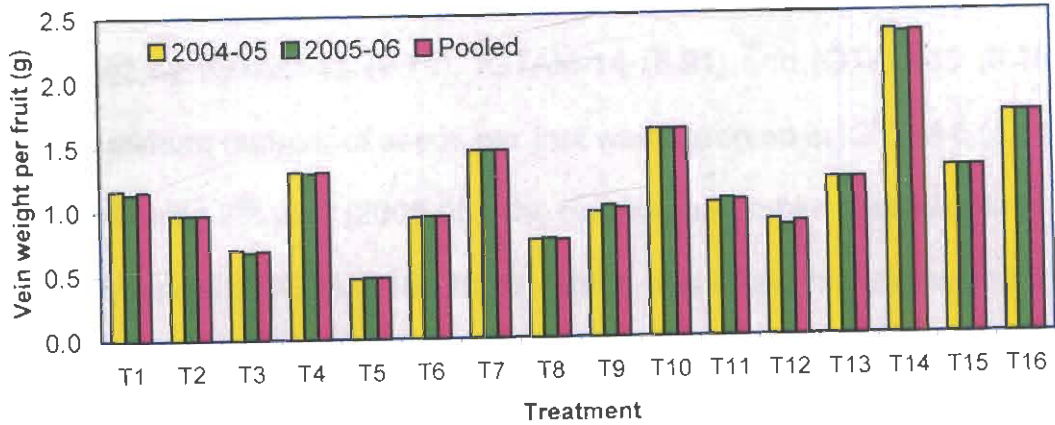
Data recorded on number of seeds per fruit are presented in Table 4.3 and Fig. 4.3.

It was observed that number of seeds per fruit in different genotypes included in this study varied from 4.14 seeds per fruit (IGTAM-5) to 10.07 seeds per fruit (IGTAM-16), during 1st year (2004-05), 4.16 seeds per fruit (IGTAM-5) to 10.09 (IGTAM-16) seeds per fruit during 2nd year (2005-06) and 4.15 seeds per fruit (IGTAM-5) to 10.08 (IGTAM-16) seeds per fruit in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of number of seeds per fruit during both the years as well as in pooled basis.

During 1st year (2004-05), the maximum number of seeds per fruit was recorded in IGTAM-16 (10.07) which was found higher than all the

Table 4.3 : Vein weight, shell weight and number of seeds per fruit of different Tamarind genotypes

Treatments	Vein weight per fruit (g)		Shell weight per fruit (g)		Number of seeds per fruit	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	1.16	1.13	4.97	4.96	7.14	7.17
IGTAM-2	0.97	0.97	4.71	4.68	7.80	7.77
IGTAM-3	0.70	0.68	4.91	4.90	8.03	8.09
IGTAM-4	1.30	1.29	4.82	4.81	6.69	6.69
IGTAM-5	0.47	0.48	3.47	3.55	4.14	4.16
IGTAM-6	0.94	0.95	3.81	3.81	5.67	5.34
IGTAM-7	1.46	1.46	6.95	6.93	8.06	8.10
IGTAM-8	0.76	0.77	3.80	3.80	5.87	5.86
IGTAM-9	0.97	1.02	6.08	6.14	7.29	7.32
IGTAM-10	1.61	1.61	8.99	8.95	7.47	7.46
IGTAM-11	1.03	1.06	5.48	5.51	9.79	9.81
IGTAM-12	0.90	0.85	5.42	5.47	7.74	7.84
IGTAM-13	1.22	1.22	6.89	6.85	7.97	8.17
IGTAM-14	2.36	2.34	7.53	7.54	8.91	8.87
IGTAM-15	1.30	1.30	5.60	5.81	8.18	8.23
IGTAM-16	1.72	1.72	7.35	7.36	10.07	10.09
SE(m)±	0.0179	0.0227	0.0438	0.0433	0.1027	0.0295
CD(5%)	0.05	0.07	0.13	0.12	0.30	0.09
Pooled	1.15	1.15	4.96	4.96	7.15	7.15
Pooled	0.97	0.97	4.69	4.69	7.78	7.78
Pooled	0.69	0.69	4.90	4.90	8.06	8.06
Pooled	1.30	1.30	4.81	4.81	6.69	6.69
Pooled	0.48	0.48	3.51	3.51	4.15	4.15
Pooled	0.95	0.95	3.81	3.81	5.34	5.34
Pooled	1.46	1.46	6.94	6.94	8.08	8.08
Pooled	0.76	0.76	3.80	3.80	5.87	5.87
Pooled	1.00	1.00	6.11	6.11	7.31	7.31
Pooled	1.61	1.61	8.97	8.97	7.47	7.47
Pooled	1.05	1.05	5.49	5.49	9.80	9.80
Pooled	0.88	0.88	5.45	5.45	7.79	7.79
Pooled	1.22	1.22	6.87	6.87	8.07	8.07
Pooled	2.35	2.35	7.54	7.54	8.89	8.89
Pooled	1.30	1.30	5.71	5.71	8.21	8.21
Pooled	1.72	1.72	7.36	7.36	10.08	10.08
Pooled	0.0124	0.0124	0.0288	0.0288	0.0297	0.0297



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.3 : Vein weight, shell weight and number of seeds per fruit of different Tamarind genotypes

genotype studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-11 (9.79), IGTAM-14 (8.91) and IGTAM-15 (8.18). The minimum number of seeds per fruit was observed in IGTAM-5 (4.14).

During 2nd year (2005-06), the maximum number of seeds per fruit was observed in IGTAM-16 (10.09) which was found higher than all the genotypes studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-11 (9.81), IGTAM-14 (8.87) and IGTAM-15 (8.23). The minimum number of seeds per fruit was recorded in IGTAM-5 (4.16).

In case of pooled data, highest number of seeds per fruit was observed in IGTAM-16 (10.08) which was found higher than all the genotypes studied in this investigation. This genotype (IGTAM-16) was followed by IGTAM-11 (9.80), IGTAM-14 (8.89) and IGTAM-15 (8.21). The lowest number of seeds per fruit was recorded on IGTAM-5 (4.15).

Thus, the data recorded on number of seeds per fruit clearly indicate that maximum number of seeds per fruit was observed in IGTAM-16 and minimum number of seeds per fruit was recorded in IGTAM-5 in case of both the years as well as in pooled data.

4.1.10 Pulp per cent

The data on per cent of pulp per fruit are given in Table 4.4 and Fig. 4.4.

A perusal of data indicate that pulp per cent per fruit in different genotypes included in this study ranged between 40.18 per cent (IGTAM-7) to 53.98 per cent (IGTAM-1) during 1st year (2004-05), 40.23 per cent (IGTAM-7) to 53.98 per cent (IGTAM-1) during 2nd year (2005-06) and

40.20% (IGTAM-7) to 53.98 per cent (IGTAM-1) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of pulp per cent per fruit during both the years as well as in pooled basis.

During 1st year (2004-05), the highest pulp per cent was observed in IGTAM-1 (53.98%) which was found exceptionally best than all the genotypes studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-13 (51.62%), IGTAM-2 (50.66%) and IGTAM-10 (48.82%). The lowest pulp per cent was recorded in IGTAM-7 (40.18%) which was at par with IGTAM-16 (41.23%).

During 2nd year (2005-06) the maximum pulp per cent was observed in IGTAM-1 (53.98%) which was found exceptionally best than all the genotypes studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-13 (52.38%), IGTAM-2 (50.68%) and IGTAM-10 (48.87%). The minimum pulp per cent was recorded in IGTAM-7 (40.23%).

In case of pooled data, the highest pulp per cent was observed in IGTAM-1 (53.98%) which was found exceptionally best than all the genotypes studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-13 (52.00%), IGTAM-2 (50.67%) and IGTAM-10 (48.85%). The lowest pulp per cent was recorded in IGTAM-7 (40.20%).

It is obvious from the data obtained on pulp per cent per fruit clearly show that maximum pulp per cent was observed in IGTAM-1 and

minimum pulp per cent in IGTAM-7 in case of 1st year and 2nd year of the study as well as in pooled data.

4.1.11 Shell per cent

The data gathered on shell per cent per fruit are presented in Table 4.4 and Fig. 4.4.

It is evident from the data that shell per cent per fruit in different genotypes ranged from 17.93 per cent (IGTAM-15) to 25.58 per cent (IGTAM-10) during 1st year (2004-05), 18.69 per cent (IGTAM-15) to 25.45 per cent (IGTAM-10) during 2nd year (2005-06) and 18.45 per cent (IGTAM-15) to 25.51 per cent (IGTAM-10) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of shell per cent per fruit during both the years as well as in pooled mean basis.

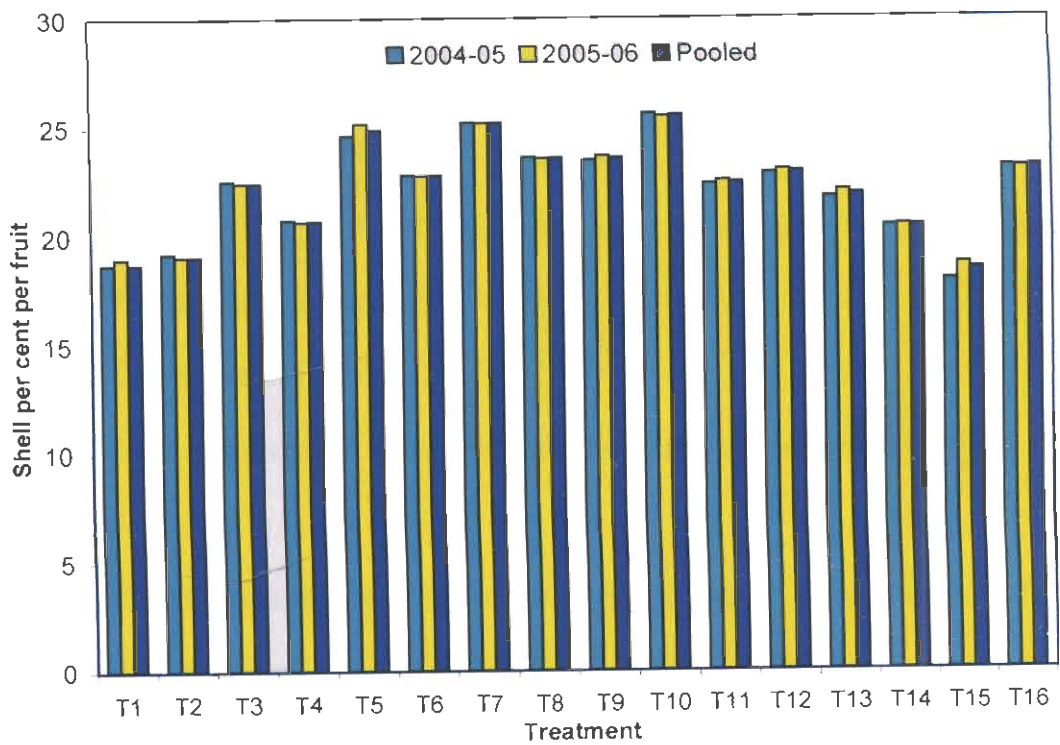
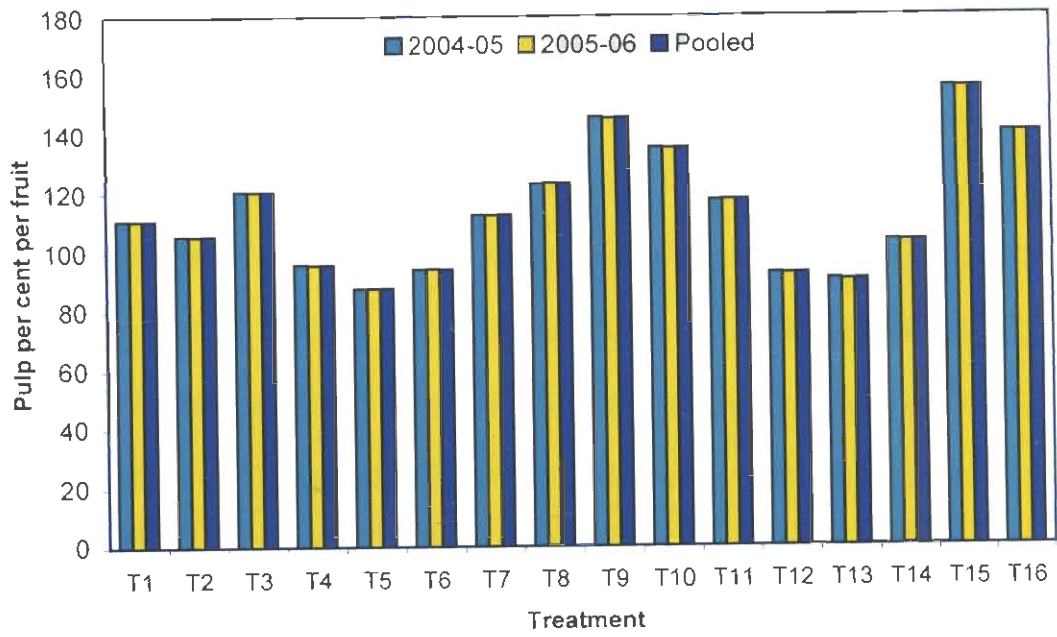
During 1st year (2004-05), the highest shell per cent per fruit was observed in IGTAM-10 (25.58%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-7 (25.19%) and IGTAM-5 (24.58%), which was followed by IGTAM-8 (23.59%) and IGTAM-9 (23.46%). The lowest shell per cent per fruit was recorded in IGTAM-15 (17.93%) which was found significantly lower than all the other treatments except IGTAM-1 (18.72%).

During 2nd year (2005-06), the maximum shell per cent per fruit was observed in IGTAM-10 (25.45%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-7 (25.16%) and IGTAM-5 (25.13%), which was followed by IGTAM-9

Table 4.4 : Variability exhibited with respect to pulp per cent and shell per cent content of different Tamarind genotypes

Treatments	Pulp per cent per fruit			Shell per cent per fruit		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
IGTAM-1	53.98	53.98	53.98	18.72 (4.38)	18.98 (4.41)	18.71 (4.38)
IGTAM-2	50.66	50.68	50.67	19.21 (4.44)	19.07 (4.42)	19.07 (4.43)
IGTAM-3	43.70	43.51	43.61	22.52 (4.80)	22.42 (4.79)	22.42 (4.79)
IGTAM-4	46.14	45.06	45.60	20.74 (4.61)	20.65 (4.60)	20.69 (4.60)
IGTAM-5	45.91	45.17	45.54	24.58 (5.01)	25.13 (5.06)	24.85 (5.04)
IGTAM-6	42.35	42.58	42.46	22.79 (4.83)	22.76 (4.82)	22.78 (4.82)
IGTAM-7	40.18	40.23	40.20	25.19 (5.07)	25.16 (5.07)	25.18 (5.07)
IGTAM-8	41.97	41.92	41.99	23.59 (4.91)	23.52 (4.90)	23.56 (4.90)
IGTAM-9	47.47	47.47	47.47	23.46 (4.90)	23.65 (4.91)	23.56 (4.90)
IGTAM-10	48.82	48.87	48.85	25.58 (5.11)	25.45 (5.09)	25.51 (5.10)
IGTAM-11	45.34	45.50	45.42	22.37 (4.78)	22.52 (4.80)	22.44 (4.79)
IGTAM-12	45.39	45.26	45.32	22.85 (4.83)	23.00 (4.85)	22.93 (4.84)
IGTAM-13	51.62	52.38	52.00	21.74 (4.72)	22.06 (4.75)	21.90 (4.73)
IGTAM-14	48.07	48.05	48.06	20.42 (4.57)	20.47 (4.58)	20.44 (4.58)
IGTAM-15	44.47	47.06	45.76	17.93 (4.29)	18.69 (4.38)	18.45 (4.35)
IGTAM-16	41.23	41.29	41.26	23.12 (4.86)	23.09 (4.86)	23.11 (4.86)
SE(m)±	0.4202	0.2735	0.2238	0.033	0.029	0.021
CD(5%)	1.21	0.79	0.65	0.09	0.08	0.06

Value in parentheses indicates transformed value.



- | | | | |
|--------------------------|--------------------------|----------------------------|----------------------------|
| T ₁ : IGTAM-1 | T ₅ : IGTAM-5 | T ₉ : IGTAM-9 | T ₁₃ : IGTAM-13 |
| T ₂ : IGTAM-2 | T ₆ : IGTAM-6 | T ₁₀ : IGTAM-10 | T ₁₄ : IGTAM-14 |
| T ₃ : IGTAM-3 | T ₇ : IGTAM-7 | T ₁₁ : IGTAM-11 | T ₁₅ : IGTAM-15 |
| T ₄ : IGTAM-4 | T ₈ : IGTAM-8 | T ₁₂ : IGTAM-12 | T ₁₆ : IGTAM-16 |

Fig. 4.4 : Variability exhibited with respect to pulp per cent and shell per cent content of different Tamarind genotypes

(23.65%) and IGTAM-8 (23.52%). The lowest shell per cent per fruit was recorded in IGTAM-15 (18.69%) which was significantly lower than all the treatments except IGTAM-1 (18.98%).

In case of pooled, data highest shell per cent per fruit was observed in IGTAM-10 (25.51%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-7 (25.18%) and IGTAM-5 (24.85%) which was followed by IGTAM-8 (23.56%) and IGTAM-9 (23.56%). The lowest shell per cent per fruit was recorded in IGTAM-15 (18.45%) which was found significantly lower than all the treatments except IGTAM-1 (18.71%).

Thus, the data recorded on shell per cent clearly show that maximum shell per cent per fruit was observed in IGTAM-10 and minimum shell per cent per fruit was recorded in IGTAM-15 in case of both the years as well as in pooled data.

4.1.12 Seed per cent

Data obtained on seed per cent per fruit are presented in Table 4.5 and Fig.4.5.

It was observed that seed per cent per fruit in different genotypes included in this study varied from 20.97 per cent (IGTAM-1) to 30.62 per cent (IGTAM-16) during 1st year (2005-06), 20.93 (IGTAM-1) to 30.48 per cent (IGTAM-16) during 2nd year (2005-06) and 20.95 per cent (IGTAM-1) to 30.55 per cent (IGTAM-16) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in

respect of seed per cent per fruit during both the years as well as in pooled mean basis.

During 1st year (2004-05), the maximum seed per cent per fruit was observed in IGTAM-16 (30.62%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-3 (29.92%) and IGTAM-6 (29.89%), which was followed by IGTAM-8 (29.57%) and IGTAM-7 (29.28%). The lowest seed per cent per fruit was recorded in IGTAM-1 (20.97%) which was found significantly lower than other all the treatments except IGTAM-10 (21.31%).

During 2nd year (2005-06) the highest seed per cent per fruit was observed in IGTAM-16 (30.48%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-3 (29.82%) and IGTAM-8 (29.52%), which was followed by IGTAM-7 (29.37%) and IGTAM-12 (28.74%). The lowest seed per cent per fruit was recorded in IGTAM-1 (20.93%) which was significantly lower than other treatments except IGTAM-10 (21.22%).

In case of pooled data, maximum seed per cent per fruit was observed in IGTAM-16 (30.55%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-3 (29.87%) and IGTAM-8 (29.55%) which was followed by IGTAM-7 (29.32%) and IGTAM-6 (29.14%). The lowest seed per cent per fruit was recorded in IGTAM-1 (20.95%) which was found significantly lower than all the treatments except IGTAM-10 (20.95%).

Thus, the data revealed that maximum seed per cent per fruit was observed in IGTAM-16 and minimum seed per cent per fruit was recorded in IGTAM-1 in case of 1st year and 2nd year of the study as well as in pooled mean basis.

4.1.13 Vein per cent

The data on per cent of vein per fruit are given in Table 4.5 and Fig. 4.5.

A perusal of data indicates that vein per cent per fruit in different genotypes included in this study ranged between 3.20 per cent (IGTAM-3) to 6.39 per cent (IGTAM-14) during 1st year (2004-05), 3.37 per cent (IGTAM-3) to 6.35 per cent (IGTAM-14) during 2nd year (2005-06) and 6.37 per cent (IGTAM-14) to 3.16 (IGTAM-3) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of vein per cent per fruit during both the years as well as pooled basis.

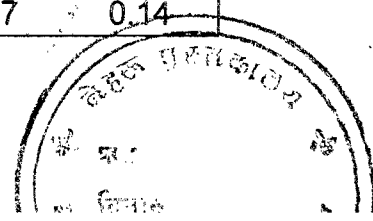
During 1st year (2004-05), the highest vein per cent per fruit was recorded in IGTAM-14 (6.39%) which was found significantly higher than all the genotypes studied in the investigation. This genotypes (IGTAM-14) was followed by IGTAM-6 (5.65%), IGTAM-4 (5.58%) and IGTAM-16 (5.42%). The lowest vein per cent per fruit was observed in IGTAM-3 (3.20%) which was found significantly lower than all the other treatments except IGTAM-5 (3.24%).

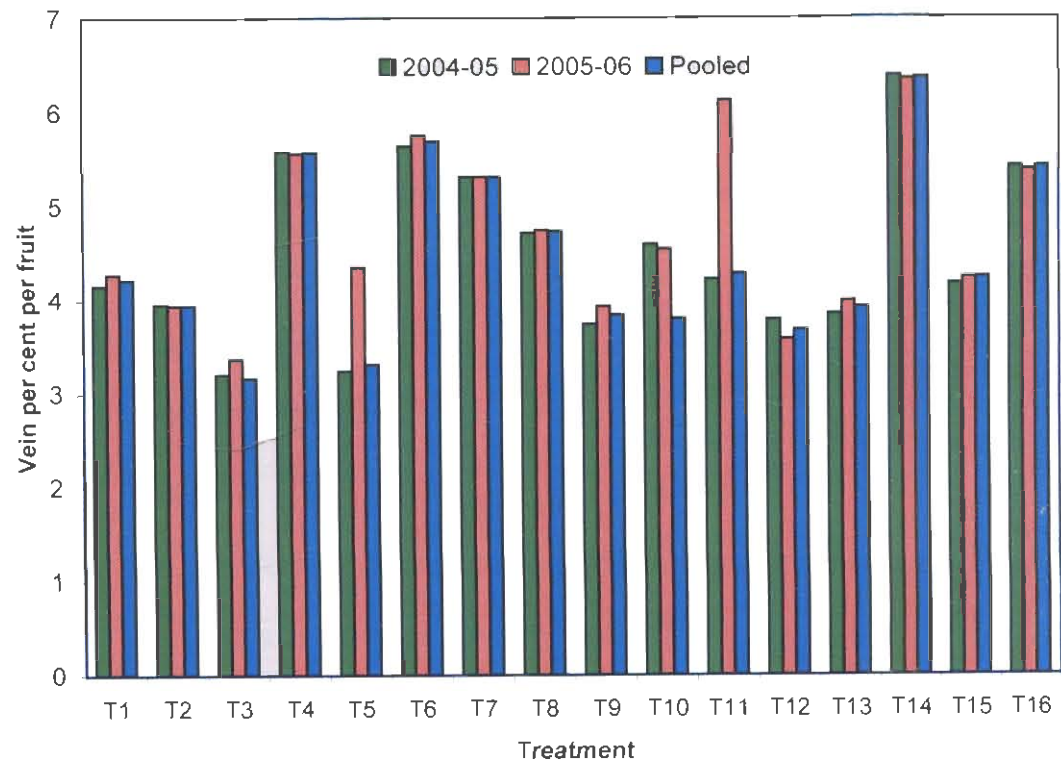
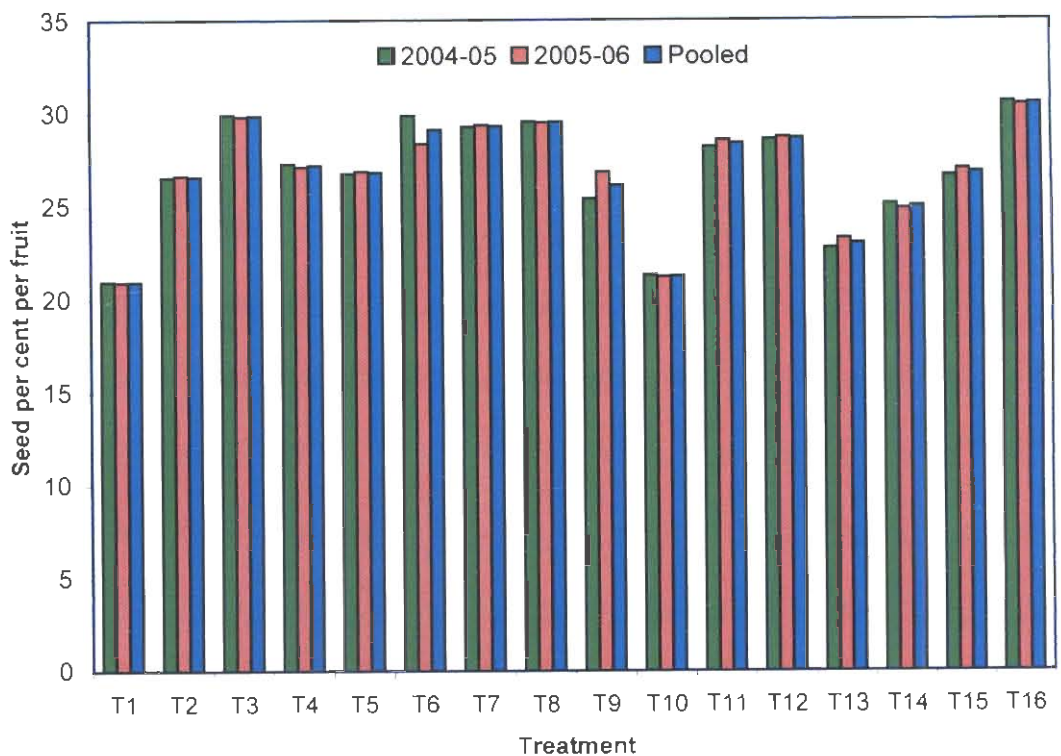
During 2nd year (2005-06), the maximum vein per cent per fruit was recorded in IGTAM-14 (6.35%) which was found significantly higher

Table 4.5 : Variability exhibited with respect to seed per cent and vein per cent content of different tamarind genotypes

Treatments	Seed per cent per fruit			Vein per cent per fruit		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
IGTAM-1	20.97 (4.63)	20.93 (4.63)	20.95 (4.63)	4.15 (2.16)	4.27 (2.18)	4.21 (2.17)
IGTAM-2	26.56 (5.20)	26.64 (5.21)	26.60 (5.21)	3.95 (2.11)	3.94 (2.11)	3.94 (2.11)
IGTAM-3	29.92 (5.52)	29.82 (5.51)	29.87 (5.51)	3.20 (1.92)	3.37 (1.97)	3.16 (1.91)
IGTAM-4	27.31 (5.27)	27.13 (5.26)	27.22 (5.27)	5.58 (2.47)	5.56 (2.46)	5.57 (2.46)
IGTAM-5	26.77 (5.22)	26.88 (5.23)	26.83 (5.23)	3.24 (1.93)	4.35 (2.20)	3.31 (1.95)
IGTAM-6	29.89 (5.51)	28.38 (5.37)	29.14 (5.44)	5.65 (2.48)	5.76 (2.50)	5.70 (2.50)
IGTAM-7	29.28 (5.46)	29.37 (5.47)	29.32 (5.46)	5.31 (2.41)	5.31 (2.41)	5.31 (2.41)
IGTAM-8	29.57 (5.48)	29.52 (5.48)	29.55 (5.48)	4.71 (2.28)	4.74 (2.29)	4.73 (2.29)
IGTAM-9	25.43 (5.09)	26.86 (5.23)	26.14 (5.16)	3.74 (2.06)	3.93 (2.10)	3.84 (2.08)
IGTAM-10	21.31 (4.67)	21.22 (4.66)	21.26 (4.67)	4.59 (2.26)	4.54 (2.24)	3.80 (2.06)
IGTAM-11	28.22 (5.36)	28.58 (5.39)	28.40 (5.38)	4.22 (2.17)	6.13 (2.57)	4.28 (2.19)
IGTAM-12	28.61 (5.40)	28.74 (5.41)	28.68 (5.40)	3.79 (2.07)	3.58 (2.02)	3.68 (2.05)
IGTAM-13	22.76 (4.82)	23.29 (4.88)	23.03 (4.85)	3.85 (2.09)	3.99 (2.12)	3.92 (2.10)
IGTAM-14	25.15 (5.06)	24.89 (5.04)	25.02 (5.05)	6.39 (2.62)	6.35 (2.62)	6.37 (2.62)
IGTAM-15	26.67 (5.21)	27.03 (5.25)	26.85 (5.23)	4.17 (2.16)	4.24 (2.18)	4.24 (2.18)
IGTAM-16	30.62 (5.58)	30.48 (5.57)	30.55 (5.57)	5.42 (2.43)	5.39 (2.43)	5.42 (2.43)
SE(m)±	0.025	0.028	0.020	0.021	0.024	0.050
CD(5%)	0.07	0.08	0.06	0.06	0.07	0.14

Value in parentheses indicates transformed value.





