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Study of correlation and index ranging of markingnut (*Semecarpus anacardium* l.) genotypes in Marathwada Region.

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ABSTRACT

The present investigation entitled "Study of Correlation and Index Ranging of Markingnut (Semecarpus anacardium L.) Genotypes in Marathwada Region " was carried out on sixty strains of Markingnut from Nanded, Parbhani and Beed district of Marathwada regions in Maharashtra. The correlation studies among 17 characters exhibited highest significant positive association of hypocarp weight, fruit weight, kernel weight, volume of tree, fruit volume, hypocarp length, hypocarp volume and size of fruit with yield of tree. Wide range of variability was noticed with respect to growth, fruiting parameters and chemical characteristics. The genotypes ND-7, ND-8, ND-16, PBN-5, PBN-1, PBN-6, BD-13, BD-16, and BD-18 could be rated as most promising genotypes on the basis of the yield of different genotypes.

INTRODUCTION

The Marking nut (*Semecarpus anacardium* L.) is important dry land fruit crops which belong to family anacardiaceae. The important relatives of