- | | | | |
|--------------------------|--------------------------|----------------------------|----------------------------|
| T ₁ : IGTAM-1 | T ₅ : IGTAM-5 | T ₉ : IGTAM-9 | T ₁₃ : IGTAM-13 |
| T ₂ : IGTAM-2 | T ₆ : IGTAM-6 | T ₁₀ : IGTAM-10 | T ₁₄ : IGTAM-14 |
| T ₃ : IGTAM-3 | T ₇ : IGTAM-7 | T ₁₁ : IGTAM-11 | T ₁₅ : IGTAM-15 |
| T ₄ : IGTAM-4 | T ₈ : IGTAM-8 | T ₁₂ : IGTAM-12 | T ₁₆ : IGTAM-16 |

Fig. 4.5 : Variability exhibited with respect to seed per cent and vein per cent content of different Tamarind genotypes

than all the genotypes studied in this investigation except IGTAM-11 (6.13%), which was followed by IGTAM-6 (5.76%), IGTAM-4 (5.56%) and IGTAM-16 (5.39%). The minimum vein per cent per fruit was observed in IGTAM-3 (3.37%) which was found significantly lower than all the treatments except IGTAM-12 (3.58%).

In case of pooled data, highest vein per cent per fruit was recorded in IGTAM-14 (6.37%) which was found at par with IGTAM-6 (5.70 %) and was found significantly higher than all the genotypes studied in this investigation. This genotype was followed by IGTAM-4 (5.57%), IGTAM-16 (5.42%) and IGTAM-7 (5.31%). The lowest vein per cent per fruit was observed in IGTAM-3 (3.16%) which was found statistically similar with IGTAM-5 (3.31%).

Thus, the data recorded on vein per cent clearly show that maximum pulp per cent per fruit was observed in IGTAM-14 and minimum vein per cent per fruit in IGTAM-3 in case of both the years as well as in pooled data.

4.2 Chemical characters

4.2.1 Acidity

The per cent of acidity among different genotypes was estimated during 2004-05 and 2005-06 and the results are presented in Table 4.6 and Fig. 4.6.

It is apparent from the data that acidity content ranged from 7.95 per cent (IGTAM-4) to 19.55 per cent (IGTAM-6) during 1st year (2004-05), 7.98 per cent (IGTAM-4) to 19.63 per cent (IGTAM-6) during 2nd year

(2005-06) and 7.97 per cent (IGTAM-4) to 19.59 per cent (IGTAM-6) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of acidity content during both the years as well as pooled mean basis.

During 1st year (2004-05), the highest acidity content was recorded in IGTAM-6 (19.55%) which was found significantly higher than all the genotypes studied in the investigation. This genotype (IGTAM-6) was followed by IGTAM-9 (13.60%), IGTAM-12 (13.50%) and IGTAM-10 (12.25%). The lowest acidity content was observed in IGTAM-4 (7.95%).

During 2nd year (2005-06), maximum acidity content was recorded in IGTAM-6 (19.63%) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-6) was followed by IGTAM-9 (13.56%) IGTAM-12 (12.92%) and IGTAM-10 (12.27%). The minimum acidity content was observed in IGTAM-4 (7.98%).

In case of pooled data, highest acidity content was observed in IGTAM-6 (19.59%) which was significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-6) was followed by IGTAM-9 (13.58%), IGTAM-12 (13.21%) and IGTAM-10 (12.26%). The lowest acidity content was recorded in IGTAM-4 (7.79%).

Thus, it is evident from the data that acidity content of tamarind was high and data clearly show that higher value (%) of acidity content was recorded in IGTAM-6 and minimum value (%) of acidity content was

observed in IGTAM-4 in case of 1st year and 2nd year of the study as well as in pooled data.

4.2.2 Total soluble solids (TSS)

The results pertaining to total soluble solids of pulp are furnished in Table 4.6 and Fig. 4.6.

The range of variation in total soluble solids was from 12.06 (IGTAM-12) to 19.66 °Brix (IGTAM-15) during 1st year (2004-05), 12.17 (IGTAM-12) to 19.61 °Brix (IGTAM-15) during 2nd year (2005-06) and 12.13 (IGTAM-12) to 19.63 °Brix (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the different tamarind genotypes with respect to total soluble solids of pulp during both the years as well as pooled basis.

During 1st year (2004-05), the highest total soluble solids was recorded in IGTAM-15 (19.66 °B) which was found remarkably good than all the genotypes studied in the investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (18.72 °B), IGTAM-14 (18.20°B) and IGTAM-9 (17.60°B). The lowest TSS was recorded in IGTAM-12 (12.06°B).

During 2nd year (2005-06), the maximum total soluble solids was recorded in IGTAM-15 (19.61°B) which was found significantly higher than all the genotypes studied in the in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (18.83°B), IGTAM-14 (18.21°B) and IGTAM-9 (17.82°B). The least TSS was observed in IGTAM-12 (12.17°B).

In case of pooled data, highest total soluble solids was observed in IGTAM-15 (19.63°B) which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (18.77°B), IGTAM-14 (18.21°B) and IGTAM-9 (17.71°B). The lowest TSS was recorded in IGTAM-12 (12.13°B).

Thus, the data recorded on TSS of pulp clearly show that higher pulp was recorded in IGTAM-15 and least TSS of pulp observed in IGTAM-12 in case of both the year of study as well as in pooled data.

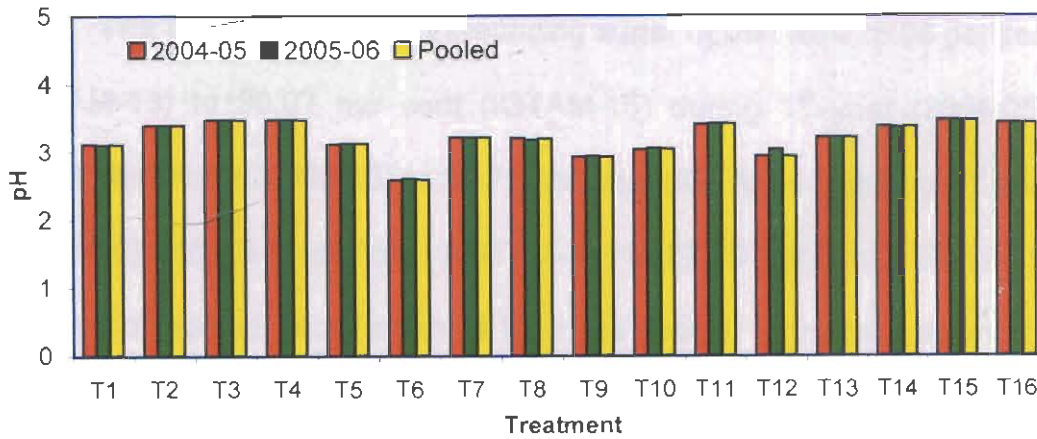
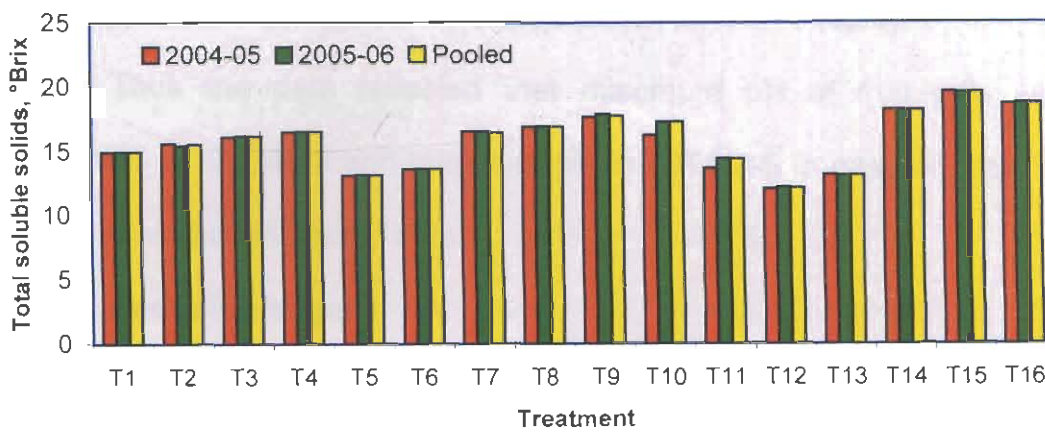
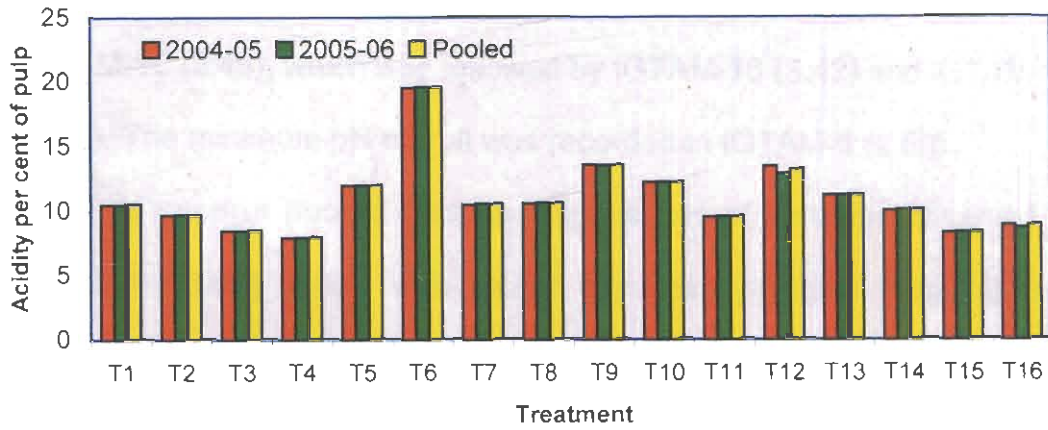
4.2.3 pH of fruit pulp

The data pertaining to pH of fruit pulp are presented in Table 4.6 and Fig. 4.6.

It was observed that pH of fruit in different genotypes of tamarind included in this study varied from 2.58 (IGTAM-6) to 3.47 (IGTAM-3) during 1st year (2004-05), 2.60 (IGTAM-6) to 3.47 (IGTAM-3) during 2nd year (2005-06) and 2.59 (IGTAM-6) to 3.47 (IGTAM-3) in case of pooled data. Significant difference was observed among the genotypes in respect of pH of fruit during both the years as well as pooled mean basis.

During 1st year (2004-05), the highest pH of fruit was recorded in IGTAM-3 (3.47) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-4 (3.46) and IGTAM-15 (3.46) which was followed by IGTAM-16 (3.42) and IGTAM-11 (3.40). The lowest pH of fruit was observed in IGTAM-6 (2.58).

During 2nd year (2005-06), the maximum pH of fruit was observed in IGTAM-3 (3.47) which was found significantly higher than all the



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.6 : Variation in chemical composition of different Tamarind genotypes (acidity, TSS and pH) character

genotypes studied in this investigation except IGTAM-4 (3.47) and IGTAM-15 (3.46), which was followed by IGTAM-16 (3.42) and IGTAM-11 (3.41). The minimum pH of fruit was recorded in IGTAM-6 (2.60).

In case of pooled data, the highest pH of fruit was observed in IGTAM-3 (3.47) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-4 (3.47) and IGTAM-15 (3.46), which was followed by IGTAM-16 (3.42) and IGTAM-11 (3.41). The lowest pH of fruit was recorded in IGTAM-6 (2.59).

Thus the data revealed that maximum pH of fruit pulp was observed in IGTAM-3 and minimum pH in IGTAM-6 in case of both the years as well as in pooled data.

4.2.4 Reducing sugar

The data pertaining to reducing sugar content of fruit is furnished in Table 4.7 and Fig. 4.7.

The range of variation in reducing sugar of fruit was 25.08 per cent (IGTAM-13) to 38.07 per cent (IGTAM-15) during 1st year (2004-05), 25.22 per cent (IGTAM-13) to 37.72 per cent (IGTAM-15) during 2nd year (2005-06) and 25.19 per cent (IGTAM-13) to 37.89 per cent (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the different genotypes with respect to reducing sugar of fruit during both the years as well as in pooled basis.

During 1st year (2004-05), the highest reducing sugar per cent of fruit was recorded in IGTAM-15 (38.07%) which was found excellent than all the genotypes studied in the investigation. This genotype (IGTAM-15)

was followed by IGTAM-16 (37.13%), IGTAM-14 (36.58%) and IGTAM-9 (35.21%). The lowest reducing sugar content was recorded in IGTAM-13 (25.08%).

During 2nd year (2005-06), the maximum reducing sugar per cent of fruit was recorded in IGTAM-15 (37.72%) which was found significantly higher than all the genotypes studied in this investigation except IGTAM-16 (37.23%), which was followed by IGTAM-14 (36.50%), IGTAM-9 (35.72%) and IGTAM-7 (35.50%). The lowest reducing sugar content of fruit was recorded in IGTAM-13 (25.22) which was found statistically similar to IGTAM-2 (25.31%).

In case of pooled data, highest sugar per cent of fruit was observed in IGTAM-15 (37.89%) which was found exceptionally better than all the other genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (37.18%), IGTAM-14 (36.54%) and IGTAM-9 (35.72%). The lowest reducing sugar content of fruit was observed in IGTAM-13 (25.19%) which was found significantly lower than all the genotypes except IGTAM-2 (25.20%).

Thus, the data recorded on reducing sugar per cent of fruit clearly show that higher reducing sugar per cent was observed in IGTAM-15 and lower reducing sugar per cent was recorded in IGTAM-13 in case of 1st year and 2nd year of the study as well as in pooled data.

4.2.5 Non-reducing sugar

Data obtained on non-reducing sugar per cent of fruit are presented in Table 4.7 and Fig. 4.7.

It was observed that non-reducing sugar content of fruit in different genotypes included in this study varied from 7.85 per cent (IGTAM-6) to 14.74 per cent (IGTAM-1) during 1st year (2004-05), 7.92 per cent (IGTAM-6) to 15.00 per cent (IGTAM-1) during 2nd year (2005-06) and 7.89 per cent (IGTAM-6) to 14.87 per cent (IGTAM-1) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of non-reducing sugar content of fruit during both the years as well as in pooled basis.

During 1st year (2004-05), the maximum non-reducing sugar per cent of fruit was observed in IGTAM-1 (14.74%) which was found at par with IGTAM-15 (13.82%) and IGTAM-11 (13.47%). This genotype (IGTAM-1) was found significantly higher than all the other genotypes included in this investigation which was followed by IGTAM-3 (12.60%) and IGTAM-5 (12.44%). The lowest non-reducing sugar content of fruit was found in IGTAM-6 (7.86%) which was found statistically similar to IGTAM-13 (8.17%), IGTAM-2 (8.93%) and IGTAM-4 (9.30%).

During 2nd year (2005-06) highest non-reducing sugar per cent of fruit was observed in IGTAM-1 (15.00%) which was found significantly higher than all the other genotypes studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-11 (13.78%), IGTAM-3 (12.67%) and IGTAM-10 (12.65%). The lowest non-reducing sugar per cent of fruit was recorded in IGTAM-6 (7.92%) which was significantly lower than all the other treatments except IGTAM-13 (8.16%).

In case of pooled data, maximum non-reducing sugar per cent of fruit was recorded in IGTAM-1 (14.87%) which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-11 (13.62%), IGTAM-15 (12.83%) and IGTAM-3 (12.63%). The lowest non-reducing sugar content of fruit was recorded in IGTAM-6 (7.89%) which was significantly lower than all the treatments except IGTAM-13 (8.17%) and IGTAM-2 (8.95%).

Thus, it is obvious from the data that highest non-reducing sugar per cent of fruit was recorded in IGTAM-1 and least non-reducing sugar per cent of fruit was observed in IGTAM-6 in case of both the years as well as in pooled data.

4.2.6 Total sugar

The data pertaining to total sugar per cent of fruit are presented in Table 4.7 and Fig. 4.7.

It was observed that total sugar per cent of fruit in different genotypes of tamarind included in this study ranged between 33.34 per cent (IGTAM-13) to 51.88 per cent (IGTAM-15) during 1st year (2004-05), 33.37 per cent (IGTAM-13) to 49.68 per cent (IGTAM-15) during 2nd year (2005-06) and 33.36 per cent (IGTAM-13) to 50.72 per cent (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of total sugar per cent of fruit during both the years as well as pooled mean basis.

During 1st year (2004-05), the highest total sugar per cent of fruit was recorded in IGTAM-15 (51.88%) which was found exceptionally

better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (48.12%), IGTAM-14 (47.22%) and IGTAM-9 (45.77%). The lowest total sugar per cent of fruit was observed in IGTAM-13 (33.34%) which was found significantly lower than all the treatments except IGTAM-6 (33.80%).

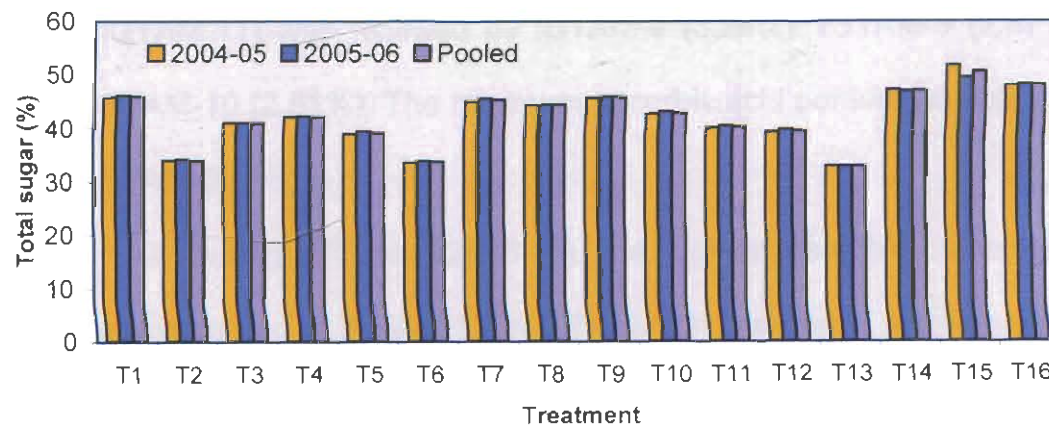
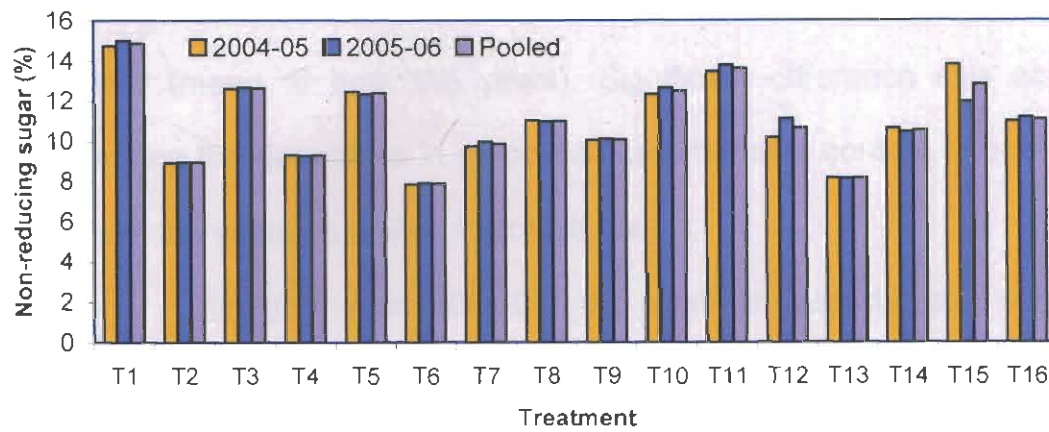
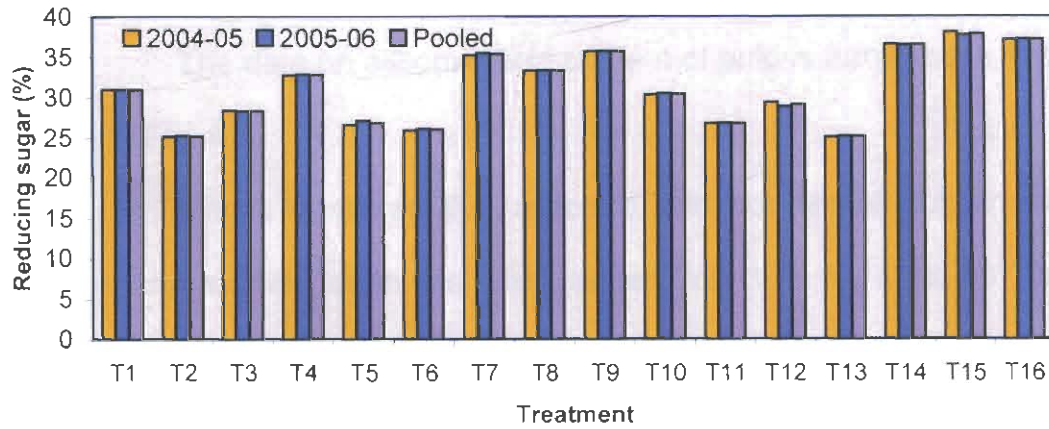
During 2nd year (2005-06), the maximum total sugar per cent of fruit was recorded in IGTAM-15 (49.68%) which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (48.42%), IGTAM-14 (46.96%) and IGTAM-1 (46.00%). The least total sugar per cent of fruit was observed in IGTAM-13 (33.37%) which was found significantly lower than all the treatments except IGTAM-6 (34.07%).

In case of pooled data, the highest total sugar per cent of fruit was recorded in IGTAM-15 (50.72%) which was found exceptionally better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (48.27%), IGTAM-14 (47.09%) and IGTAM-1 (45.86%). The least total sugar per cent of fruit was observed in IGTAM-13 (33.36%) which was found significantly lower than all the treatment except IGTAM-6 (33.80%).

Thus, the data recorded on total sugar per cent of fruit clearly show that maximum total sugar per cent was found in IGTAM-15 and minimum total sugar per cent was observed in IGTAM-13 in case of both the years as well as in pooled data.

Table 4.7 : Reducing, non-reducing and total sugar content in fruit pulp of different Tamarind genotypes

Treatments	Reducing sugar (%)		Non-reducing sugar (%)		Total sugar (%)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	30.99	30.99	14.74	15.00	45.73	46.00
IGTAM-2	25.17	25.31	8.93	8.96	34.01	34.27
IGTAM-3	28.40	28.33	12.60	12.67	41.00	41.00
IGTAM-4	32.76	32.88	9.30	9.28	42.06	42.17
IGTAM-5	26.60	27.14	12.44	12.33	39.04	39.48
IGTAM-6	25.95	26.14	7.85	7.92	33.80	34.07
IGTAM-7	35.21	35.50	9.73	9.98	44.95	45.48
IGTAM-8	33.31	33.34	11.02	10.98	44.33	44.32
IGTAM-9	35.71	35.72	10.06	10.12	45.77	45.84
IGTAM-10	30.36	30.50	12.34	12.65	42.70	43.15
IGTAM-11	26.81	26.86	13.47	13.78	40.28	40.64
IGTAM-12	29.41	28.87	10.19	11.13	39.60	40.01
IGTAM-13	25.08	25.22	8.17	8.16	33.34	33.37
IGTAM-14	36.58	36.50	10.64	10.47	47.22	46.96
IGTAM-15	38.07	37.72	13.82	11.97	51.88	49.68
IGTAM-16	37.13	37.23	11.00	11.18	48.12	48.42
SE(m)±	0.2186	0.2284	0.6449	0.2989	0.6378	0.3829
CD(5%)	0.63	0.66	1.86	0.86	1.84	1.11
		0.49		1.24		2.13



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.7 : Reducing, non-reducing and total sugar content in fruit pulp of different Tamarind genotypes

4.2.7 Ascorbic acid

The data on ascorbic acid content of pulp is furnished in Table 4.8 and Fig. 4.8.

It was observed that ascorbic acid content of pulp in different genotypes included in this study ranged from 1.81 per cent (IGTAM-8) to 4.03 per cent (IGTAM-11) during 1st year (2004-05), 1.81 per cent (IGTAM-8) to 4.05 per cent (IGTAM-11) during 2nd year (2005-06) and 1.81 per cent (IGTAM-8) to 4.04 per cent (IGTAM-11) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of ascorbic acid content of pulp during both the years as well as in pooled data.

During 1st year (2004-05), the maximum ascorbic acid content of pulp was recorded in IGTAM-11 (4.03%) which was found excellent than all the other genotypes studied in this investigation. This genotype (IGTAM-11) was followed by IGTAM-4 (3.24%), IGTAM-9 (2.91%) and IGTAM-10 (2.81%). The minimum ascorbic acid content was observed in IGTAM-8 (1.81%).

During 2nd year (2005-06), the highest ascorbic content of pulp was recorded in IGTAM-11 (4.03%) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-11) was followed by IGTAM-4 (3.23%), IGTAM-10 (2.82%) and IGTAM-9 (2.79%). The lowest ascorbic acid content of pulp was noticed in IGTAM-8 (1.81%) which was found significantly lower than all the treatments except IGTAM-1 (1.93%).

In case of pooled data, the maximum ascorbic acid content of pulp was recorded in IGTAM-11 (4.04%) which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-11) was followed by IGTAM-4 (3.24%), IGTAM-9 (2.85%) and IGTAM-10 (2.82%). The minimum ascorbic acid content of pulp was observed in IGTAM-8 (1.81%).

Thus, the data clearly reveal that highest ascorbic acid per cent of pulp was recorded in IGTAM-11 and lowest ascorbic acid content was observed in IGTAM-8 during 1st year and 2nd year of the study as well as in pooled data.

4.2.8 Protein

The data gathered on protein per cent of pulp are presented in Table 4.8 and Fig. 4.8.

It is clear from the data that protein per cent of pulp in different genotypes included in this study varied from 2.03 per cent (IGTAM-8) to 6.71 per cent (IGTAM-15) during 1st year (2004-05), 2.04 per cent (IGTAM-8) to 6.67 per cent (IGTAM-15) during 2nd year (2005-06) and 2.03 per cent (IGTAM-8) to 6.69 per cent (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was recorded among the genotypes in respect of protein per cent of pulp during both the years as well as in pooled data.

During 1st year (2004-05), the highest protein per cent of pulp was observed in IGTAM-15 (6.71%) which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15)

was followed by IGTAM-14 (5.44%), IGTAM-6 (5.22%) and IGTAM-10 (5.12%). The lowest protein per cent of pulp was recorded in IGTAM-8 (2.03%) which was found at par with IGTAM-4 (2.11%).

During 2nd year (2005-06), the maximum protein per cent of pulp was recorded in IGTAM-15 (6.67%) which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (5.72%), IGTAM-14 (5.39%) and IGTAM-6 (5.27%). The lowest protein per cent of pulp was observed in IGTAM-8 (2.04%) which as found statistically similar with IGTAM-4 (2.14), IGTAM-3 (2.50%) and IGTAM-7 (2.75%).

In case of pooled data, the maximum protein per cent of pulp was noticed in IGTAM-15 (6.69%) which was found exceptionally superior than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-14 (5.42%), IGTAM-6 (5.25%) and IGTAM-10 (5.12%). The minimum protein per cent of pulp was noticed in IGTAM-8 (1.95%).

Thus, the data on protein per cent of pulp reveal that higher protein per cent of pulp was recorded in IGTAM-15 and lower protein per cent of pulp was observed in IGTAM-8 in case of both the years as well as in pooled data.

4.2.9 Crude fibre

The data obtained on crude fibre are presented in Table 4.8 and Fig. 4.8. It is apparent from the data that crude fibre per cent of pulp ranged between 3.29 per cent (IGTAM-13) to 10.39 per cent (IGTAM-1)

during 1st year (2004-05), 3.23 per cent (IGTAM-13) to 10.36 per cent (IGTAM-1) during 2nd year (2005-06) and 3.26 per cent (IGTAM-13) to 10.37 per cent (IGTAM-1) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of crude fibre per cent of pulp during both the years as well as pooled mean basis.

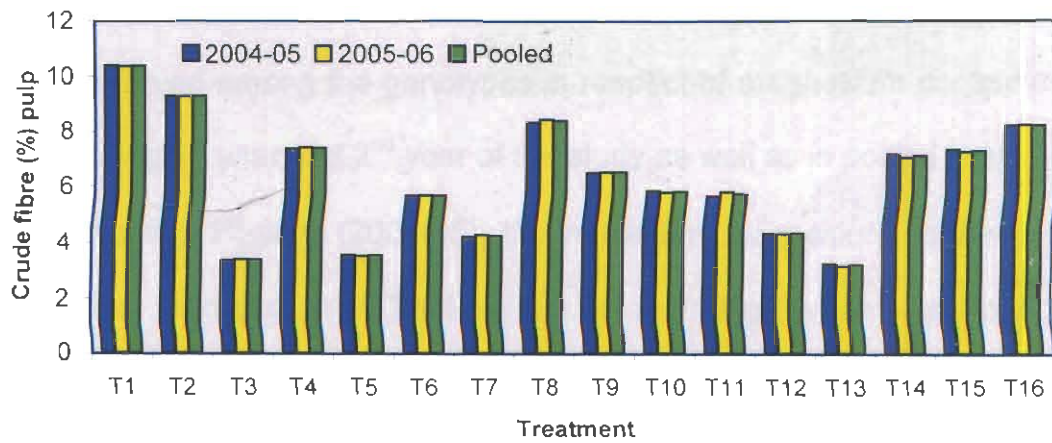
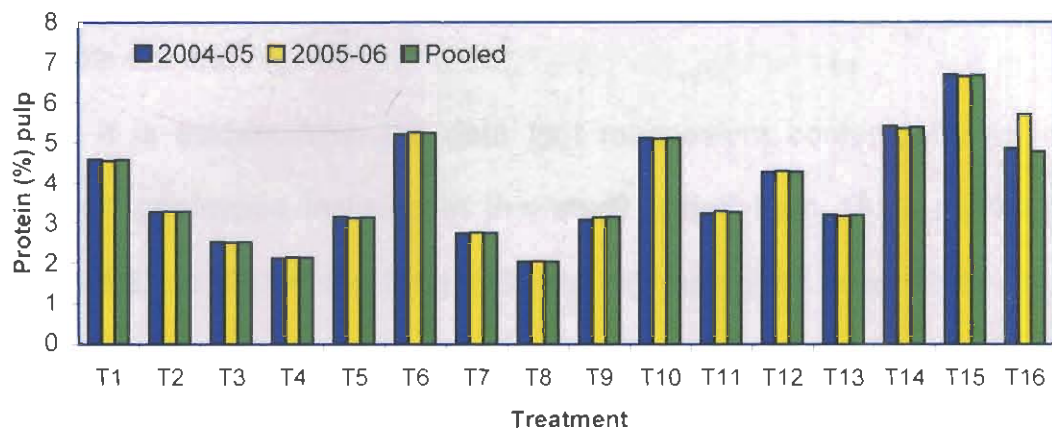
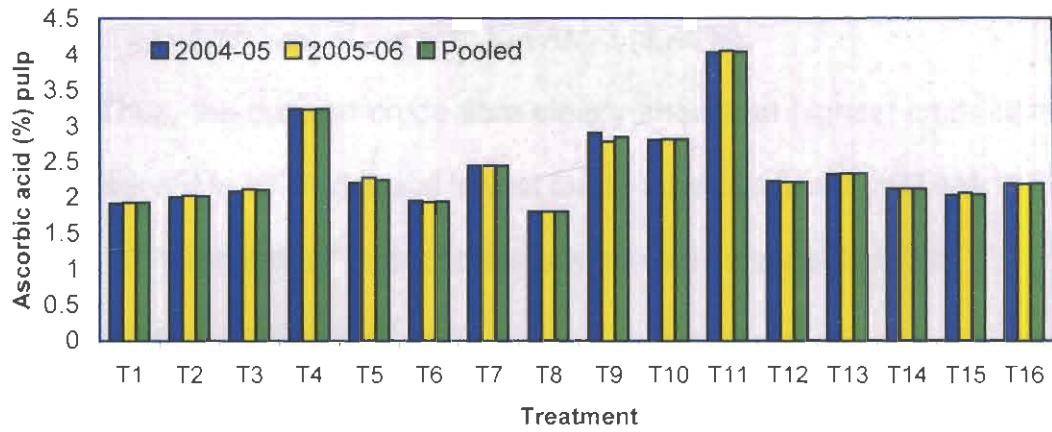
During 1st year (2004-05), the highest crude fibre per cent of pulp was recorded in IGTAM-1 (10.39%) which was found significantly higher than all the genotypes studied in the investigation. The genotype (IGTAM-1) was followed by IGTAM-2 (9.30%), IGTAM-8 (8.28%) and IGTAM-16 (8.16%). The lowest crude fibre per cent of pulp was recorded in IGTAM-13 (3.29%) which was found at par with IGTAM-3 (3.38%).

During 2nd year (2005-06), the maximum crude fibre per cent of pulp was recorded in IGTAM-1 (10.36%) which was found significantly higher than all the genotypes studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-2 (9.30%) IGTAM-8 (8.38%) and IGTAM-16 (8.18%). The minimum crude fibre per cent of pulp was noticed in IGTAM-13 (3.23%) which was found statistically similar to IGTAM-3 (3.41%).

In case of pooled data, the highest crude fibre per cent of pulp was recorded in IGTAM-1 (10.37%) which was found significantly higher than all the genotype studied in this investigation. This genotype (IGTAM-1) was followed by IGTAM-2 (9.30%) IGTAM-8 (8.33%) and IGTAM-16

Table 4.8 : Ascorbic acid, protein and crude fibre (%) of different Tamarind genotypes

Treatments	Ascorbic acid (%) pulp		Protein (%) pulp		Crude fibre (%) pulp	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	1.92	1.93	4.58	4.55	10.39	10.36
IGTAM-2	2.01	2.03	3.28	3.29	9.30	9.30
IGTAM-3	2.09	2.12	2.52	2.50	3.38	3.41
IGTAM-4	3.24	3.23	2.11	2.14	7.33	7.38
IGTAM-5	2.21	2.28	3.14	3.11	3.58	3.54
IGTAM-6	1.96	1.94	5.22	5.27	5.64	5.65
IGTAM-7	2.45	2.45	2.73	2.75	4.24	4.30
IGTAM-8	1.81	1.81	2.03	2.04	8.28	8.38
IGTAM-9	2.91	2.79	3.07	3.12	6.44	6.47
IGTAM-10	2.81	2.82	5.12	5.11	5.79	5.75
IGTAM-11	4.03	4.05	3.25	3.31	5.61	5.76
IGTAM-12	2.23	2.22	4.28	4.30	4.38	4.39
IGTAM-13	2.33	2.34	3.22	3.19	3.29	3.23
IGTAM-14	2.13	2.13	5.44	5.39	7.10	7.01
IGTAM-15	2.04	2.07	6.71	6.67	7.27	7.18
IGTAM-16	2.20	2.19	4.87	5.72	8.16	8.18
SE(m)±	0.0138	0.0423	0.0341	0.2471	0.0905	0.0799
CD(5%)	0.04	0.12	0.1	0.71	0.26	0.23
Pooled	1.93	1.93	4.57	4.57	10.37	10.37
Pooled	2.02	2.02	3.29	3.29	9.30	9.30
Pooled	2.11	2.11	2.51	2.51	3.40	3.40
Pooled	3.24	3.24	2.13	2.13	7.36	7.36
Pooled	2.25	2.25	3.12	3.12	3.56	3.56
Pooled	1.95	1.95	5.25	5.25	5.64	5.64
Pooled	2.45	2.45	2.74	2.74	4.27	4.27
Pooled	1.81	1.81	2.03	2.03	8.33	8.33
Pooled	2.85	2.85	3.14	3.14	6.46	6.46
Pooled	2.82	2.82	5.12	5.12	5.77	5.77
Pooled	4.04	4.04	3.28	3.28	5.69	5.69
Pooled	2.22	2.22	4.29	4.29	4.39	4.39
Pooled	2.34	2.34	3.21	3.21	3.26	3.26
Pooled	2.13	2.13	5.42	5.42	7.05	7.05
Pooled	2.05	2.05	6.69	6.69	7.22	7.22
Pooled	2.20	2.20	4.79	4.79	8.17	8.17
Pooled	0.0226	0.0226	0.0271	0.0271	0.0683	0.0683



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.8 : Ascorbic acid, protein and crude fibre (%) of different Tamarind genotypes

(8.17%). The lowest crude fibre per cent of pulp was recorded in IGTAM-13 (3.26%) which was at par with IGTAM-3 (3.40%).

Thus, the data on crude fibre clearly show that highest crude fibre was observed in IGTAM-1 and lowest crude fibre per cent in IGTAM-13 in case of 1st year and 2nd year of the study as well as in pooled data.

4.3 Mineral contents of pulp

4.3.1 Magnesium (pulp)

Data recorded on magnesium (Mg) content of pulp are presented in Table 4.9 and Fig. 4.9.

It is evident from the data that magnesium content of pulp in different genotypes included in this study varied from 18.03 mg/100g (IGTAM-6) to 29.94 mg/100g (IGTAM-15) during 1st year (2004-05), 18.52 mg/100g (IGTAM-6) to 30.63 mg/100g (IGTAM-15) during 2nd year (2005-06) and 18.28 mg/100g (IGTAM-6) to 30.32 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of magnesium content of pulp during 1st year and 2nd year of the study as well as in pooled basis.

During 1st year (2004-05), the maximum magnesium content of pulp was recorded in IGTAM-15 (29.94 mg/100g) which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (27.98 mg/100g), IGTAM-9 (27.23 mg/100g) and IGTAM-14 (25.44 mg/100g). The minimum magnesium content of pulp was noticed in IGTAM-6 (18.03 mg/100g).

During 2nd year (2005-06), the highest magnesium content of pulp was recorded in IGTAM-15 (30.63 mg/100g) which was found significantly excellent than all the other genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (28.41 mg/100g), IGTAM-9 (27.03 mg/100g) and IGTAM-14 (25.12 mg/100g). The lowest magnesium content of pulp was observed in IGTAM-6 (18.52 mg/100g).

In case of pooled data, maximum magnesium content of pulp was recorded in IGTAM-15 (30.32 mg/100g) which was found significantly better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (28.20 mg/100g), IGTAM-9 (27.13 mg/100g) and IGTAM-14 (25.28 mg/100g). The minimum magnesium content of pulp was recorded in IGTAM-6 (18.28 mg/100g).

Thus, the data presented on magnesium clearly show that highest magnesium content of pulp was observed in IGTAM-15 and least magnesium content of pulp was recorded in IGTAM-6 in case of both the years as well as in pooled data.

4.3.2 Copper (pulp)

Data gathered on copper (Cu) content of pulp are furnished in Table 4.9 and Fig. 4.9.

The data reveal that copper content of pulp in different genotypes included in this study ranged from 5.48 mg/100g (IGTAM-9) to 19.09 mg/100g (IGTAM-15) during 1st year (2004-05), 5.45 mg/100g (IGTAM-9) to 19.10 mg/100g (IGTAM-15) during 2nd year (2005-06) and 5.47

mg/100g (IGTAM-9) to 19.10 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of copper content of pulp during 1st year and 2nd year of the study as well as in pooled basis.

During 1st year (2004-05), the maximum copper content of pulp was recorded in IGTAM-15 (19.09 mg/100g) which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (17.03 mg/100g), IGTAM-1 (15.39 mg/100g) and IGTAM-14 (15.39 mg/100g). The minimum copper content of pulp was recorded in IGTAM-9 (5.48 mg/100g).

During 2nd year (2005-06), the highest copper content of pulp was recorded in IGTAM-15 (19.10 mg/100g) which was found excellent than all the other genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (17.10 mg/100g), IGTAM-1 (15.47 mg/100g) and IGTAM-14 (14.38 mg/100g). The lowest copper content of pulp was observed in IGTAM-9 (5.45 mg/100g).

In case of pooled data, maximum copper content of pulp was recorded in IGTAM-15 (19.10 mg/100g) which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (17.07 mg/100g), IGTAM-1 (15.43 mg/100g) and IGTAM-14 (14.39 mg/100g). The minimum copper content of pulp was observed in IGTAM-9 (5.47 mg/100g).

Thus, the data presented on copper content of pulp clearly show that higher copper content of pulp was recorded on IGTAM-15 and lower

copper content of pulp in IGTAM-9 in case of 1st year and 2nd year of the study as well as in pooled data.

4.3.3 Iron (pulp)

Data obtained on iron (Fe) content of pulp are presented in Table 4.9 and Fig. 4.9.

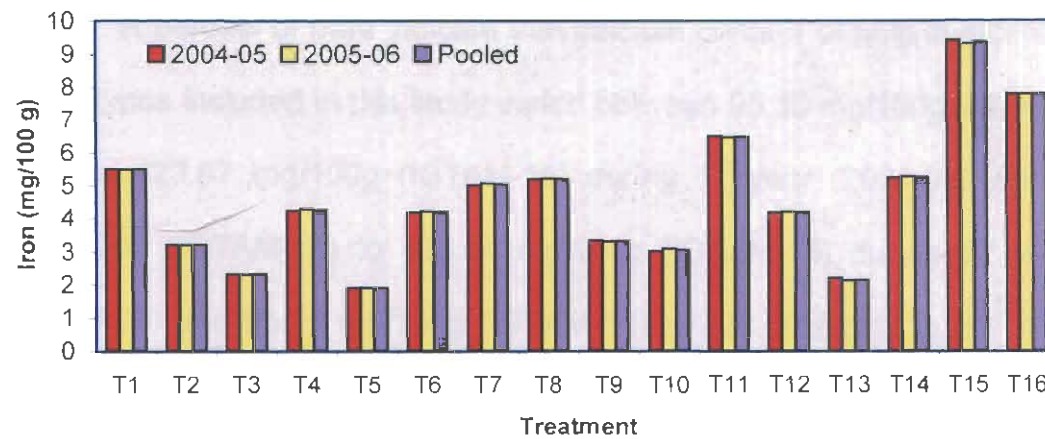
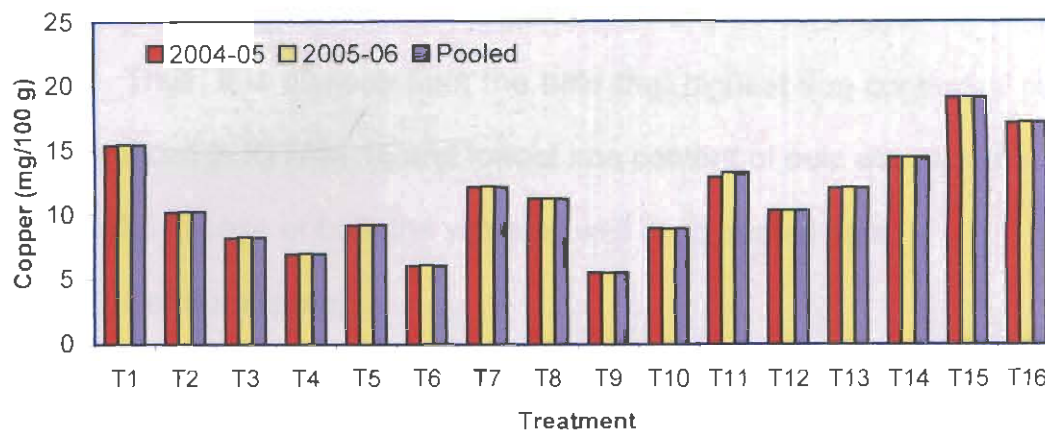
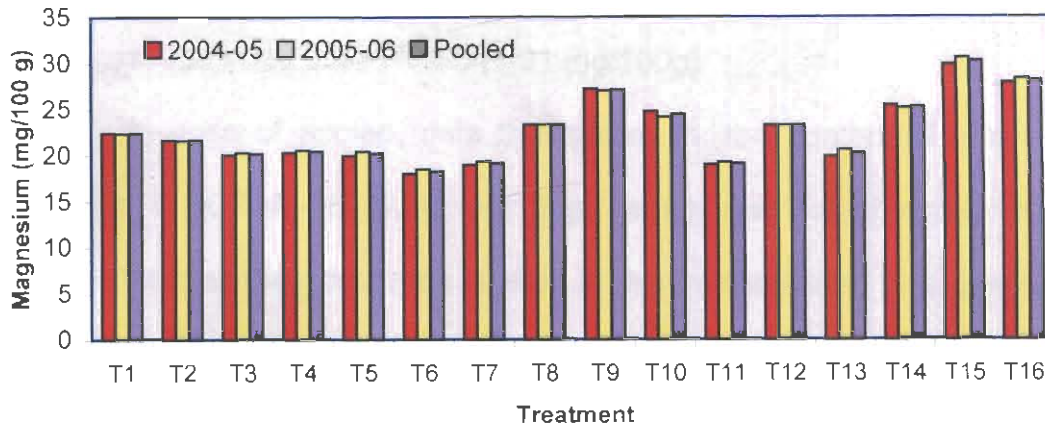
It is obvious from the data that iron content of pulp in different genotypes included in this study ranged between 1.90 mg/100g (IGTAM-5) to 9.43 mg/100g (IGTAM-15) during 1st year (2004-06), 1.91 mg/100g (IGTAM-5) to 9.93 mg/100g (IGTAM-15) during 2nd year (2005-06) and 1.90 mg/100g (IGTAM-5) to 9.38 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of iron content of pulp during 1st year and 2nd year of study as well as in pooled data basis.

During 1st year (2004-05), the highest iron content of pulp was recorded in IGTAM-15 (9.43 mg/100g) which was found exceptionally better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (7.81 mg/100g), IGTAM-11 (6.50 mg/100g) and IGTAM-1 (5.49 mg/100g). The lowest iron content of pulp was observed in IGTAM-5 (1.90 mg/100g).

During 2nd year (2005-06), the maximum iron content of pulp was observed in IGTAM-15 (9.93 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (7.81 mg/100g), IGTAM-11 (6.46

Table 4.9 : Variation in mineral composition of different Tamarind genotypes (Mg, Cu and Fe content of pulp)

Treatments	Magnesium (mg/100 g)		Copper (mg/100 g)		Iron (mg/100 g)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	22.45	22.37	15.39	15.47	5.49	5.48
IGTAM-2	21.70	21.60	10.17	10.22	3.20	3.20
IGTAM-3	20.09	20.33	8.16	8.27	2.31	2.31
IGTAM-4	20.31	20.58	6.91	6.97	4.23	4.28
IGTAM-5	19.99	20.44	9.15	9.20	1.90	1.91
IGTAM-6	18.03	18.52	6.00	6.07	4.18	4.22
IGTAM-7	19.01	19.36	12.08	12.12	5.00	5.06
IGTAM-8	23.37	23.35	11.17	11.17	5.18	5.20
IGTAM-9	27.23	27.03	5.48	5.45	3.33	3.30
IGTAM-10	24.77	24.17	8.89	8.83	3.00	3.08
IGTAM-11	19.03	19.27	12.86	13.21	6.50	6.46
IGTAM-12	23.30	23.25	10.29	10.29	4.18	4.20
IGTAM-13	19.92	20.59	12.00	12.05	2.20	2.12
IGTAM-14	25.44	25.12	14.40	14.38	5.23	5.27
IGTAM-15	29.94	30.63	19.09	19.10	9.43	9.33
IGTAM-16	27.98	28.41	17.03	17.10	7.81	7.81
SE(m) [±]	0.3117	0.1317	0.0965	0.0255	0.0228	0.0256
CD(5%)	0.90	0.38	0.28	0.07	0.07	0.07
Pooled	22.41	21.65	15.43	10.20	5.49	5.49
Pooled	20.21	20.45	8.22	6.94	2.31	2.32
Pooled	20.22	18.28	9.18	6.03	4.23	4.26
Pooled	19.18	23.36	12.10	11.17	1.90	1.90
Pooled	27.13	24.47	5.47	8.86	4.18	4.20
Pooled	19.15	23.28	13.21	10.29	5.00	5.03
Pooled	23.28	20.26	10.29	12.02	5.18	5.19
Pooled	25.28	30.32	14.39	19.10	3.30	3.31
Pooled	28.20	28.20	17.07	17.07	3.00	3.04
Pooled	0.164	0.47	0.0253	0.07	6.46	6.48
Pooled	0.07	0.07	0.07	0.07	4.18	4.19
Pooled	0.07	0.07	0.07	0.07	2.20	2.13
Pooled	0.07	0.07	0.07	0.07	5.23	5.25
Pooled	0.07	0.07	0.07	0.07	9.43	9.38
Pooled	0.07	0.07	0.07	0.07	7.81	7.81
Pooled	0.07	0.07	0.07	0.07	0.0228	0.0256
Pooled	0.07	0.07	0.07	0.07	0.07	0.07



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.9 : Variation in mineral composition of different Tamarind genotypes (Mg, Cu and Fe content of pulp)

mg/100g) and IGTAM-1 (5.48 mg/100g). The minimum iron content of pulp was recorded in IGTAM-5 (1.91 mg/100g).

In case of pooled, data the maximum iron content of pulp was noticed in IGTAM-15 (9.38 mg/100g), which was found exceptionally better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (7.81 mg/100g), IGTAM-11 (6.48 mg/100g) and IGTAM-1 (5.49 mg/100g). The minimum iron content of pulp was recorded in IGTAM-5 (1.90 mg/100g).

Thus, it is obvious from the data that highest iron content of pulp was noticed in IGTAM-15 and lowest iron content of pulp was recorded in IGTAM-5 in case of both the years as well as in pooled data.

4.3.4 Calcium (pulp)

Data recorded on calcium (Ca) content of pulp are presented in Table 4.10 and Fig.4.10.

A perusal of data indicate that calcium content of pulp in different genotypes included in this study varied between 95.36 mg/100g (IGTAM-13) to 423.67 mg/100g (IGTAM-15) during 1st year (2004-05). 95.14 mg/100g (IGTAM-13) to 423.54 mg/100g (IGTAM-15) during 2nd year (2005-06) and 95.25 mg/100g (IGTAM-13) to 423.60 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of calcium content of pulp during 1st year and 2nd year of the study as well as in pooled data basis

During 1st year (2004-05), the maximum calcium content of pulp was noticed in IGTAM-15 (423.67 mg/100g), which was found remarkably

better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (341.70 mg/100g), IGTAM-8 (340.82 mg/100g) and IGTAM-9 (306.95 mg/100g). The minimum calcium content of pulp was observed in IGTAM-13 (95.36 mg/100g).

During 2nd year (2005-06), the highest calcium content of pulp was recorded in IGTAM-15 (423.54 mg/100g), which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (341.34 mg/100g), IGTAM-8 (340.10 mg/100g) and IGTAM-9 (306.72 mg/100g). The lowest calcium content of pulp was noticed in IGTAM-13 (95.14 mg/100g).

In case of pooled data, the maximum calcium content of pulp was observed in IGTAM-15 (423.60 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (341.52 mg/100g), IGTAM-8 (340.46 mg/100g) and IGTAM-9 (306.84 mg/100g). The minimum calcium content of pulp was recorded in IGTAM-13 (95.25 mg/100g).

Thus, the data recorded on calcium content of pulp clearly show that highest calcium content of pulp was noticed in IGTAM-15 and least calcium content of pulp was observed in IGTAM-13 in case of both the years as well as in pooled data.

4.3.5 Phosphorus (pulp)

Data gathered on phosphorus (p) content of pulp are presented in Table 4.10 and Fig. 4.10.

It is apparent from the data that phosphorus content of pulp in different genotypes included in this study ranged between 87.60 mg/100g (IGTAM-5) to 155.78 mg/100g (IGTAM-15) during 1st year (2004-05), 87.64 mg/100g (IGTAM-5) to 155.56 mg/100g (IGTAM-15) during 2nd year (2005-06) and 87.62 mg/100g (IGTAM-5) to 155.67 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of phosphorus content of pulp during 1st year and 2nd year of study as well as in pooled data.

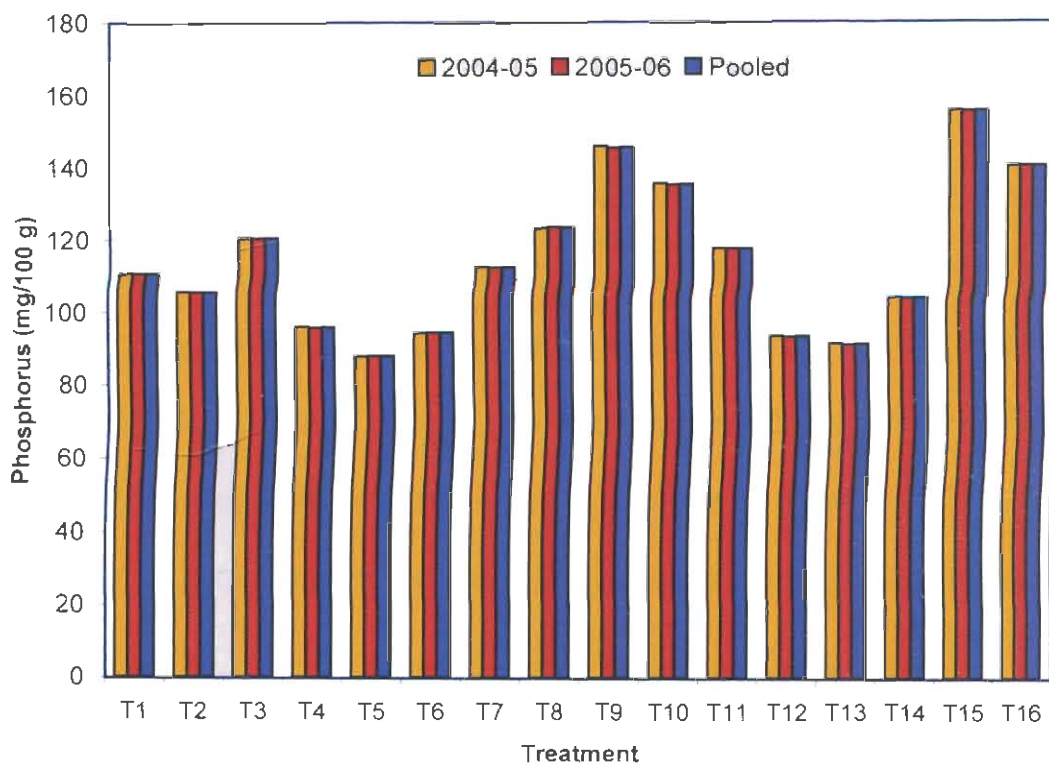
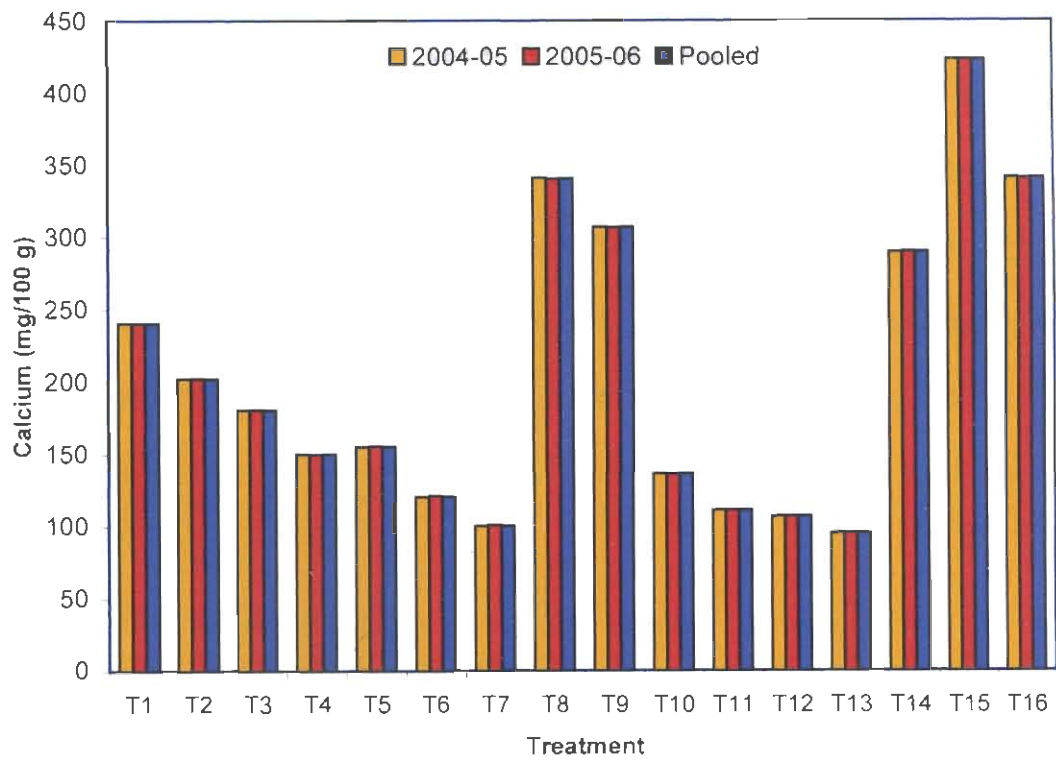
During 1st year (2004-05), the highest phosphorus content of pulp was noticed in IGTAM-15 (155.78 mg/100g), which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-9 (145.80 mg/100g), IGTAM-16 (140.43 mg/100g) and IGTAM-10 (135.45 mg/100g). The lowest phosphorus content of pulp was observed in IGTAM-5 (87.60 mg/100g).

During 2nd year (2005-06), the maximum phosphorus content of pulp was noticed in IGTAM-15 (155.56 mg/100g), which was found better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-9 (145.36 mg/100g), IGTAM-16 (140.30 mg/100g) and IGTAM-10 (135.14 mg/100g). The minimum phosphorus content of pulp was recorded in IGTAM-5 (87.64 mg/100g).

In case of pooled data, the highest phosphorus content of pulp was observed in IGTAM-15 (155.67 mg/100g), which was found excellent

Table 4.10 : Variation in mineral composition of different tamarind genotypes (Ca and P content of pulp)

Treatments	Calcium (mg/100 g)			Phosphorus (mg/100 g)		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
IGTAM-1	240.60	240.64	240.62	110.73	110.69	110.71
IGTAM-2	201.82	202.14	201.99	105.45	105.35	105.40
IGTAM-3	180.43	180.53	180.48	120.48	120.33	120.41
IGTAM-4	150.10	149.82	149.96	95.73	95.48	95.61
IGTAM-5	155.03	155.62	155.33	87.60	87.64	87.62
IGTAM-6	120.47	121.17	120.82	93.97	94.05	94.01
IGTAM-7	99.96	100.41	100.18	112.43	112.28	112.36
IGTAM-8	340.82	340.10	340.46	123.13	123.46	123.30
IGTAM-9	306.95	306.72	306.84	145.80	145.36	145.58
IGTAM-10	136.13	135.78	135.96	135.45	135.14	135.30
IGTAM-11	110.88	110.85	110.86	117.36	117.43	117.40
IGTAM-12	106.75	106.74	106.75	92.61	92.34	92.48
IGTAM-13	95.36	95.14	95.25	90.53	90.09	90.31
IGTAM-14	289.91	290.44	290.34	103.44	103.26	103.35
IGTAM-15	423.67	423.54	423.60	155.78	155.56	155.67
IGTAM-16	341.70	341.34	341.52	140.43	140.30	140.37
SE(m)±	0.3466	0.2464	0.1954	0.3121	0.0802	0.1749
CD(5%)	1.00	0.71	0.56	0.90	0.23	0.51



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.10 : Variation in mineral composition of different tamarind genotypes (Ca and P content of pulp)

than all the other genotypes studied in this investigation. This genotype was followed by IGTAM-9 (145.58 mg/100g), IGTAM-16 (140.37 mg/100g) and IGTAM-10 (135.30 mg/100g). The lowest phosphorus content of pulp was recorded in IGTAM-5 (87.62 mg/100g).

Thus, the data clearly reveal that maximum phosphorus content of pulp was noticed in IGTAM-15 and minimum phosphorus content of pulp was observed in IGTAM-5 in case of both the years as well as in pooled data.

4.3.6 Potassium (pulp)

The data recorded on potassium (K) content of pulp are presented in Table 4.11 and Fig. 4.11.

A perusal of data indicate that potassium content of pulp in different genotypes included in this study varied from 70.3 mg/100g (IGTAM-13) to 490.46 mg/100g (IGTAM-15) during 1st year (2004-05), 70.90 mg/100g (IGTAM-13) to 491.73 mg/100g (IGTAM-15) during 2nd year (2005-06) and 70.60 mg/100g (IGTAM-13) to 491.09 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of potassium content of pulp during 1st year and 2nd year of study as well as in pooled basis.

During 1st year (2004-05), the maximum potassium content of pulp was recorded in IGTAM-15 (490.45 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (410.68 mg/100g),

IGTAM-8 (380.16 mg/100g) and IGTAM-9 (301.45 mg/100g). The minimum potassium content of pulp was recorded in IGTAM-13 (70.3 mg/100g).

During 2nd year (2005-06), the highest potassium content of pulp was noticed in IGTAM-15 (491.73 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (411.04 mg/100g), IGTAM-8 (380.75 mg/100g) and IGTAM-9 (301.72 mg/100g). The lowest potassium content of pulp was observed in IGTAM-13 (70.9 mg/100g).

In case of pooled data, the maximum potassium content of pulp was recorded in IGTAM-15 (491.09 mg/100g), which was found remarkably better than all the genotype studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (410.86 mg/100g), IGTAM-8 (380.45 mg/100g) and IGTAM-9 (301.59 mg/100g). The minimum potassium content of pulp was noticed in IGTAM-13 (70.6 mg/100g).

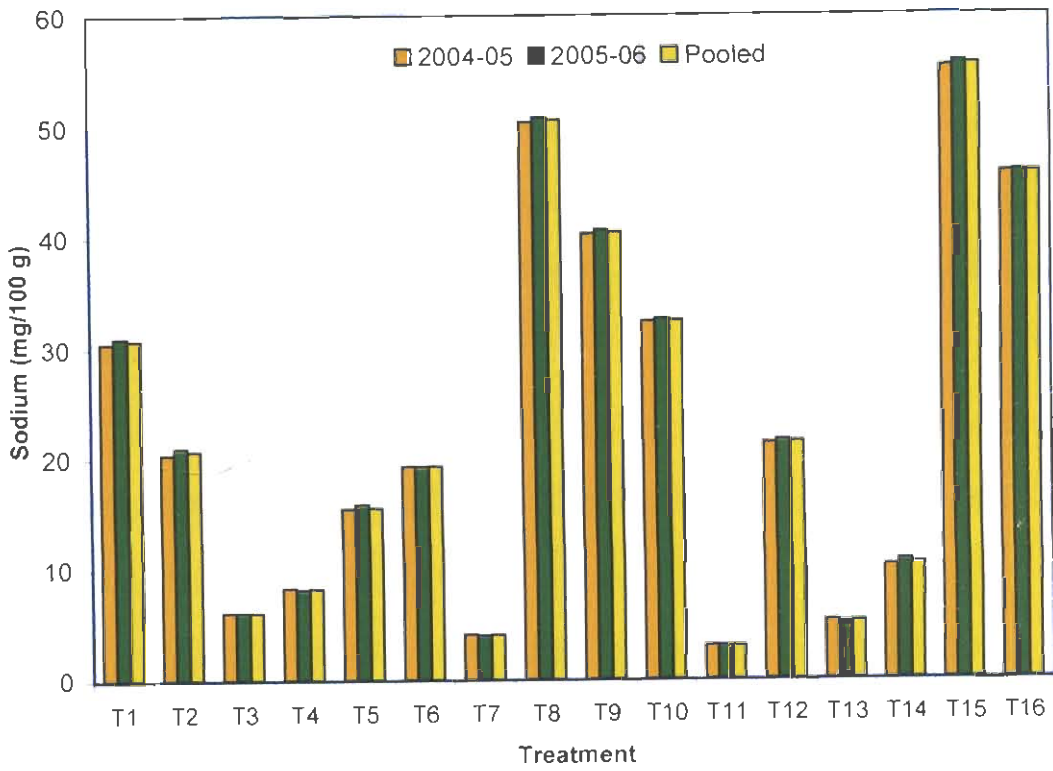
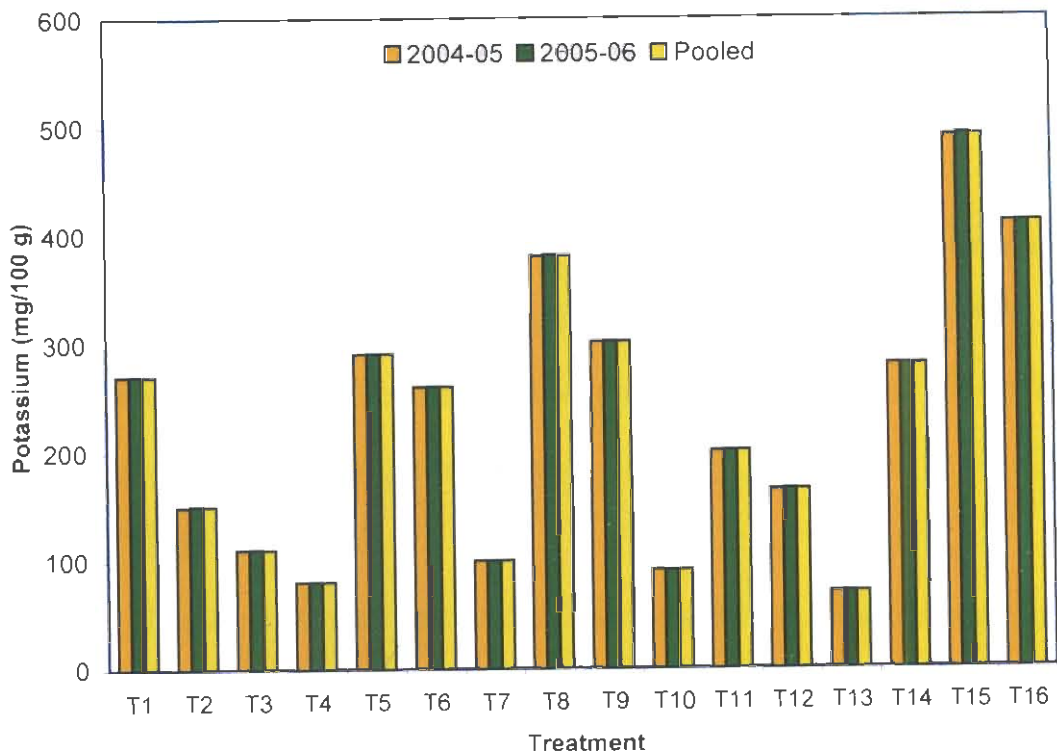
Thus, the data recorded on potassium content of pulp clearly indicate that highest potassium content of pulp was observed in IGTAM-15 and lowest potassium content of pulp was recorded in IGTAM-13 in case of 1st year and 2nd year of study as well as in pooled data.

4.3.7 Sodium (pulp)

The data pertaining to sodium (Na) content of pulp are furnished in Table 4.11 and Fig. 4.11.

Table 4.11 : Variation in mineral composition of different tamarind genotypes (K and Na content of pulp)

Treatments	Potassium (mg/100 g)			Sodium (mg/100 g)		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
IGTAM-1	270.31	270.84	270.38	30.46	30.93	30.73
IGTAM-2	150.12	151.22	150.67	20.34	20.94	20.64
IGTAM-3	110.61	110.83	110.72	6.08	6.08	6.08
IGTAM-4	80.42	80.77	80.59	8.30	8.15	8.23
IGTAM-5	290.57	290.81	290.69	15.44	15.86	15.49
IGTAM-6	260.42	260.69	260.56	19.26	19.24	19.25
IGTAM-7	100.27	100.28	100.28	4.09	4.00	4.05
IGTAM-8	380.16	380.75	380.45	50.35	50.77	50.56
IGTAM-9	301.45	301.72	301.59	40.30	40.65	40.48
IGTAM-10	91.06	91.22	91.14	32.39	32.62	32.51
IGTAM-11	201.30	201.61	201.46	3.03	3.00	3.02
IGTAM-12	165.25	165.97	165.61	21.27	21.51	21.39
IGTAM-13	70.30	70.90	70.60	5.29	5.12	5.21
IGTAM-14	280.61	280.45	280.53	10.28	10.75	10.52
IGTAM-15	490.45	491.73	491.09	55.28	55.70	55.49
IGTAM-16	410.68	411.04	410.86	45.74	45.87	45.80
SE(m)±	0.0897	0.2812	0.1609	0.0299	0.1821	0.082
CD(5%)	0.26	0.81	0.46	0.09	0.53	0.24



- | | | | |
|--------------------------|--------------------------|----------------------------|----------------------------|
| T ₁ : IGTAM-1 | T ₅ : IGTAM-5 | T ₉ : IGTAM-9 | T ₁₃ : IGTAM-13 |
| T ₂ : IGTAM-2 | T ₆ : IGTAM-6 | T ₁₀ : IGTAM-10 | T ₁₄ : IGTAM-14 |
| T ₃ : IGTAM-3 | T ₇ : IGTAM-7 | T ₁₁ : IGTAM-11 | T ₁₅ : IGTAM-15 |
| T ₄ : IGTAM-4 | T ₈ : IGTAM-8 | T ₁₂ : IGTAM-12 | T ₁₆ : IGTAM-16 |

Fig. 4.11 : Variation in minerals composition of different tamarind genotypes (K and Na content of pulp)

(IGTAM-15) was followed by IGTAM-8 (50.56 mg/100g), IGTAM-16 (45.80 mg/100g) and IGTAM-9 (40.48 mg/100g). The minimum sodium content of pulp was observed in IGTAM-11 (3.00 mg/100g).

Thus, the data presented on sodium content of pulp clearly show that highest sodium content of pulp was observed in IGTAM-15 and lowest sodium content of pulp was recorded in IGTAM-11, in case of both the years as well as in pooled data.

4.3.8 Zinc (pulp)

The Zinc (Zn) content of pulp was determined for all the genotypes included in this study during both 1st year (2004-05) and 2nd year (2005-06) and it was observed that zinc content of pulp was found nil in all the genotypes studied in this investigation except IGTAM-9 and IGTAM-8. Thus, the data are not presented in the table.

During 1st year (2004-05), maximum zinc content of pulp was observed in IGTAM-9 (0.52 mg/100g) which was followed by IGTAM-8 (0.40 mg/100g).

During 2nd year (2005-06), highest zinc content of pulp was recorded in IGTAM-9 (0.51 mg/100g) which was followed by IGTAM-8 (0.43 mg/100g).

In case of pooled mean (mean of both the years), maximum zinc content of pulp was observed in IGTAM-9 (0.51 mg/100g) which was followed by IGTAM-8 (0.42 mg/100g).

4.3.9 Manganese (pulp)

The manganese (Mn) content of pulp was determined for all the genotypes included in this study during 1st year (2004-05) and 2nd year (2005-06) and it was observed that manganese content of pulp was found nil in all the genotypes studied in this investigation. Thus, the data on manganese content of pulp are not presented in the table.

4.4 Mineral contents of seed

4.4.1 Magnesium (seed)

Data obtained on magnesium (Mg) content of seed are presented in Table 4.12 and Fig. 4.12.

It is evident from the data that magnesium content of seed in different genotypes included in this study varied from 14.84 mg/100g (IGTAM-6) to 39.25 mg/100g (IGTAM-15) during 1st year (2004-05), 14.58 mg/100g (IGTAM-6) to 39.00 mg/100g (IGTAM-15) during 2nd year (2005-06) and 14.73 mg/100g (IGTAM-6) to 39.13 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of magnesium content of seed during both the years as well as in pooled data.

During 1st year (2004-05), the maximum magnesium content of seed was recorded in IGTAM-15 (39.25 mg/100g) which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (35.95 mg/100g), IGTAM-9 (24.01 mg/100g) and IGTAM-14 (23.95 mg/100g). The minimum magnesium content of seed was noticed in IGTAM-6 (14.58

mg/100g) which was found significantly lower than all the genotypes studied in this investigation except IGTAM-7 (15.03 mg/100g), IGTAM-2 (15.14 mg/100g) and IGTAM-1 (15.17 mg/100g).

During 2nd year (2005-06), highest magnesium content of seed was recorded in IGTAM-15 (39.00 mg/100g), which was found significantly excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (36.65 mg/100g), IGTAM-9 (24.54 mg/100g) and IGTAM-14 (23.29 mg/100g). The lowest magnesium content of seed was observed in IGTAM-6 (14.58 mg/100g) which was significantly lower than all the genotypes studied in this investigation except IGTAM-2 (14.58 mg/100g).

In case of pooled data, maximum magnesium content of seed was recorded in IGTAM-15 (39.13 mg/100g), which was found significantly better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (36.30 mg/100g), IGTAM-9 (24.28 mg/100g) and IGTAM-14 (23.62 mg/100g). The minimum magnesium content of seed was recorded in IGTAM-6 (14.73 mg/100g) which was found significantly lower than all the genotypes except IGTAM-2 (15.08 mg/100g).

Thus, the data presented on magnesium content of seed clearly show that highest magnesium content of seed was observed in IGTAM-15 and least magnesium content of seed was recorded in IGTAM-6 in case of both the years as well as in pooled data.

4.4.2 Copper (seed)

Data gathered on copper (Cu) content of seed are furnished in Table 4.12 and Fig.4.12.

The data revealed that copper content of seed in different genotypes included in this study ranged from 1.84 mg/100g (IGTAM-4) to 16.14 mg/100g (IGTAM-15) during 1st year (2004-05), 1.79 mg/100g (IGTAM-4) to 16.12 mg/100g (IGTAM-15) during 2nd year (2005-06) and 1.81 mg/100g (IGTAM-4) to 16.13 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of copper content of seed, during 1st year and 2nd year of the study as well as in pooled basis.

During 1st year (2004-05), the maximum copper content of seed was recorded in IGTAM-15 (16.14 mg/100g), which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (14.28 mg/100g), IGTAM-14 (11.32 mg/100g) and IGTAM-13 (10.10 mg/100g). The minimum copper content of seed was recorded in IGTAM-4 (1.84 mg/100g).

During 2nd year (2005-06), the highest copper content of seed was recorded in IGTAM-15 (16.12 mg/100g), which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (14.29 mg/100g), IGTAM-14 (11.31 mg/100g) and IGTAM-13 (10.11 mg/100g). The lowest copper content of seed was observed in IGTAM-4 (1.79 mg/100g).

In case of pooled data, maximum copper content of seed was recorded in IGTAM-15 (16.13 mg/100g), which was found significantly excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (14.29 mg/100g), IGTAM-14 (11.32 mg/100g) and IGTAM-13 (10.11 mg/100g). The minimum copper content of seed was observed in IGTAM-4 (1.81 mg/100g).

Thus, the data presented on copper content of seed clearly show that higher copper content of seed was recorded in IGTAM-15 and lower copper content of seed was observed in IGTAM-4 in case of 1st year and 2nd year of the study as well as in pooled data.

4.4.3 Iron (seed)

Data obtained on iron (Fe) content of seed are presented in Table 4.12 and Fig. 4.12.

It is obvious from the data that iron content of seed in different genotypes included in this study ranged between 1.66 mg/100g (IGTAM-5) to 6.13 mg/100g (IGTAM-15) during 1st year (2004-05), 1.64 mg/100g (IGTAM-5) to 6.11 mg/100g (IGTAM-15) during 2nd year (2005-06) and 1.65 mg/100g (IGTAM-5) to 6.12 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of iron content of seed during 1st year and 2nd year of the study as well as in pooled mean basis.

During 1st year (2004-05), the highest iron content of seed was observed in IGTAM-15 (6.13 mg/100g), which was found better than all

the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (5.55 mg/100g), IGTAM-11 (4.30 mg/100g) and IGTAM-7 (4.26 mg/100g). The lowest iron content of seed was observed in IGTAM-5 (1.66 mg/100g) which was found significantly lower than all the genotypes except IGTAM-13 (1.70 mg/100g).

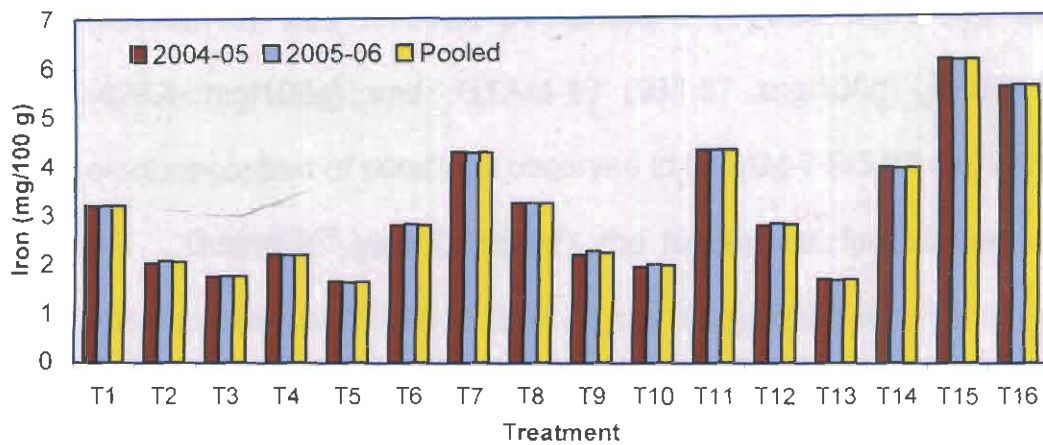
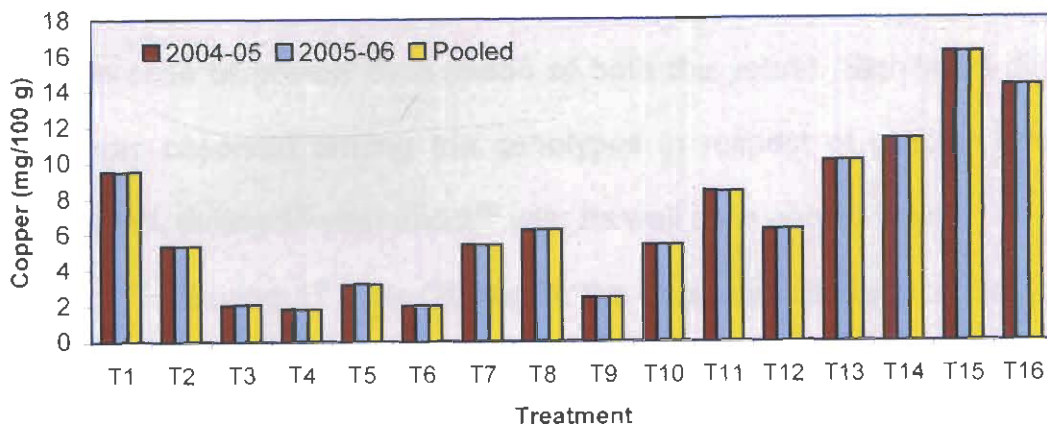
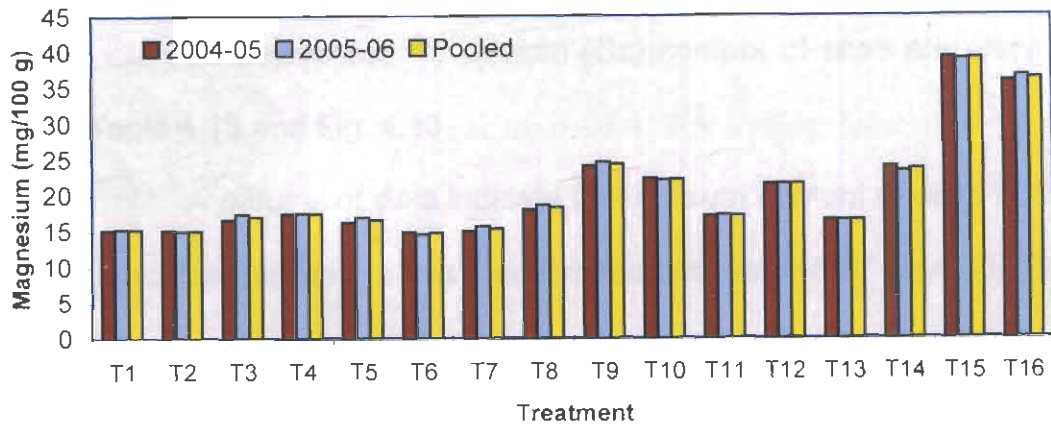
During 2nd year (2005-06), the maximum iron content of seed was observed in IGTAM-15 (6.11 mg/100g) which was found better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (5.58 mg/100g), IGTAM-11 (4.30 mg/100g) and IGTAM-7 (4.25 mg/100g). The minimum iron content of seed was recorded in IGTAM-5 (1.64 mg/100g) which was found statistically similar to IGTAM-13 (1.68 mg/100g).

In case of pooled data, the maximum iron content of seed was noticed in IGTAM-15 (6.12 mg/100), which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (5.57 mg/100g), IGTAM-11 (4.30 mg/100g) and IGTAM-7 (4.26 mg/100g). The minimum iron content of seed was recorded in IGTAM-5 (1.65 mg/100g) which was found at par with IGTAM-13 (1.69 mg/100g).

Thus, it is obvious from the data highest iron content of seed was noticed in IGTAM-15 and lowest iron content of seed was recorded in IGTAM-5 in case of 1st year and 2nd year of the study as well as in pooled data.

Table 4.12 : Variation in mineral composition of different Tamarind genotypes (Mg, Cu and Fe content of seed)

Treatments	Magnesium (mg/100 g)		Copper (mg/100 g)		Iron (mg/100 g)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
IGTAM-1	15.17	15.27	9.55	9.51	3.21	3.21
IGTAM-2	15.14	15.03	5.35	5.32	2.03	2.08
IGTAM-3	16.60	17.40	2.05	2.08	1.76	1.77
IGTAM-4	17.42	17.48	1.84	1.79	2.21	2.20
IGTAM-5	16.23	16.88	3.17	3.23	1.66	1.64
IGTAM-6	14.89	14.58	2.00	2.01	2.77	2.80
IGTAM-7	15.03	15.66	5.41	5.39	4.26	4.25
IGTAM-8	17.97	18.59	6.23	6.24	3.22	3.22
IGTAM-9	24.01	24.54	2.48	2.45	2.19	2.27
IGTAM-10	22.27	22.06	5.40	5.39	1.95	2.00
IGTAM-11	17.07	17.21	8.40	8.38	4.30	4.30
IGTAM-12	21.50	21.57	6.27	6.27	2.74	2.78
IGTAM-13	16.52	16.48	10.10	10.11	1.70	1.68
IGTAM-14	23.95	23.29	11.32	11.31	3.92	3.90
IGTAM-15	39.25	39.00	16.14	16.12	6.13	6.11
IGTAM-16	35.95	36.65	14.28	14.29	5.55	5.58
SE(m)±	0.2347	0.1787	0.0188	0.0177	0.0285	0.0343
CD(5%)	0.68	0.52	0.05	0.05	0.08	0.10
Pooled	15.22	15.08	9.53	9.53	3.21	3.21
Pooled	17.00	17.45	2.06	2.06	2.06	2.06
Pooled	16.56	16.56	3.20	3.20	1.64	1.65
Pooled	14.73	14.73	2.01	2.01	2.80	2.78
Pooled	15.35	15.35	5.40	5.40	4.25	4.26
Pooled	18.28	18.28	6.24	6.24	3.22	3.22
Pooled	24.28	24.28	2.47	2.47	2.27	2.23
Pooled	22.16	22.16	5.40	5.40	1.98	1.98
Pooled	17.14	17.14	8.39	8.39	4.30	4.30
Pooled	21.54	21.54	6.27	6.27	2.76	2.76
Pooled	16.50	16.50	10.11	10.11	1.68	1.68
Pooled	23.62	23.62	11.32	11.32	3.91	3.91
Pooled	39.13	39.13	16.13	16.13	6.12	6.12
Pooled	36.30	36.30	14.29	14.29	5.57	5.57
Pooled	0.1475	0.1475	0.0093	0.0093	0.0285	0.0285
Pooled	0.43	0.43	0.03	0.03	0.08	0.08



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.12 : Variation in mineral composition of different Tamarind genotypes (Mg, Cu and Fe content of seed)

4.4.4 Calcium (seed)

Data recorded on calcium (Ca) content of seed are presented in Table 4.13 and Fig. 4.13.

A perusal of data indicate that calcium content of seed in different genotype included in this study varied between 45.37 mg/100g (IGTAM-7) to 557.5 mg/100g (IGTAM-15) during 1st year (2004-05), 45.03 mg/100g (IGTAM-7) to 557.53 mg/100g (IGTAM-15) during 2nd year (2005-06) and 45.20 mg/100g (IGTAM-7) to 557.58 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of calcium content of seed, during 1st year and 2nd year as well as in pooled basis.

During 1st year (2004-05), the maximum calcium content of seed was noticed in IGTAM-15 (557.5 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-8 (511.99 mg/100g), IGTAM-9 (426.4 mg/100g) and IGTAM-16 (931.67 mg/100g). The minimum calcium content of seed was observed in IGTAM-7 (45.37 mg/100g).

During 2nd year (2005-06), the highest calcium content of seed was recorded in IGTAM-15 (557.53 mg/100g), which was found excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-8 (512.17 mg/100g), IGTAM-9 (426.33 mg/100g) and IGTAM-16 (390.44 mg/100g). The lowest calcium content of seed was noticed in IGTAM-7 (45.03 mg/100g).

In case of pooled data, the maximum calcium content of seed was observed in IGTAM-15 (557.52 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-8 (512.08 mg/100g), IGTAM-9 (426.38 mg/100g) and IGTAM-16 (391.05). The lowest calcium content of seed was noticed in IGTAM-7 (45.20 mg/100g).

Thus, the data recorded on calcium content of seed clearly show that highest calcium content of seed was noticed in IGTAM-15 and least calcium content in IGTAM-7 in case of both the years as well as in pooled data.

4.4.5 Phosphorus (seed)

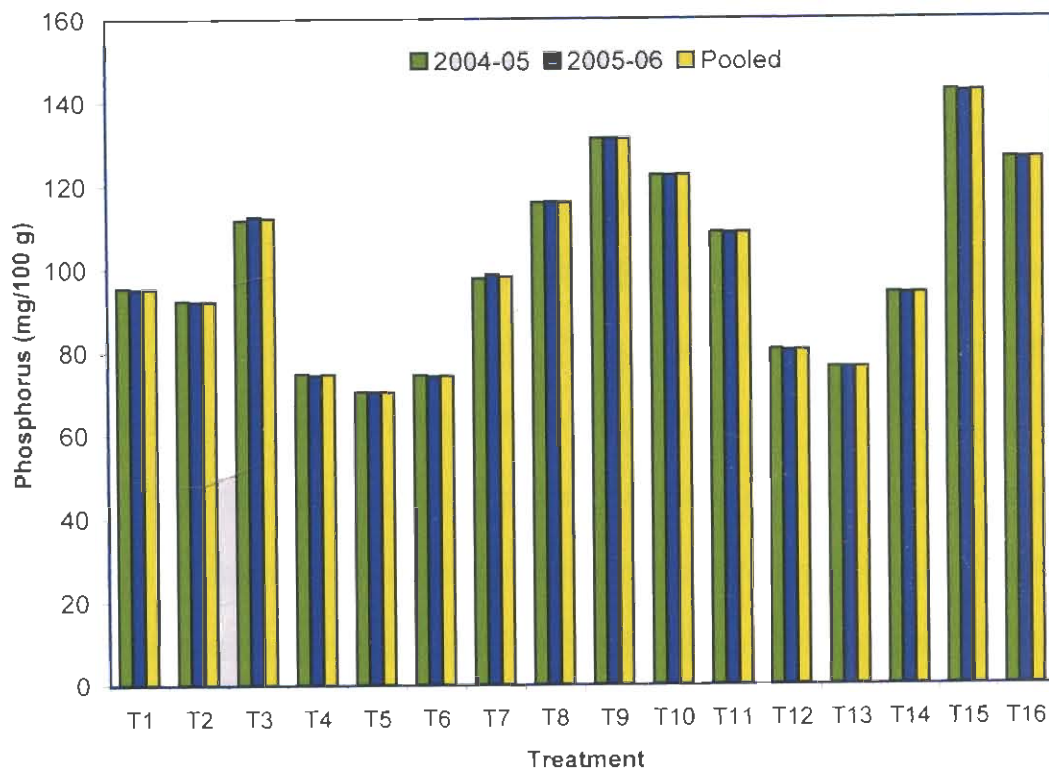
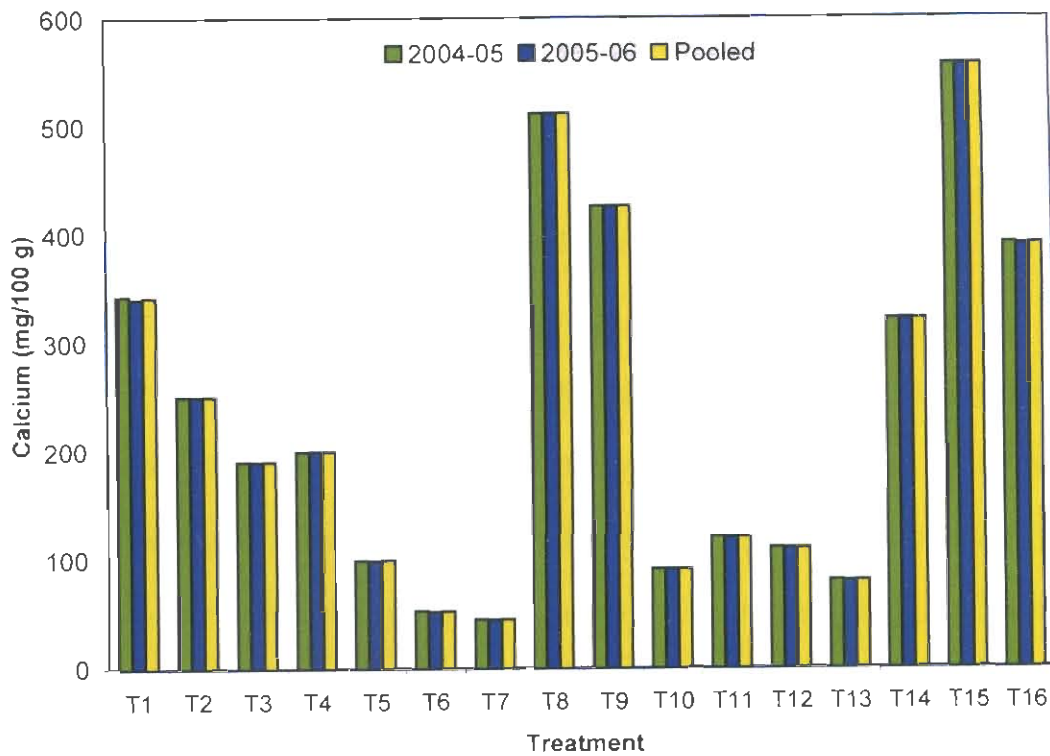
Data gathered on phosphorus (P) content of seed are presented in Table 4.13 and Fig. 4.13.

It is apparent from the data that phosphorus content of seed in different genotypes included in this study ranged between 70.46 mg/100g (IGTAM-5) to 142.74 mg/100g (IGTAM-15) during 1st year (2004-05), 70.42 mg/100g (IGTAM-5) to 142.41 mg/100g (IGTAM-15) during 2nd year (2005-06) and 70.44 mg/100g (IGTAM-5) to 142.58 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of phosphorus content of seed during 1st year and 2nd year of study as well as in pooled mean basis.

During 1st year (2004-05), the highest phosphorus content of seed was noticed in IGTAM-15 (142.74 mg/100g), which was found

Table 4.13 : Variation in mineral composition of different tamarind genotypes (Ca and P content of seed)

Treatments	Calcium (mg/100 g)			Phosphorus (mg/100 g)		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
IGTAM-1	343.30	340.54	341.92	95.50	95.14	95.32
IGTAM-2	250.71	250.38	250.55	92.36	92.17	92.26
IGTAM-3	190.97	190.55	190.76	111.72	112.55	112.14
IGTAM-4	200.10	200.29	200.20	74.77	74.38	74.58
IGTAM-5	100.30	100.13	100.22	70.46	70.42	70.44
IGTAM-6	53.00	52.07	52.53	74.44	74.12	74.28
IGTAM-7	45.37	45.03	45.20	97.71	98.58	98.14
IGTAM-8	511.99	512.17	512.08	115.92	116.06	115.99
IGTAM-9	426.40	426.33	426.38	131.20	131.24	131.22
IGTAM-10	91.03	91.25	91.14	122.43	122.38	122.51
IGTAM-11	120.67	120.16	120.42	108.67	108.54	108.60
IGTAM-12	110.51	110.22	110.37	80.63	80.30	80.47
IGTAM-13	80.66	80.32	80.49	76.28	76.23	76.26
IGTAM-14	322.54	322.66	322.60	94.23	94.05	94.14
IGTAM-15	557.50	557.53	557.52	142.74	142.41	142.58
IGTAM-16	391.67	390.44	391.05	126.65	126.46	126.56
SE(m)±	0.2132	0.0399	0.2132	0.2269	0.0918	0.1378
CD(5%)	0.62	0.12	0.62	0.66	0.27	0.40



- | | | | |
|--------------------------|--------------------------|----------------------------|----------------------------|
| T ₁ : IGTAM-1 | T ₅ : IGTAM-5 | T ₉ : IGTAM-9 | T ₁₃ : IGTAM-13 |
| T ₂ : IGTAM-2 | T ₆ : IGTAM-6 | T ₁₀ : IGTAM-10 | T ₁₄ : IGTAM-14 |
| T ₃ : IGTAM-3 | T ₇ : IGTAM-7 | T ₁₁ : IGTAM-11 | T ₁₅ : IGTAM-15 |
| T ₄ : IGTAM-4 | T ₈ : IGTAM-8 | T ₁₂ : IGTAM-12 | T ₁₆ : IGTAM-16 |

Fig. 4.13 : Variation in mineral composition of different tamarind genotypes (Ca and P content of seed)

significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-9 (131.20 mg/100g), IGTAM-16 (126.65 mg/100g), and IGTAM-10 (122.48 mg/100g). The lowest phosphorus content of seed was observed in IGTAM-5 (70.46 mg/100g).

During 2nd year (2005-06), the maximum phosphorus content of seed was recorded in IGTAM-15 (142.41 mg/100g), which was found better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-9 (131.24 mg/100g), IGTAM-16 (126.46 mg/100g). The minimum phosphorus content of seed was noticed in IGTAM-5 (70.42 mg/100g).

In case of pooled data, the highest phosphorus content of seed was observed in IGTAM-15 (142.58 mg/100g), which was found excellent than all the genotypes studied in this investigation. This genotype was followed by IGTAM-9 (131.22 mg/100g), IGTAM-16 (126.56 mg/100g) and IGTAM-10 (122.56 mg/100g). The lowest phosphorus content of seed was recorded in IGTAM-5 (70.44 mg/100g).

Thus, the data obtained on phosphorus content of seed clearly reveal that maximum phosphorus content of seed was noticed in IGTAM-15 and minimum phosphorus content of seed was observed in IGTAM-5 in case of both the years as well as in pooled data.

4.4.6 Potassium (seed)

The data recorded on potassium (K) content of seed are presented in Table 4.14 and Fig. 4.14.

A perusal of data indicate that potassium content of seed in different genotypes included in this study varied from 263.74 mg/100g (IGTAM-10) to 523.83 mg/100 (IGTAM-15) during 1st year (2004-05), 262.76 mg/100g (IGTAM-10) to 523.42 mg/100g (IGTAM-15) during 2nd year (2005-06) and 263.25 mg/100g (IGTAM-10) to IGTAM-15 (523.46 mg/100g) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of potassium content of seed, during 1st year and 2nd year of study as well as pooled basis.

During 1st year (2004-05), the maximum potassium content of seed was recorded in IGTAM-15 (523.83 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (504.92 mg/100g), IGTAM-9 (412.60 mg/100g). The minimum potassium content of pulp was recorded in IGTAM-10 (263.74 mg/100g).

During 2nd year (2005-06), the highest potassium content of pulp was noticed in IGTAM-15 (523.42 mg/100g), which was found remarkably better than all the genotypes included in this investigation. This genotype (IGTAM-15) was followed by IGTAM-16 (504.08 mg/100g), IGTAM-14 (413.24 mg/100g) and IGTAM-9 (412.73 mg/100g). The lowest potassium content of seed was observed in IGTAM-10 (262.76 mg/100g).

In case of pooled data, the maximum potassium content of pulp was recorded in IGTAM-15 (523.42 mg/100g), which was found remarkably better than all the genotypes studied in this investigation. This

genotype (IGTAM-15) was followed by IGTAM-16 (504.50 mg/100g), IGTAM-9 (412.67 mg/100g) and IGTAM-14 (412.67 mg/100g). The minimum potassium content of seed was observed in IGTAM-10 (263.25 mg/100 g).

Thus, the data on potassium content of seed clearly revealed that highest potassium content of seed was observed in IGTAM-15 and lowest potassium content of seed was recorded in IGTAM-10 in case both the years as well as in pooled data.

4.4.7 Sodium (seed)

The data pertaining to sodium (Na) content of pulp are furnished in Table 4.14 and Fig. 4.14.

A perusal of data indicates that sodium content of seed in different genotypes included in this study varied from 15.15 mg/100g (IGTAM-7) to 27.5 mg/100g (IGTAM-15) during 1st year (2004-05), 15.35 mg/100g (IGTAM-7) to 27.62 mg/100g (IGTAM-15) during 2nd year (2005-06) and 15.28 mg/100g (IGTAM-7) to 27.56 mg/100g (IGTAM-15) in case of pooled data (mean of both the years). Significant difference was observed among the genotypes in respect of sodium content of seed during 1st year and 2nd year of study as well as in pooled data.

During 1st year (2004-05), the maximum sodium content of seed was recorded in IGTAM-15 (27.50 mg/100g), which was found significantly superior than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-8 (25.34 mg/100g), IGTAM-16 (25.33 mg/100g) and IGTAM-9 (24.34 mg/100g). The

minimum sodium content of seed was noticed in IGTAM-7 (15.15 mg/100g).

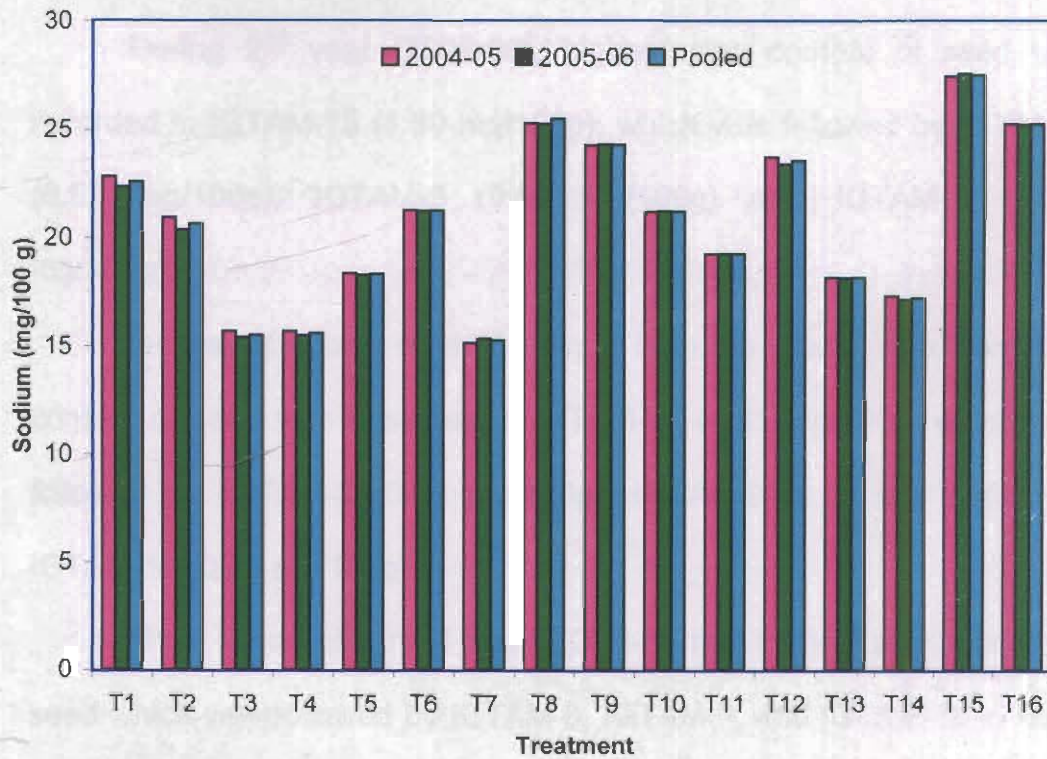
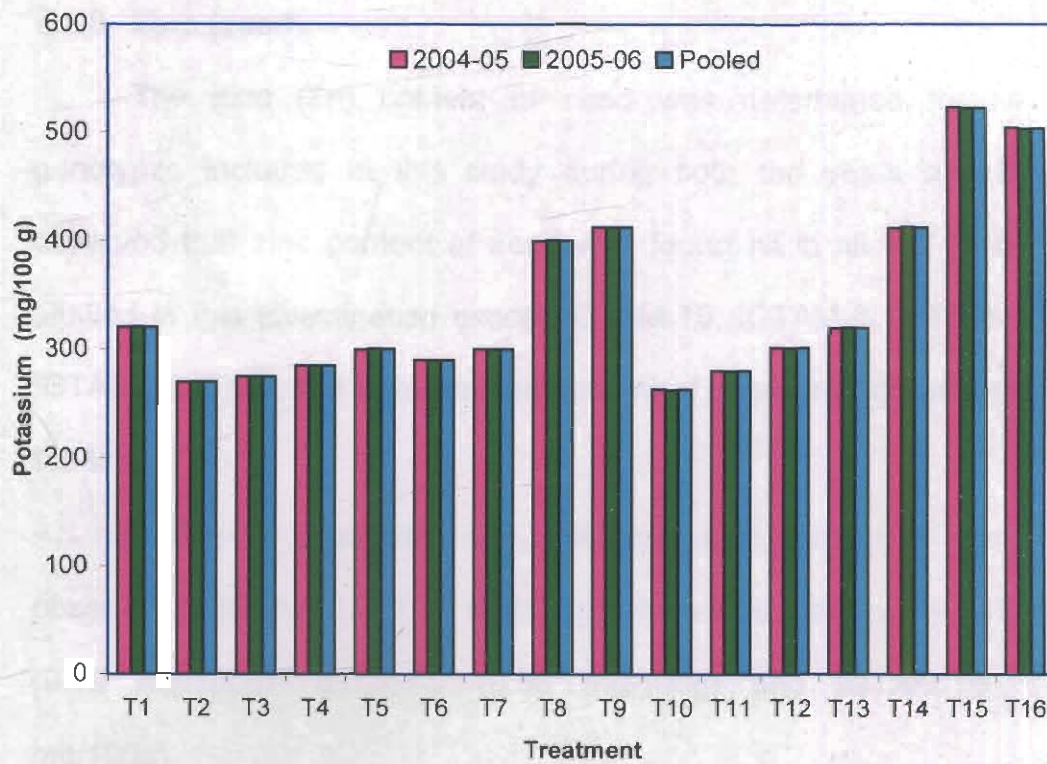
During 2nd year (2005-06), the highest sodium content of seed was recorded in IGTAM-15 (27.62 mg/100g), which was found significantly excellent than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-8 (25.31 mg/100g), IGTAM-16 (25.29 mg/100g) and IGTAM-9 (24.38 mg/100g). The lowest sodium content of pulp was observed in IGTAM-7 (15.35 mg/100g) which was found at par with IGTAM-3 (15.42 mg/100g) and IGTAM-4 (15.50 mg/100g).

In case of pooled data the maximum sodium content of seed was recorded in IGTAM-15 (27.56 mg/100g), which was found significantly better than all the genotypes studied in this investigation. This genotype (IGTAM-15) was followed by IGTAM-8 (25.55 mg/100g), IGTAM-16 (25.32 mg/100g) and IGTAM-9 (24.36 mg/100g). The minimum sodium content of seed was observed in IGTAM-7 (15.28 mg/100g) which was found significantly lower than all the genotypes except IGTAM-3 (15.52 mg/100g).

Thus, the data presented on sodium content of seed clearly show that highest sodium content of seed was observed in IGTAM-15 and lowest sodium content of seed was recorded in IGTAM-7 in case of both the years as well as in pooled data.

Table 4.14 : Variation in mineral composition of different tamarind genotypes (K and Na content of seed)

Treatments	Potassium (mg/100 g)			Sodium (mg/100 g)		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
IGTAM-1	320.33	320.70	320.52	22.87	22.39	22.63
IGTAM-2	270.23	270.53	270.38	20.93	20.37	20.65
IGTAM-3	275.12	275.21	275.17	15.69	15.42	15.52
IGTAM-4	285.25	285.10	285.18	15.69	15.50	15.60
IGTAM-5	300.12	300.79	300.45	18.38	18.30	18.34
IGTAM-6	290.31	290.21	290.26	21.27	21.24	21.26
IGTAM-7	300.24	300.25	300.21	15.15	15.35	15.28
IGTAM-8	400.13	400.87	400.50	25.34	25.31	25.55
IGTAM-9	412.60	412.73	412.67	24.34	24.38	24.36
IGTAM-10	263.74	262.76	263.25	21.21	21.24	21.23
IGTAM-11	280.51	280.21	280.36	19.26	19.28	19.27
IGTAM-12	301.88	301.41	301.65	23.75	23.42	23.58
IGTAM-13	319.82	320.31	320.06	18.18	18.17	18.18
IGTAM-14	412.09	413.24	412.67	17.33	17.17	17.25
IGTAM-15	523.83	523.42	523.46	27.50	27.62	27.56
IGTAM-16	504.92	504.08	504.50	25.33	25.29	25.32
SE(m)±	0.2835	0.1949	0.1921	0.1743	0.0617	0.0964
CD(5%)	0.82	0.56	0.55	0.50	0.18	0.28



T ₁ : IGTAM-1	T ₅ : IGTAM-5	T ₉ : IGTAM-9	T ₁₃ : IGTAM-13
T ₂ : IGTAM-2	T ₆ : IGTAM-6	T ₁₀ : IGTAM-10	T ₁₄ : IGTAM-14
T ₃ : IGTAM-3	T ₇ : IGTAM-7	T ₁₁ : IGTAM-11	T ₁₅ : IGTAM-15
T ₄ : IGTAM-4	T ₈ : IGTAM-8	T ₁₂ : IGTAM-12	T ₁₆ : IGTAM-16

Fig. 4.14 : Variation in mineral composition of different tamarind genotypes (K and Na content of seed)

4.4.8 Zinc (seed)

The zinc (Zn) content of seed was determined for all the genotypes included in this study during both the years and it was observed that zinc content of seed was found nil in all the genotypes studied in this investigation except IGTAM-15, IGTAM-8, IGTAM-9 and IGTAM-16. Thus, the data on zinc content of seed are not presented in the table.

During 1st year (2004-05), maximum zinc content of seed was observed in IGTAM-15 (1.82 mg/100g) which was followed by IGTAM-8 (0.58 mg/100g), IGTAM-9 (0.55 mg/100g) and IGTAM-16 (0.38 mg/100g).

During 2nd year (2005-06), highest zinc content of seed was recorded in IGTAM-15 (1.80 mg/100g), which was followed by IGTAM-8 (0.57 mg/100g), IGTAM-9 (0.54 mg/100g) and IGTAM-16 (0.41 mg/100g).

In case of pooled mean (mean of both the years), maximum zinc content of seed was observed in IGTAM-15 (1.81 mg/100g) which was followed by IGTAM-8 (0.56 mg/100g), IGTAM-9 (0.55 mg/100g) and IGTAM-16 (0.40 mg/100g).

Thus, it was observed that IGTAM-15 had highest zinc content of seed which was followed by IGTAM-8, IGTAM-9, and IGTAM-16 in case of both the years as well as in pooled mean.

4.4.9 Manganese (seed)

The manganese (Mn) content of seed was determined for all the genotypes included in this study during 1st year (2004-05) and 2nd year (2005-06) and it was observed that manganese content of seed was found nil in all the genotypes studied in this investigation.

Thus, the data on manganese content of seed are not presented in the table.

4.5 Correlation coefficient of physico-chemical characters

The correlation matrix of tamarind physico-chemical characters is presented in Table 4.15.

4.5.1 Fruit length

Fruit length was positively and significantly associated with fruit weight, shell weight, seed weight, vein weight, shell weight, number of seeds per fruit, TSS, reducing sugar, total sugar and protein.

Fruit length was positively and non-significantly associated with pH, crude fibre and non-reducing sugar.

4.5.2 Fruit width

Fruit width was positively and non-significantly associated with fruit weight, pulp weight, vein weight, shell weight, acidity and non-reducing sugar.

Fruit width was negatively and non-significantly associated with number of seeds per fruit.

4.5.3 Fruit thickness

Fruit thickness was positively and significantly associated with ascorbic acid.

Fruit thickness was positively and non-significantly associated with number of seeds per fruit and non-reducing sugar.

4.5.4 Fruit weight

Fruit weight was positively and significantly associated with fruit length, pulp weight, seed weight, vein weight, shell weight, number of seeds, TSS and protein.

Fruit weight was positively and non-significantly associated with pH, reducing sugar and total sugar.

4.5.5 Pulp weight

Pulp weight was positively and significantly associated with fruit length, fruit weight, seed weight, vein weight, shell weight, number of seeds and protein.

Pulp weight was positively and non-significantly associated with TSS, reducing sugar, total sugar and crude fibre.

4.5.6 Seed weight

Seed weight was positively and significantly associated with fruit length, fruit weight, pulp weight, vein weight, shell weight, number of seeds, TSS, reducing sugar and total sugar.

4.5.7 Vein weight

Vein weight was positively and significantly associated with fruit length, fruit weight, pulp weight, seed weight, shell weight, number of seeds, TSS, reducing sugar and protein.

Vein weight was positively and non-significantly associated with fruit width, pH and total sugar.

4.5.8 Shell weight

Shell weight was positively and significantly associated with fruit length, fruit weight, pulp weight, seed weight, vein weight and number of seeds.

Shell weight was positively and non-significantly associated with fruit width, TSS, reducing sugar and total sugar.

4.5.9 Number of seeds

Number of seeds was positively and significantly associated with fruit length, fruit weight, pulp weight, seed weight, vein weight, shell weight and pH.

Number of seeds was negatively and significantly associated with acidity.

4.5.10 Acidity

The acidity was negatively and significantly associated with number of seeds, TSS and pH.

The acidity was negatively and non-significantly associated with reducing sugar, non-reducing sugar and total sugar.

4.5.11 TSS

The TSS (Total soluble solids) was positively and significantly associated with fruit length, fruit weight, seed weight, vein weight, reducing sugar and total sugar.

The TSS was positively and non-significantly associated with pulp weight, shell weight, number of seeds, protein and crude fibre.

4.5.12 pH

The pH was positively and significantly associated with number of seeds.

The pH was positively and non-significantly associated with fruit length, pulp weight, seed weight.

The pH was negatively and significantly associated with acidity.

4.5.13 Reducing sugar

Reducing sugar was positively and significantly associated with fruit length, seed weight, vein weight, TSS, and total sugar.

Reducing sugar was positively and non-significantly associated with fruit weight, pulp weight, protein and crude fibre.

4.5.14 Non-reducing sugar

Non-reducing sugar was positively and significantly associated with total sugar.

Non-reducing sugar was positively and non-significantly associated with fruit length and reducing sugar.

4.5.15 Total sugar

Total sugar was positively and significantly associated with fruit length, seed weight, TSS, reducing sugar and non-reducing sugar.

Total sugar was positively and non-significantly associated with fruit weight, pulp weight, vein weight, protein and crude fibre.

Total sugar was negatively and non-significantly associated with the acidity.

4.5.16 Ascorbic acid

Ascorbic acid was positively and significantly associated with the fruit thickness.

4.5.17 Protein

Protein was positively and significantly associated with the fruit length, fruit weight, pulp weight, and vein weight.

Protein was positively and non-significantly associated with the fruit width, seed weight, shell weight, TSS, reducing sugar and total sugar.

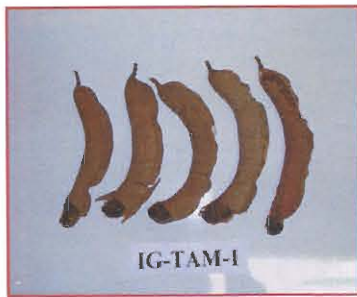
4.5.18 Crude fibre

Crude fibre was positively and non-significantly associated with fruit length, fruit thickness, pulp weight, vein weight, TSS, reducing sugar and total sugar.

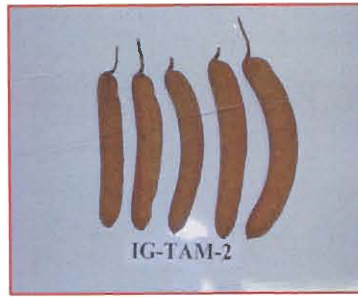
Table 4.15 : Correlation matrix of tamarind physico-chemical characters

	Fruit length (cm)	Fruit width (cm)	Fruit thickness (cm)	Fruit weight (g)	Pulp weight (g)	Seed weight (g)	Vein weight (g)	Shell weight (g)	Number of seeds	Acidity (%)	TSS (°Brix)	pH	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)	Ascorbic acid (%)	Protein (%)
Fruit width (cm)	-0.012																
Fruit thickness (cm)	-0.122	0.007															
Fruit weight (g)	0.903**	0.217	-0.012														
Pulp weight (g)	0.826**	0.249	-0.021	0.956**													
Seed weight (g)	0.890**	-0.044	0.064	0.875**	0.715**												
Vein weight (g)	0.769**	0.248	-0.136	0.861**	0.766**	0.819**											
Shell weight (g)	0.769**	0.359	-0.119	0.914**	0.829**	0.810**	0.784**										
Number of seeds	0.760**	-0.247	0.226	0.723**	0.609**	0.861**	0.580*	0.638**									
Acidity (%)	-0.410	0.347	-0.262	-0.336	-0.290	-0.420	-0.228	-0.183	-0.499*								
TSS (°Brix)	0.650**	-0.110	-0.061	0.515*	0.372	0.596**	0.563*	0.430	0.387	-0.461*							
pH	0.375	-0.442	0.343	0.320	0.258	0.460	0.265	0.150	0.539*	-0.958**	0.462						
Reducing sugar (%)	0.634**	0.012	-0.167	0.451	0.279	0.582*	0.568*	0.397	0.319	-0.343	0.836**	0.266					
Non reducing sugar (%)	0.157	0.190	0.169	0.074	0.095	-0.023	-0.079	0.021	0.156	-0.394	0.160	0.277	0.155				
Total sugar (%)	0.609**	0.083	-0.079	0.420	0.278	0.495*	0.462	0.352	0.337	-0.448	0.785**	0.336	0.925**	0.518*			
Ascorbic acid (%)	-0.063	0.169	0.591**	0.116	0.088	0.116	0.070	0.220	0.311	-0.178	-0.046	0.197	-0.082	0.138	-0.018		
Protein (%)	0.517**	0.401	0.119	0.517*	0.491*	0.429	0.487*	0.366	0.233	0.209	0.289	-0.164	0.286	0.197	0.323	-0.260	
Crude fibre (%)	0.326	-0.038	-0.105	0.145	0.191	0.072	0.253	-0.079	0.120	-0.234	0.443	0.182	0.340	0.184	0.365	-0.183	0.211

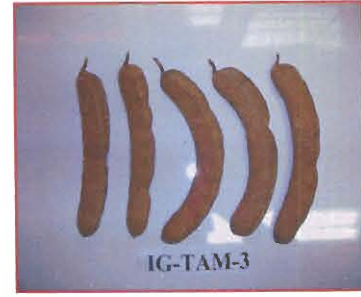
* : Significant at 5 per cent level, ** : Significant at 1 per cent level



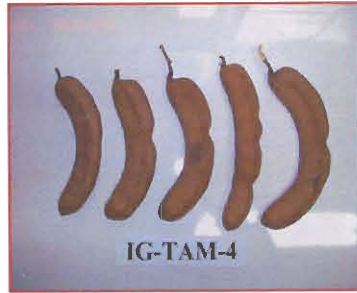
IG-TAM-1



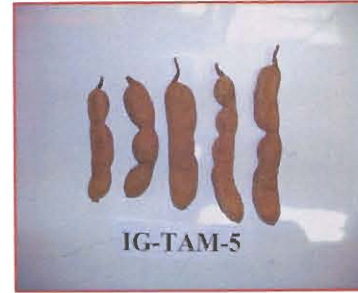
IG-TAM-2



IG-TAM-3



IG-TAM-4



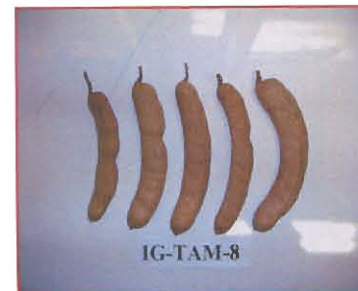
IG-TAM-5



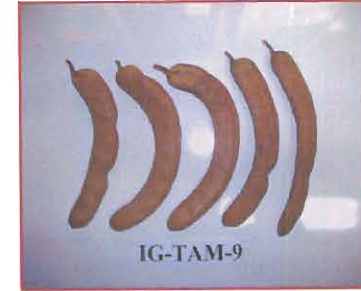
IG-TAM-6



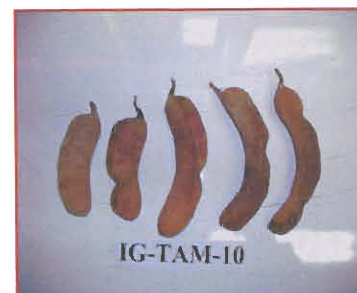
IG-TAM-7



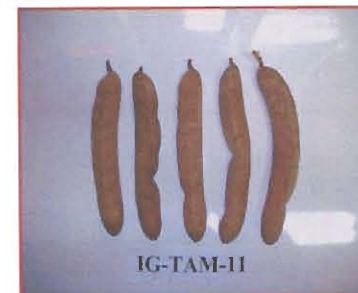
IG-TAM-8



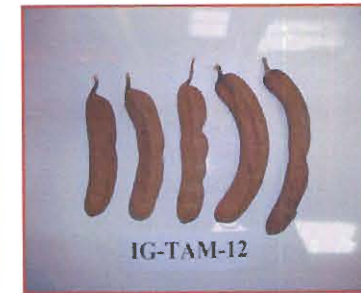
IG-TAM-9



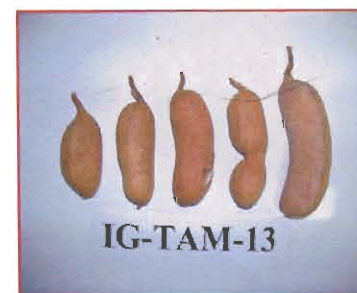
IG-TAM-10



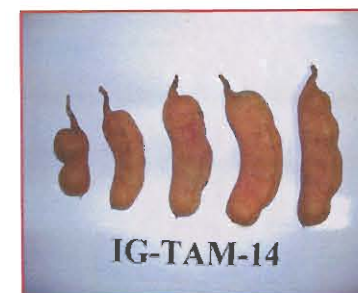
IG-TAM-11



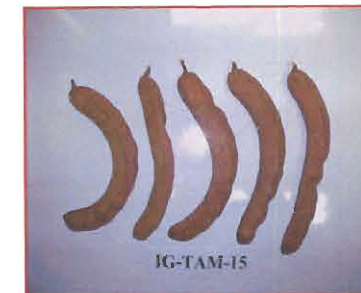
IG-TAM-12



IG-TAM-13



IG-TAM-14



IG-TAM-15



IG-TAM-16

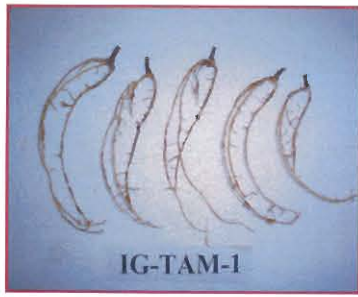
PLATE 1 : Variability in shape and size of fruits of different tamarind genotypes



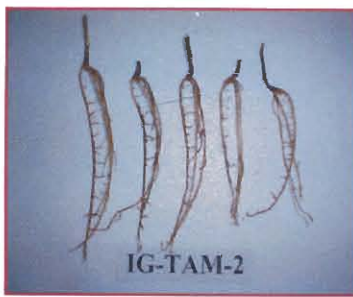
PLATE 2 : Variability in among the genotypes as deshelled fruit



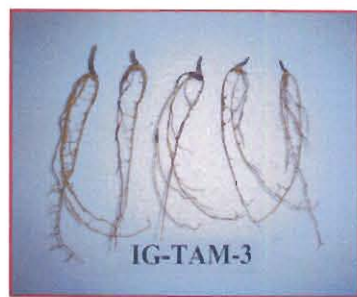
PLATE 3 : Variability in shape, size and colour of seeds of different tamarind genotypes



IG-TAM-1



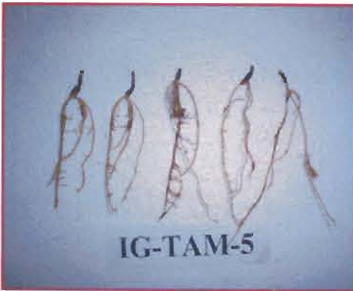
IG-TAM-2



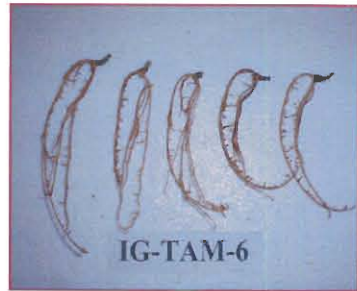
IG-TAM-3



IG-TAM-4



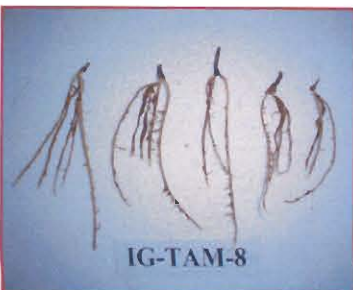
IG-TAM-5



IG-TAM-6



IG-TAM-7



IG-TAM-8



IG-TAM-9



IG-TAM-10



IG-TAM-11



IG-TAM-12



IG-TAM-13



IG-TAM-14



IG-TAM-15



IG-TAM-16

PLATE 4 : Variability in vein (fibre) content of fruit of different tamarind genotypes

Discussion

CHAPTER-V

DISCUSSION

Tamarind is one of the hardiest trees, which is ideally suited for arid and semi-arid regions. Although, it is not found grown on a large scale, there are many scattered pockets where it is grown on wastelands, besides being grown on bunds, roadsides and on river or *nala* banks in isolation.

Being a highly cross-pollinated crop, there exists a high degree of variation in performance of the tree (Thimmaraju *et al.*, 1978). The large genetic diversity present in the seeding population owing to its wide geographical distribution and wide adaptability to different agro-climatic regions of the state, there is a great potential for evaluation of promising type having uniform sized pods of superior quality.

In the present investigation, an attempt was made to evaluate 16 different tamarind genotypes with respect to physico-chemical characters of fruits including mineral content of the fruit pulp and seeds.

The present study has revealed the occurrence of high degree of phenotypic variation in the experimental material. It is evident from the data collected among 16 different genotypes that there is a great variation in quantitative and qualitative characters of fruits.

Tamarind is a highly cross-pollinated crop, hence wide variability is common in this species. It offers more avenues for identifying desirable seeding tree (plus tree) and further multiplying them by vegetative

means. The same technique was successfully adopted in mango with wide variation prevalent as a result of cross-pollination, which helped in easy selection of new types (Singh and Singh, 1958; Singh, 1963).

The present investigation entitled "Studies on physico-chemical evaluation of Tamarind (*Tamarindus indica* L.) genotypes prevailing in Bastar region of Chhattisgarh" has led to some important observations. The salient features of these observations have been discussed and interpreted below in the light of available literature under the following heads:

5.1 Physical characters

5.1.1 Fruit length, fruit width and fruit thickness

5.1.2 Fruit weight, pulp weight and seed weight

5.1.3 Vein weight, shell weight and number of seeds

5.1.4 Pulp per cent and shell per cent

5.1.5 Seed per cent and vein per cent

5.2 Chemical characters

5.2.1 Acidity, TSS and pH

5.2.2 Sugar content

5.2.3 Ascorbic acid, protein and crude fibre

5.3 Minerals content of pulp

5.3.1 Magnesium, copper and iron (pulp)

5.3.2 Calcium and phosphorus (pulp)

5.3.3 Potassium and sodium (pulp)

5.3.4 Zinc and manganese (pulp)

5.4 Minerals content of seed

5.4.1 Magnesium, copper and iron (seed)

5.4.2 Calcium and phosphorus (seed)

5.4.3 Potassium and sodium (seed)

5.4.4 Zinc and manganese (seed)

5.5 Correlation coefficient of physico-chemical characters

5.1 Physical characters

5.1.1 Fruit length, fruit width and fruit thickness

The result of present investigation (Table 4.1) revealed that fruit length significantly varied from 10.46 cm (IGTAM-5) to 22.15 cm (IGTAM-16). The differences in the length of fruit may be attributed to the genetic make up of each genotypes. The variation regarding fruit length have also been reported by Hernandez-Unzon and Lakshminarayana (1982) as 12-15 cm and maximum 22.5 cm by Kokate (1988) and these findings are in consonance with the present results.

Among the 16 different tamarind genotypes studied, the fruit width ranged from 3.06 cm to 4.40 cm with a maximum of 4.40 cm in IGTAM-10 and minimum of 3.06 cm in IGTAM-3. The variation in width of fruit might be due to genetic difference among the selected genotypes. The observation regarding fruit width was 2.40-5.50 cm as reported by Keskar (1989), 2.90 cm by Ilango and Vijayalakshmi (2002) and these findings are in line with the present results.

The fruit thickness also varied among the genotypes studied in this investigation. Maximum fruit thickness was recorded in IGTAM-11 (2.17

cm) and lowest fruit thickness was recorded in IGTAM-7 (1.24 cm). The observations regarding fruit thickness was 1.31 cm to 1.70 cm by Hanamashetti and Sulikeri (1997) and 1.41 cm by Shivanandam (1980). The present findings are in agreement with the earlier reports.

5.1.2 Fruit weight, pulp weight and seed weight

Data presented in Table 4.2 indicates that there was significant difference in all the genotypes studied in this investigation in respect of fruit weight, pulp weight and seed weight.

Among the 16 different genotypes studied, the fruit weight varied from 14.11g (IGTAM-5) to 36.89 g (IGTAM-14). The difference in fruit weight in the present study may be attributed to number of seeds, seed weight, pulp content, shell weight among the different genotypes. Similar variation in fruit weight of seedling origin tamarind trees was noticed by Shivanandam (1980) and Mastan *et al.* (1997).

The maximum pulp weight 17.73 g and minimum 6.40 g per fruit was recorded in IGTAM-14 and IGTAM-5, respectively. Such variation in pulp weight of fruit may be attributed to difference in fruit length, breadth and thickness. The pulp weight is positively correlated to fruit weight in tamarind (Shivanandam and Thimmaraju, 1988). Similar results of variation in pulp weight were reported by various workers (Shivanandam, 1980; Challapilli, 1992; Hanamashetti and Sulikeri, 1997; Mastan *et al.*, 1997 and Singh *et al.*, 1997) in tamarind.

Maximum seed weight per fruit was recorded in IGTAM-16 (9.74 g), whereas, minimum seed weight per fruit was recorded in IGTAM-5

fruit. The supporting reference have been reported by Mastan *et al.* (1997).

Maximum number of seeds per fruit was recorded in IGTAM-16 (10.09) whereas minimum number of seeds per fruit was recorded in IGTAM-5 (4.14). The difference in seed number may be attributed to difference in length of pod and ovule fertility. In conformity of this Bailey (1947) also reported in tamarind that long pods contains seeds ranging from 6 to 12 but in short pods, the number of seeds varies from 1 to 4. Similar results have also been reported by several workers (Cowen, 1970; Shivanandam 1980; Challapilli 1992; Keskar *et al.*, 1989; Hanamashetti and Sulikeri 1997; Azhaimanavaln and Vadivel 1997; Mastan *et al.*, 1997; Singh *et al.*, 1997; Benjamin and Seegobin, 1999).

5.1.4 Pulp per cent and shell per cent

The results presented in Table 4.4 regarding pulp per cent and shell per cent of fruits showed a huge variation.

The pulp content varied from 40.18 per cent (IGTAM-7) to 53.98 per cent (IGTAM-1) and the shell content ranged from 17.93 per cent (IGTAM-15) to 25.58 per cent (IGTAM-10). The variation in pulp content and shell content might be due to the distinct feature of different genotypes. Similar variations with respect to pulp content and shell content were also observed in tamarind by Shivanandam (1980), Challapilli (1992), Rao (1995), Hanamashetti and Sulikeri (1997), Mastan *et al.* (1997), Sivakumar (2000), Vennila (2000) and Prabhushankar *et al.* (2004).

5.1.5 Seed per cent and vein per cent

The result presented in Table 4.5 regarding seed per cent and vein per cent indicated the significant response among genotypes.

As regards to the seed per cent, IGTAM-16 (30.62%) reported maximum seed per cent and IGTAM-1 (20.93%) gave minimum seed per cent. The variations in seed content might be due to the difference in length of pod and ovule fertility. The present results are also in agreement with the findings of Shivanandam (1980), Challapilli (1992), Rao (1995), Hanamashetti and Sulikeri (1997), Mastan *et al.* (1997), Anon (2000), Vannila (2000) and Prabhushankar (2004) in tamarind.

As regards to the vein per cent IGTAM-14 (6.39%) recorded maximum vein per cent and IGTAM-3 (3.20%) recorded minimum vein per cent. The variations with respect to vein content might be due to the distinct feature of the different genotypes.

Similar variations with respect to vein content were also reported by Shivanandam (1980), Challapilli (1992), Rao (1995), Hanamashetti and Sulikeri (1997), Mastan *et al.* (1997) and Prabhushankar *et al.* (2004) in tamarind.

5.2 Chemical characters

5.2.1 Acidity, TSS and pH

The data presented in Table 4.6 indicates that there was a significant difference in all the genotypes studied in respect of acidity, TSS and pH of tamarind pulp.

The variation in titrable acidity in the different tamarind genotypes showed a significant deviation in this investigation. The titrable acidity (as per cent tartaric acid) ranged between minimum of 7.95 per cent (IGTAM-4) to maximum of 19.63 per cent (IGTAM-6). Such type of results have been also reported by Prameshwar and Sadashivaiah (1985) in tamarind, who observed that tamarind pulp contained 8 to 18 per cent tartaric acid. The difference in tartaric acid content are attributed to the difference in genotypes and varies from season to season. These results are also in agreement with the findings of Shivanandam (1980), Duke (1981), Keshar *et al.* (1989), Challapilli (1992), Hanamashetti and Sulikeri (1997), Mastan *et al.* (1997), Benjamin and Seegobin (1999) and Prabhushankar *et al.* (2004).

The total soluble solids (TSS) content of 16 different genotypes varied significantly. The maximum TSS was recorded in IGTAM-15 (19.66°B) and minimum TSS recorded in IGTAM-12 (12.06°B). This difference in TSS content of pulp may be due to difference in sugar content of fruits. Similar outcome with respect to TSS was reported by Shivanandam (1980), Keskar *et al.* (1989) and Prabhushankar *et al.* (2004).

The pH content of the pulp also varied significantly. The maximum pH was recorded in IGTAM-3 (3.47) and minimum pH in IGTAM-6 (2.58). The difference in pH content are attributed to the difference in genotypes and varies from season to season. A pH of 3.15 was reported by Duke (1981) in case of tamarind. Similar results were also reported by

Azhakiamanavalan and Vadivel (1997) and Prabhashankar (2001) in tamarind.

5.2.2 Sugar content

The result of present investigation (Table 4.7) revealed that there was significant difference in all the genotypes studied in this investigation in respect of reducing, non-reducing and total sugar content of tamarind.

As regards to reducing sugar and total sugar content of tamarind fruit, the maximum reducing sugar and total sugar was recorded in IGTAM-15, 38.09 and 51.88 per cent, respectively, while the minimum reducing sugar and total sugar was recorded in IGTAM-13, 25.08 per cent and 33.34 per cent, respectively. In case of non-reducing sugar, maximum content was recorded in IGTAM-1 (15.00%) and minimum in IGTAM-6 (7.85%).

The level of sugar content in tamarind was possible due to ripening of fruits, which is associated with high metabolic changes in the fruits leading to conversion of complex polysaccharides into simple sugars. The difference in sugar content are attributed to the difference in genotypes. These results are supported by the findings of Ishola *et al.* (1990) and Shankaracharya (1998).

5.2.3 Ascorbic acid, protein and crude fibre

Data analyzed for ascorbic acid, protein and crude fibre revealed significant variation (Table 4.8) in tamarind genotypes.

The ascorbic acid content in different tamarind genotypes included in this study ranged between minimum of 1.81 per cent (IGTAM-8) to

maximum of 4.05 per cent (IGTAM-11). The difference in ascorbic acid content of fruit may be due to perpetual synthesis of glucose-6-phosphate throughout the growth and development of fruits which is thought to be the precursor of vitamin 'C' (ascorbic acid). The results are also in agreement with the findings of Ishola *et al.* (1990).

The protein content of fruit significantly varied from minimum 2.04 per cent (IGTAM-8) to maximum of 6.71 per cent (IGTAM-15). The variation among the genotypes may be due to concentration of nitrogen in the fruits of different genotypes. These results are in close conformity with the findings of Ishola *et al.* (1990) and Shankaracharya (1998) in tamarind.

Among the 16 different tamarind genotypes studied, the crude fibre ranged from 3.23 per cent to 10.39 per cent with a maximum of 10.39 per cent in IGTAM-1 and minimum of 3.23 per cent in IGTAM-13. The variation in crude fibre of fruit might be due to genetic difference among the genotypes included in this study. The supporting references have also been reported by Ishola *et al.* (1990) and Shankaracharya (1998).

5.3 Minerals of pulp

5.3.1 Magnesium, Copper and Iron (pulp)

In the present investigation, variations were also observed in magnesium (Mg), Copper (Cu) and iron (Fe) content of pulp among the different tamarind genotypes studied (Table 4.9).

The maximum magnesium content in the pulp was recorded in IGTAM-15 (30.63 mg/100g) while minimum magnesium content in IGTAM-6 (18.03 mg/100g). The copper (Cu) content of pulp varied between 5.45 mg/100g (IGTAM-9) to 19.10 mg/100g (IGTAM-15) and the maximum was recorded in IGTAM-15 (19.10 mg/100g), while minimum was recorded in IGTAM-9 (5.45 mg/100g). The maximum iron content of pulp was recorded in IGTAM-15 (9.93 mg/100g) and minimum iron content of pulp in IGTAM-5 (1.58 mg/100g). The difference in minerals (Mg, Cu and Fe) content of pulp may be due to genetic nature of the genotypes. The results are also in close agreement with the findings of Ishola *et al.* (1990), who reported that tamarind pulp contain magnesium (72.00 mg/100g), copper (21.8 mg/100g) and iron (1.30-10.90 mg/100g). Similar results on Mg, Cu and Fe content of tamarind pulp have been reported by Bhattacharya *et al.* (1994) and Parvez *et al.* (2003).

5.3.2 Calcium and Phosphorus (pulp)

In the present investigation, variations were also observed in calcium (Ca) and phosphorus (P) content of pulp among the different tamarind genotypes studied (Table 4.10).

The maximum calcium content of pulp was recorded in IGTAM-15 (423.67 mg/100g) and minimum in IGTAM-13 (95.14 mg/100g). The phosphorus content of pulp ranged between 87.60 mg/100g (IGTAM-5) to 155.78 mg/100g (IGTAM-15).

The difference in mineral (Ca and P) content of tamarind pulp was possibly due to genetic difference among the genotypes studied in this

investigation. These results are in close conformity with the findings of Ishola *et al.* (1990) and Bhattacharya *et al.* (1994), who reported that tamarind pulp contain 81.00 to 466.00 mg/100 g calcium and 86.00 to 190.0 mg/100 g phosphorus.

5.3.3 Potassium and sodium (pulp)

The data presented in Table 4.11 indicates significant variation among the genotypes included in this study in respect of potassium (K) and sodium (Na) content of tamarind pulp.

The maximum potassium content of pulp was recorded in IGTAM-15 (491.09 mg/100g) and minimum potassium content in IGTAM-13 (70.30 mg/100g) while the sodium content of pulp varied between 3.00 mg/100g (IGTAM-11) to 55.70 mg/100g (IGTAM-15).

The difference in mineral (K and Na) content of tamarind pulp might be due to genetic nature of the genotypes. These results are supported by the findings of Ishola *et al.* (1990), who reported that tamarind pulp contain potassium 62.0 to 570 mg/100g and sodium 3.0 to 76.7 mg/100g. Similar results on K and Na was also reported by Bhattacharya *et al.* (1994) and Parvez *et al.* (2003).

5.3.4 Zinc and manganese (pulp)

The zinc (Zn) content of pulp was recorded maximum in IGTAM-9 (0.52 mg/100g) and minimum zinc content in IGTAM-8 (0.40 mg/100g).

In present investigation it was observed that zinc content of pulp among different genotypes of tamarind studied was found nil in 14 genotypes out of 16 genotype studied and only two genotypes had

recorded zinc content of pulp. The observation regarding zinc (Zn) content of tamarind pulp was 1.10 (mg/100g) by Ishola *et al.* (1990), 0.8 to 0.9 mg/100g by Parvez *et al.* (2003) and these results are in line with the present findings.

As regards manganese (Mn) content of pulp, it was observed that manganese content of pulp was found nil in all the genotypes included in this study. Similar results were also reported by Ishola *et al.* (1990) and Bhattacharya *et al.* (1994).

5.4 Minerals of seed

5.4.1 Magnesium, copper and iron (seed)

In present investigation, variations were also observed in magnesium (Mg), Copper (Cu) and iron (Fe) content of seed among the different tamarind genotypes studied (Table 4.12).

The maximum magnesium content of seed was recorded in IGTAM-15 (39.25 mg/100g) and minimum magnesium content of seed in IGTAM-6 (14.58 mg/100g). The copper (Cu) content of seed varied between 1.79 mg/100 g (IGTAM-4) to 16.14 mg/100g (IGTAM-15). The maximum iron content of seed was recorded in IGTAM-15 (6.14 mg/100g) and minimum iron content of seed was recorded in IGTAM-5 (1.64 mg/100g).

The difference in mineral (Mg, Cu and Fe) content of seeds may be due to genetic nature of the genotypes. The results are also in close agreement with the findings of Ishola *et al.* (1990), who reported that tamarind seed contain magnesium (17.50–118.30 mg/100g), copper

(1.60-19.00 mg/100g) and iron (6.50 mg/100g). Similar results on Mg, Cu and Fe content of tamarind seed was also reported by Bhattacharya *et al.* (1994).

5.4.2 Calcium and phosphorus(seed)

In the present investigation, variations were also observed in calcium (Ca) and phosphorus (P) content of seed among the different tamarind genotypes studied (Table 4.13).

The maximum calcium content of seed was recorded in IGTAM-15 (557.53 mg/100g) and minimum calcium content of seed in IGTAM-7 (45.03 mg/100g). While the phosphorus content of seed ranged between 70.42 mg/100g (IGTAM-5) and 142.74 mg/100g (IGTAM-15).

The difference in mineral (Ca and P) content of tamarind pulp was possibly due to genetic difference among the genotypes studied in this investigation. These results are in close conformity with the finding of Ishola *et al.* (1990) and Bhattacharya *et al.* (1994), who reported that tamarind seed contain 9.30 to 786.00 mg/100g calcium and 68.40 to 165.00 mg/100g phosphorus.

5.4.3 Potassium and sodium (seeds)

The data presented in Table 4.14 indicates significant variation among the genotypes included in this study in respect of potassium (K) and sodium (Na) content of tamarind seed.

The maximum potassium content of seed was recorded in IGTAM-15 (523.83 mg/100g) and minimum potassium content of seed in IGTAM-

10 (263.25 mg/100g), whereas the sodium content of seed varied between 15.15 mg/100g (IGTAM-7) to 27.62 mg/100g (IGTAM-15).

The difference in mineral (K and Na) content of seed might be due to genetic nature of the genotypes. These results are supported by the findings of Ishola *et al.* (1990), who reported that tamarind seed contain potassium 272.80 to 610.00 mg/100g and sodium 19.20-28.80 mg/100g. Similar result on K and Na was also reported by Bhattacharya *et al.* (1994).

5.4.4 Zinc and Manganese (seed)

The zinc (Zn) content of seed was recorded maximum in IGTAM-15 (1.82 mg/100g) and minimum zinc content of seed was recorded in IGTAM-8 (0.38 mg/100g).

In the present investigation, it was observed that zinc content of seed among different genotypes of tamarind studied was found nil in 16 genotypes out of 16 genotypes studied and only four genotypes had recorded zinc content of seed. The observation regarding zinc (Zn) content of tamarind seed was 2.80 (mg/100g) as reported by Ishola *et al.* (1990) and these results are in line with the present findings.

As regards manganese (Mn) content of seed in the present investigation, it was observed that manganese content of seed found nil in all the genotypes included in this study. Similar results were also reported by Ishola *et al.* (1990) and Bhattacharya *et al.* (1994).

5.5 Correlation studies

The data on degree of correlation among the different physico-chemical characters are given in Table 4.15.

Fruit length was positively and significantly associated with fruit weight, seed weight, vein weight, shell weight, number of seed per fruit, TSS, reducing sugar, total sugar and protein. Further, fruit weight was positively and significantly associated with fruit length, pulp, seed weight, vein weight, shell weight, number of seeds and protein. Seed weight was positively and significantly associated with fruit length, fruit weight, pulp weight, vein weight, shell weight, number of seeds, TSS, reducing sugar and total sugar.

Vein weight was positively and significantly associated with fruit length, fruit weight, pulp, seed, shell weight, number of seeds, TSS, reducing sugar and protein. Shell weight was positively and significantly associated with fruit length, fruit weight, seed weight, vein weight and number of seeds.

Number of seeds was positively and significantly associated with fruit length, fruit weight, pulp weight, seed weight, vein weight, shell weight and pH. The acidity was negatively and significantly associated with TSS and pH.

The TSS (total soluble solids) was positively and significantly associated with fruit length, fruit weight, seed weight, vein weight, reducing sugar and total sugar. The pH was negatively and significantly associated with the acidity.

Reducing sugar was positively and significantly associated with fruit length, vein weight, TSS and total sugar. Non-reducing sugar was positively and significantly associated with total sugar. Further, total sugar was positively and significantly associated with fruit length, seed weight, TSS, reducing sugar and non-reducing sugar. Ascorbic acid was positively and significantly associated with fruit thickness. The protein was positively and significantly associated with fruit length, fruit weight, pulp weight and vein weight.

Similar attempts have been made to assess the correlations among different fruit parameters. Challapilli *et al.* (1995) evaluated fruit from 24 established tamarind trees which were compared for eight characters and found that fruit weight was positively and significantly associated with pulp, fibre and seed weights and fruit length and breadth.

Correlation analysis of several fruit parameters indicated that breeding for high pulp weight should focus on selection of high fruit weight and low seed, seed and shell weight (Karale *et al.*, 1999).

Birdar and Hanamashetti (2001) evaluated the correlation among different pod characters (pod length, pod width, pod thickness, pod weight, pulp weight, shell weight, vein weight, number of seeds and seed weight) of 17 tamarind genotypes. The significant and positive correlations were observed among the various pod characteristics studied.

*Summary, Conclusion and
Suggestions for Future Work*

(3.78 g). The difference in seed weight may be attributed to the difference in the number and size of seeds among the genotypes studied. Similar divergence in seed weight was recorded in tamarind by David (1907), Shivanandam (1980), Challapilli (1992), Hanamashetti and Sulikeri (1997), Azhakiamaavalan and Vadivel (1997), Mastan *et al.* (1997), Singh *et al.* (1997) and Prabhushankar *et al.* (2004).

5.1.3 Vein weight, shell weight and number of seeds

The results presented in Table 4.3 regarding vein (fibre) weight, shell weight and number of seeds indicated significant variation among the genotypes included in this study.

The vein weight per fruit varied from 0.47 g (IGTAM-5) to 2.36 g (IGTAM-14). The difference in the fibre weight among the selected tamarind genotypes may be due to difference in the rate of development of vascular tissues in fruit (Challapilli, 1992). These results are in close conformity with the findings of Mastan *et al.* (1997), who recorded wide range of variation in fibre (vein) weight ranging from 0.37 g to 4.30 g for 52 different seedling populations of tamarind in Chitoor and Anantpur district of Andhra Pradesh.

The weight of shell per fruit showed significant variation among the different genotypes considered for the present study. Maximum weight of the shell per fruit (8.99 g) was recorded in IGTAM-10, while minimum shell weight per fruit (3.47 g) was recorded in IGTAM-5. The difference in shell weight could be clearly attributed to the differences in size of the

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SUMMARY, CONCLUSION AND SUGGESTIONS

FOR FUTURE WORK

Summary

The present investigation entitled “Studies on physico-chemical evaluation of Tamarind (*Tamarindus indica* L.) genotypes prevailing in Bastar region of Chhattisgarh” was carried out for two consecutive years during 2004-05 and 2005-06 in the laboratory of Department of Horticulture and Soil Science, College of Agriculture and Dairy Chemistry laboratory (Dept. of Dairy Chemistry, College of Dairy Technology) of the Indira Gandhi Agricultural University, Raipur (C.G.). The experimental material consisted the ripe fruits of 16 selected tamarind genotypes *i.e.* IGTAM-1 to IGTAM-16 collected from different locations of Tokapal and Jagdalpur block of Bastar district (C.G.). These genotypes were evaluated with a view to assess better quality fruits, physical and chemical composition of fruits as well as nutrient status of fruit and seeds, for the further improvement of the crop. The experiment was undertaken in Randomized Block Design with three replications.

The salient findings of the present investigation are summarized below.

Physical characters

(a) Fruit length

Fruit length varied from 10.46 cm (IGTAM-5) to 22.15 cm (IGTAM-16). Maximum fruit length was recorded in IGTAM-16 (22.15 cm) followed by IGTAM-14 (21.39 cm), IGTAM-15 (20.48 cm) and minimum fruit length was recorded in IGTAM-5 (10.46 cm).

(b) Fruit width

Fruit width ranged between 3.06 cm (IGTAM-3) to 4.40 cm (IGTAM-10). Highest fruit width was observed in IGTAM-10 (4.40 cm) followed by IGTAM-12 (3.90 cm), IGTAM-5 (3.48 cm) and lowest was observed in IGTAM-3 (3.06 cm).

(c) Fruit thickness

Fruit thickness ranged between 1.24 cm (IGTAM-7) to 2.17 cm (IGTAM-11). Maximum fruit thickness was noticed in IGTAM-11 (2.17 cm) followed by IGTAM-4 (2.06 cm), and IGTAM-15 (2.05 cm), while minimum fruit thickness was observed in IGTAM-7 (1.24 cm).

(d) Fruit weight

Fruit weight varied from 14.11 g (IGTAM-5) to 36.89 g (IGTAM-14). Highest fruit weight was recorded in IGTAM-14 (36.89 g) followed by IGTAM-10 (35.16 g), IGTAM-16 (31.87 g) and lowest fruit weight was recorded in IGTAM-5 (14.11 g).

(e) Pulp weight

The pulp weight ranged from 6.40 g (IGTAM-5) to 17.73 g (IGTAM-14). Maximum pulp weight was recorded in IGTAM-14 (17.73 g),

followed by IGTAM-10 (17.18 g), IGTAM-13 (16.37 g) and minimum pulp weight was recorded in IGTAM-5 (6.40 g).

(f) Seed weight

The seed weight ranged between 3.78 g (IGTAM-5) to 9.74 g (IGTAM-16). Highest seed weight was observed in IGTAM-16 (9.74 g), followed by IGTAM-15 (9.28 g), IGTAM-15 (8.33 g) and lowest seed weight was observed in IGTAM-5 (3.78 g).

(g) Vein weight

The vein weight varied from 0.47 g (IGTAM-5) to 2.36 g (IGTAM-14). Maximum vein weight was noticed in IGTAM-14 (2.36 g), followed by IGTAM-16 (1.72 g), IGTAM-10 (1.61 g) and minimum vein weight was noticed in IGTAM-5 (0.47 g).

(h) Shell weight

The range of variation for shell weight was between 3.47 g (IGTAM-5) to 8.99 g (IGTAM-10). Higher shell weight was recorded in IGTAM-10 (8.99 g) followed by IGTAM-14 (7.54 g), IGTAM-16 (7.36 g) and lower shell weight was recorded in IGTAM-5 (3.47 g).

(i) Number of seeds

The number of seeds per fruit varied from 4.14 (IGTAM-5) to 10.09 (IGTAM-16). Maximum number of seeds per fruit was noticed in IGTAM-16 (10.09) followed by IGTAM-11 (9.81), IGTAM-14 (8.91) and minimum number of seeds per fruit was noticed in IGTAM-5.

(j) Pulp per cent

Pulp per cent of fruit ranged from 40.18 (IGTAM-7) to 53.98 per cent (IGTAM-1). Higher pulp per cent was recorded in IGTAM-1 (53.98%) followed by IGTAM-13 (52.38%), IGTAM-2 (50.68%) and lower pulp per cent was recorded in IGTAM-7 (40.18%).

(k) Shell per cent

Shell per cent per fruit ranged between 17.93 (IGTAM-15) to 25.58 per cent (IGTAM-10). Maximum shell per cent was observed in IGTAM-10 (25.58%) followed by IGTAM-7 (25.19%), IGTAM-5 (25.13%) and minimum shell per cent was observed in IGTAM-15 (17.93%).

(l) Seed per cent

The range of variation for seed per cent per fruit was from 20.93 (IGTAM-1) to 30.62 per cent (IGTAM-16). Higher seed per cent was noticed in IGTAM-16 (30.62%) followed by IGTAM-3 (29.92%), IGTAM-6 (29.89%) and lower seed per cent was noticed in IGTAM-1 (20.93%).

(m) Vein per cent

Vein per cent per fruit varied from 3.20 (IGTAM-3) to 6.39 per cent (IGTAM-14). Maximum vein per cent was recorded in IGTAM-14 (6.39%) followed by IGTAM-11 (6.13%), IGTAM-6 (5.76%) and minimum vein per cent was recorded in IGTAM-3 (3.20%).

Chemical characters

(a) Acidity

The acidity per cent per fruit ranged between 7.95 per cent (IGTAM-4) to 19.63 per cent (IGTAM-6). Higher acidity per cent was

observed in IGTAM-6 (19.63%) followed by IGTAM-9 (13.60%), IGTAM-12 (13.50%) and lower acidity per cent was observed in IGTAM-4 (7.95%).

(b) Total soluble solids (TSS)

The TSS of pulp ranged between 12.06°B (IGTAM-12) to 19.66°B (IGTAM-15). Maximum TSS of pulp was noticed in IGTAM-15 (19.66°B) followed by IGTAM-16 (18.83°B), IGTAM-14 (18.21°B) and minimum TSS of pulp was noticed in IGTAM-12 (12.06°B).

(c) pH of fruit pulp

The pH of fruit pulp varied from 2.58 (IGTAM-6) to 3.47 (IGTAM-3). Higher pH was observed in IGTAM-3 (3.47), followed by IGTAM-4 (3.47), IGTAM-15 (3.46) and lower pH was observed in IGTAM-6 (2.58).

(d) Reducing sugar

The reducing sugar per cent of pulp ranged from 25.08 (IGTAM-13) to 38.09 per cent (IGTAM-15). Maximum reducing sugar per cent was recorded in IGTAM-15 (38.09%) followed by IGTAM-16 (37.23%), IGTAM-14 (36.58%) and minimum reducing sugar per cent was recorded in IGTAM-13 (25.08%).

(e) Non-reducing sugar

The non-reducing sugar per cent of pulp ranged between 7.85 (IGTAM-6) to 15.00 per cent (IGTAM-1). Higher non-reducing sugar per cent was noticed in IGTAM-1 (15.00%) followed by IGTAM-15 (13.82%), IGTAM-11 (13.78%) and minimum non-reducing sugar per cent was noticed in IGTAM-6 (7.85%).

(f) Total sugar

The total sugar per cent of pulp varied between 33.34 (IGTAM-13) to 51.88 per cent (IGTAM-15). Higher total sugar per cent was observed in IGTAM-15 (51.88%) followed by IGTAM-16 (48.42%), IGTAM-14 (47.22%) and lower total sugar per cent was observed in IGTAM-13 (33.34%).

(g) Ascorbic acid

The ascorbic acid content of pulp ranged from 1.81 (IGTAM-8) to 4.05 per cent (IGTAM-11). Maximum ascorbic acid content was noticed in IGTAM-11 (4.05%) followed by IGTAM-4 (3.24%), IGTAM-9 (2.91%) and minimum ascorbic acid content was noticed in IGTAM-8 (1.81%).

(h) Protein

The protein content of pulp ranged between 2.04 (IGTAM-8) to 6.71 per cent (IGTAM-15). Higher protein content was recorded in IGTAM-15 (6.71%) followed by IGTAM-16 (5.72%), IGTAM-14 (5.44%) and lower protein content was recorded in IGTAM-8 (2.04%).

(i) Crude fibre

The crude fibre content of pulp was varied from 3.23 (IGTAM-13) to 10.39 per cent (IGTAM-1). Maximum crude fibre content was recorded in IGTAM-1 (10.39%) followed by IGTAM-2 (9.30%) and IGTAM-8 (8.38%), whereas minimum crude fibre content was recorded in IGTAM-13 (3.23%).

Mineral content of pulp

(a) Magnesium (pulp)

The magnesium (Mg) content of pulp ranged from 18.03 mg/100g (IGTAM-6) to 30.63 mg/100g (IGTAM-15). Higher Mg content of pulp was observed in IGTAM-15 (30.63 mg/100g) followed by IGTAM-16 (28.41 mg/100g), IGTAM-9 (27.23 mg/100g) and lower Mg content of pulp was observed in IGTAM-6 (18.03 mg/100g).

(b) Copper (pulp)

The copper (Cu) content of pulp varied from 5.45 mg/100g (IGTAM-9) to 19.10 mg/100g (IGTAM-15). Maximum copper content of pulp was noticed in IGTAM-15 (19.10 mg/100g) followed by IGTAM-16 (17.10 mg/100g), IGTAM-1 (15.47 mg/100g) and minimum copper content of pulp was noticed in IGTAM-9 (5.45 mg/100g).

(c) Iron (pulp)

The iron (Fe) content of pulp ranged between 1.58 mg/100g (IGTAM-5) to 9.93 mg/100g (IGTAM-15). Higher Fe content of pulp recorded in IGTAM-15 (9.93 mg/100g), followed by IGTAM-16 (7.81 mg/100g), IGTAM-11 (6.50 mg/100g) and lower Fe content of pulp was recorded in IGTAM-5 (1.58 mg/100g).

(d) Calcium (pulp)

The calcium (Ca) content of pulp varied from 95.14 mg/100g (IGTAM-13) to 423.67 mg/100g (IGTAM-15). Maximum Ca content of pulp was observed in IGTAM-15 (423.67 mg/100g) followed by IGTAM-

16 (341.70 mg/100g), IGTAM-8 (340.82 mg/100g) and minimum Ca content of pulp was observed in IGTAM-13 (94.14 mg/100g)

(e) Phosphorus (pulp)

The phosphorus (P) content of pulp ranged between 87.60 mg/100g (IGTAM-5) to 155.78 mg/100g (IGTAM-15). Higher P content of pulp was noticed in IGTAM-15 (155.78 mg/100g) followed by IGTAM-9 (145.80 mg/100g), IGTAM-16 (140.43 mg/100g) and lower P content of pulp was noticed in IGTAM-5 (87.60 mg/100g).

(f) Potassium (pulp)

The potassium (K) content of pulp varied from 70.30 mg/100g (IGTAM-13) to 491.73 mg/100g (IGTAM-15). Maximum K content of pulp was observed in IGTAM-15 (491.73 mg/100g) followed by IGTAM-16 (411.04 mg/100g), IGTAM-8 (380.75 mg/100g) and minimum K content of pulp was observed in IGTAM-13 (70.30 mg/100g).

(g) Sodium (Pulp)

The sodium (Na) content of pulp ranged between 3.00 mg/100g (IGTAM-11) to 55.70 mg/100g (IGTAM-15). Higher Na content of pulp was recorded in IGTAM-15 (55.70 mg/100g) followed by IGTAM-8 (50.77 mg/100g), IGTAM-16 (45.87 mg/100g) and lower Na content of pulp was recorded in IGTAM-11 (3.00 mg/100g).

(h) Zinc (pulp)

The Zinc (Zn) content of pulp was recorded nil in all the genotypes studied in this investigation except IGTAM-9 (0.52 mg/100g) and IGTAM-8 (0.40 mg/100g).

(i) Manganese (pulp)

The manganese (Mn) content of pulp was recorded nil in all the genotypes studied in this investigation.

Minerals of seed

(a) Magnesium (seed)

The magnesium (Mg) content of seed ranged between 14.58 mg/100g (IGTAM-6) to 39.25 mg/100g (IGTAM-15). Higher Mg content of seed was noticed in IGTAM-15 (39.25 mg/100g) followed by IGTAM-16 (36.16 mg/100g), IGTAM-9 (24.54 mg/100g) and minimum was noticed in IGTAM-6 (14.58 mg/100 g).

(b) Copper (seed)

The copper (Cu) content of seed varied from 1.79 mg/100g (IGTAM-4) to 16.14 mg/100g (IGTAM-15). Maximum Cu content of seed was observed in IGTAM-15 (16.14 mg/100g) followed by IGTAM-16 (14.29 mg/100g), IGTAM-14 (11.32 mg/100g) and minimum content was observed in IGTAM-4 (1.79 mg/100g).

(c) Iron (seed)

The iron (Fe) content of seed ranged between 1.64 mg/100g (IGTAM-5) to 6.13 mg/100g (IGTAM-15). Higher Fe content of seed was recorded in IGTAM-15 (6.13 mg/100 g) followed by IGTAM-16 (5.58 mg/100g), IGTAM-11 (4.30 mg/100g) and minimum was recorded in IGTAM-5 (1.64 mg/100g).

(d) Calcium (seed)

The calcium (Ca) content of seed ranged from 45.03 mg/100g (IGTAM-7) to 557.53 mg/100g (IGTAM-15). Maximum Ca content of seed was noticed in IGTAM-15 (557.53 mg/100g) followed by IGTAM-8 (512.17 mg/100g), IGTAM-9 (426.40 mg/100g) and minimum content was noticed in IGTAM-7 (45.03 mg/100g).

(e) Phosphorus (seed)

The phosphorus (P) content of seed varied from 70.42 mg/100g (IGTAM-5) to 142.74 mg/100g (IGTAM-15). Higher P content of seed was recorded in IGTAM-15 (142.74 mg/100g) followed by IGTAM-9 (131.24 mg/100g), IGTAM-16 (126.65 mg/100g) and minimum status was recorded in IGTAM-5 (70.42 mg/100g).

(f) Potassium (seed)

The potassium (K) content of seed ranged between 263.25 mg/100g (IGTAM-10) to 523.83 mg/100g (IGTAM-15). Higher K content of seed was observed in IGTAM-15 (523.83 mg/100g) followed by IGTAM-16 (504.92 mg/100g), IGTAM-9 (413.24 mg/100g) and minimum level was observed in IGTAM-10 (263.25 mg/100g).

(g) Sodium (seed)

The sodium (Na) content of seed varied from 15.15 mg/100g (IGTAM-7) to 27.62 mg/100g (IGTAM-15). Maximum Na content of seed was noticed in IGTAM-15 (27.62 mg/100g) followed by IGTAM-8 (25.34 mg/100g), IGTAM-16 (25.31 mg/100g) and minimum was recorded in IGTAM-7 (15.15 mg/100g).

(h) Zinc (Seed)

The zinc content of seed was recorded nil in all the genotypes except IGTAM-15 (1.82 mg/100g), IGTAM-8 (0.58 mg/100g), IGTAM-9 (0.55 mg/100g) and IGTAM-16 (0.41 mg/100g). Maximum Zn content of seed was recorded in IGTAM-15 (1.82 mg/100g) while minimum content was recorded in IGTAM-16 (0.41 mg/100g).

(i) Manganese (seed)

It was interesting to note that the manganese content of seed was recorded nil in all the genotypes studied in this investigation.

Correlation studies

Fruit length was positively and significantly associated with fruit weight, seed weight, vein weight, shell weight number of seeds per fruit, total soluble solids, reducing sugar, total sugar and protein content of pulp.

Conclusion

It can be concluded from the result of present investigation that huge variation was noticed among the 16 genotypes studied in this investigation for all the physical and chemical parameters as well as mineral content of pulp and seed.

The genotype IGTAM-14 was found superior to all the genotypes included in this study with respect to fruit weight and pulp weight, whereas, highest pulp per cent, non-reducing sugar and crude fibre was observed in IGTAM-1. Maximum acidity was noticed in IGTAM-6, which is important characters of tamarind fruit, while maximum ascorbic acid and

fruit thickness was recorded in IGTAM-11. Maximum fruit width was noticed in IGTAM-10. The highest pH was recorded in IGTAM-3. However, minimum shell per cent was noticed in IGTAM-15, while minimum shell weight, vein weight, seed weight and number of seeds were recorded in IGTAM-5.

Though, a special advantage was driven by the genotype IGTAM-15 with the highest TSS, reducing sugar, total sugar, protein and was noticed remarkably superior than all the genotypes studied in this investigation because of higher mineral content found in the pulp as well as in seed *i.e.*, Mg, Cu, Fe, Ca, P, K, Na (pulp and seed) and Zn (seed).

The physical parameter of the present study show that the genotype IGTAM-16 had longer fruit, higher seed weight and seed per cent than the other genotypes studied.

Among these 16 genotypes, the following three genotypes are very important *i.e.*, IGTAM-14, IGTAM-15 and IGTAM-16 with reference to higher fruit length, fruit weight, pulp weight, TSS, total sugar, protein and higher mineral content of pulp as well as in seed. These genotypes may be considered for commercial cultivation and need to be multiplication and distribution to the formers after varietal release.

The following genotypes were found superior and can be selected for various desirable traits:

Desirable traits	Superior genotypes
Higher pulp (%)	IGTAM-1 & IGTAM-13
Sugar (%)	IGTAM-15, IGTAM-16 & IGTAM-14

Acidity (%)	IGTAM-6, IGTAM-9, & IGTAM-12
Minerals (mg/100g)	IGTAM-15, IGTAM-16 & IGTAM-14
Higher pulp wt. per fruit	IGTAM-14, IGTAM-10, IGTAM-13, IGTAM-1 & IGTAM-15

Suggestions for future research work

On the basis of the result obtained after completion of present investigation, following suggestions are being made for future line of work:

1. Some of the desirable characters can be combined through breeding
2. While selecting genotypes, more emphasis needs to be given to tolerance to pests and diseases. Attractive colour also requires to be considered while selecting genotypes of tamarind
3. The recovery of higher amount of pulp and regular bearing with higher acidity may be the ideal character of a promising genotype while selecting genotypes.
4. Research work should be done on value addition work on fruits of ideal genotype of tamarind.
5. Studies on biochemical changes, insect-pests and their control during storage period is necessary.
6. The present study on these genotypes was conducted first time hence further investigations are necessary on these genotypes.

Abstract

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**STUDIES ON PHYSICO-CHEMICAL EVALUATION OF
TAMARIND (*Tamarindus indica* L.) GENOTYPES PREVAILING
IN BASTAR REGION OF CHHATTISGARH**

BY
AMIT KUMAR SHUKLA

ABSTRACT

The present investigation entitled "Studies on physico-chemical evaluation of tamarind (*Tamarindus indica* L.) genotypes prevailing in Bastar region of Chhattisgarh" was carried out in the laboratory, Department of Horticulture, College of Agriculture, IGAU, Raipur (C.G.) during the year 2004-05 and 2005-06. The study was carried out with 16 treatments (genotypes) consist of ripe fruits collected from selected trees of tamarind exist in Tokapal and Jagdalpur block of Bastar district (C.G.) under Randomized Block Design with three replications.

Among the genotypes evaluated IGTAM-15 was found superior than all the other genotypes included in the study with respect to TSS, reducing sugar, total sugar, protein and minerals *i.e.*, Mg, Cu, Fe, Ca, P, K and Na content in pulp as well as in seed.

The highest fruit weight and pulp weight both were recorded by IGTAM-14 which was found remarkably superior than all the other genotypes included in this study. Whereas, the highest pulp per cent, non-reducing sugar and crude fibre was observed in IGTAM-1. The longest fruit as well as the highest seed weight, seed per cent & number of seeds in the fruit were recorded in IGTAM-16.

The highest acidity (tartaric acid) was noticed in IGTAM-6, while the highest percentage of ascorbic acid content and the highest fruit thickness both were recorded in IGTAM-11. On the basis of findings of the present study, it is concluded that the tamarind genotypes *i.e.*, IGTAM-15, IGTAM-14, IGTAM-16, IGTAM-1 and IGTAM-6, which were found best for higher pulp, sugar, minerals and acidity content in the fruit as well as for individual fruit weight among all the genotypes studied in this investigation. Hence, these genotypes can be considered for further improvement of tamarind crop.

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* - Original not seen

Appendices

**Appendix I : Weekly meteorological data during April 2004 to March, 2005
recorded at SGCARS, Jagdalpur (C.G.)**

Week No.	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		Wind velocity (km/hr)	Eva- poration (mm/day)	Sun- shine (hr/day)
	Max.	Min.		I	II			
13	35.3	22.0	6.4	90	22	6.0	7.0	7.0
14	34.2	22.8	13.2	92	34	7.3	5.3	7.1
15	37.1	23.9	0.0	82	33	8.5	9.1	9.5
16	38.3	24.0	0.0	79	27	9.3	10.1	9.3
17	34.6	21.1	12.1	80	46	8.4	8.1	6.5
18	34.7	21.2	23.7	78	40	5.3	7.2	7.1
19	35.3	24.3	0.0	74	44	5.8	6.3	7.8
20	34.2	23.7	35.5	79	69	7.1	5.9	4.7
21	37.7	23.1	1.0	54	45	7.7	9.5	8.2
22	34.1	22.0	65.9	75	53	6.4	7.3	8.0
23	31.0	22.5	20.7	88	69	5.9	4.1	5.6
24	27.0	22.6	249.8	89	77	10.2	2.3	2.6
25	30.8	21.8	2.8	78	55	9.8	5.1	5.5
26	30.8	22.4	59.2	82	59	5.9	4.2	4.2
27	29.5	22.7	139.9	89	68	6.3	1.9	3.6
28	26.8	21.8	91.0	91	76	6.4	1.6	2.3
29	28.8	22.3	62.8	93	69	7.7	3.1	2.6
30	25.4	22.2	54.2	91	74	6.2	1.1	1.1
31	24.6	21.7	71.9	96	88	8.6	1.5	0.6
32	24.9	21.8	85.1	92	83	10.6	1.5	0.2
33	25.7	21.6	70.0	94	70	9.7	1.4	2.0
34	24.8	21.6	113.3	95	83	7.2	1.5	0.1
35	30.2	22.0	0.0	90	65	4.8	2.9	7.9
36	27.9	22.1	85.0	93	61	3.6	2.3	4.4
37	29.8	21.8	59.2	92	69	4.4	2.0	4.8
38	30.5	22.4	23.2	93	68	4.0	3.0	7.8
39	30.0	21.3	90.8	93	68	3.0	2.9	6.9
40	28.5	21.6	137.8	94	77	5.2	2.6	4.5
41	30.1	20.6	4.0	93	64	2.4	3.1	7.7
42	29.2	16.0	0.0	94	63	2.3	3.4	8.6
43	29.1	18.1	9.6	93	59	2.9	3.3	8.4
44	28.9	15.1	0.0	92	56	3.5	3.3	5.0
45	26.5	15.3	5.8	91	55	4.0	2.6	5.2
46	37.5	15.0	1.8	95	50	2.2	3.1	8.1
47	27.3	8.7	0.0	92	32	3.6	3.4	8.7
48	25.7	8.2	0.0	92	29	3.2	3.4	9.2
49	26.3	7.0	0.0	94	31	2.7	3.0	9.1
50	26.5	8.3	0.0	94	27	2.1	2.8	8.7
51	27.7	8.0	0.0	95	26	2.2	2.5	8.9
52	23.4	7.6	0.0	83	24	1.8	2.7	6.5
1	27.9	10.2	0.0	94	36	2.4	3.1	7.4
2	27.4	9.5	0.0	94	27	3.4	3.6	8.4
3	27.0	7.9	0.0	95	31	2.7	3.2	7.8
4	26.8	13.5	15.6	95	40	3.8	2.9	5.4
5	24.8	12.7	23.4	97	50	4.5	2.5	6.8
6	34.7	18.7	0.0	84	32	4.0	6.2	7.8
7	34.2	18.6	1.2	78	37	6.4	7.0	8.2
8	36.1	19.4	0.5	79	23	4.6	7.0	7.9
9	36.7	21.0	0.7	77	21	4.8	7.7	7.9
10	34.8	19.7	5.8	80	23	5.0	5.4	4.2
11	35.4	20.0	0.4	73	18	5.1	4.9	7.0
12	34.7	17.5	31.2	77	23	6.7	7.7	7.7

**Appendix II : Weekly meteorological data during April 2005 to March, 2006
recorded at SGCARS, Jagdalpur (C.G.)**

Week No.	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		Wind velocity (km/hr)	Evapo-ration (mm/day)	Sun shine (hr/day)
	Max.	Min.		I	II			
14	36.1	18.8	3.2	84	19	3.9	7.0	8.3
15	36.3	21.6	11.2	74	24	4.9	7.4	6.6
16	34.8	19.4	33.8	81	23	4.9	4.5	5.0
17	35.1	19.3	1.2	69	17	5.8	6.9	7.2
18	34.7	17.4	30.4	82	23	5.8	6.2	7.2
19	37.9	18.9	11.4	81	24	4.1	6.5	8.4
20	40.0	21.9	0.0	68	40	6.8	9.1	9.8
21	37.6	24.7	0.0	74	32	9.2	11.1	7.8
22	35.5	21.4	75.4	77	43	5.6	5.6	8.7
23	36.6	22.1	9.8	65	41	7.7	9.5	7.1
24	38.4	25.1	0.0	62	54	5.5	8.6	4.7
25	33.9	21.6	86.8	79	62	6.4	7.0	4.0
26	25.5	19.8	130.8	94	83	10.7	3.9	0.1
27	27.9	20.2	38.4	92	76	8.7	3.4	2.5
28	28.2	20.2	85.8	97	79	5.8	3.2	2.6
29	30.3	21.2	10.4	84	81	4.5	3.8	4.9
30	25.1	19.7	85.6	95	87	8.5	2.1	0.2
31	25.4	20.0	72.6	92	85	10.9	2.7	1.0
32	27.2	19.8	29.4	91	78	8.6	3.0	2.8
33	27.7	20.2	110.8	91	78	6.1	4.0	2.6
34	27.9	19.8	15.4	91	80	7.0	2.8	4.0
35	30.9	20.5	65.4	93	84	2.9	4.5	6.4
36	30.6	21.0	13.4	94	85	3.5	3.9	6.9
37	26.9	20.1	167.4	93	91	7.3	2.6	2.4
38	26.4	19.5	66.8	94	80	9.8	3.3	3.4
39	29.7	19.4	1.8	93	85	4.3	4.0	6.1
40	30.4	18.6	1.4	90	75	2.8	3.5	6.4
41	29.2	17.5	29.8	92	84	3.9	4.0	7.0
42	28.7	18.7	13.0	92	80	3.3	2.5	4.8
43	27.7	18.6	115.0	95	84	5.1	2.6	4.5
44	27.9	18.6	104.9	96	88	3.7	2.3	4.6
45	26.8	11.6	0.0	77	82	2.8	2.9	8.4
46	27.4	7.1	0.0	88	79	2.6	3.0	9.9
47	27.7	6.7	0.0	91	81	2.6	3.2	9.3
48	27.5	7.9	0.0	90	87	3.1	3.1	7.7
49	27.4	7.9	0.0	85	85	3.0	3.3	9.2
50	26.0	5.0	0.0	92	77	2.4	2.9	9.5
51	27.1	10.0	0.0	96	73	3.5	2.4	5.8
52	25.8	5.8	0.0	93	67	2.0	2.6	9.4
1	27.1	5.2	0.0	92	80	2.9	3.1	9.1
2	27.5	6.2	0.0	93	79	2.8	3.1	9.0
3	31.1	9.9	0.0	94	71	2.4	3.8	9.6
4	28.5	7.1	0.0	93	74	3.5	4.4	9.8
5	30.7	7.1	0.0	96	75	2.6	4.4	9.7
6	30.1	8.0	0.0	96	76	2.5	4.5	9.8
7	32.1	11.8	0.0	96	75	2.9	5.2	9.4
8	34.7	13.3	0.0	96	69	2.8	5.7	9.6
9	34.5	17.0	0.0	96	74	4.4	6.0	8.0
10	32.2	18.4	23.6	93	73	7.6	5.6	8.0
11	29.0	17.4	32.0	95	76	3.9	4.7	8.7
12	33.1	16.4	0.0	89	74	3.3	6.3	9.6
13	35.6	19.7	0.0	87	76	3.9	6.6	7.7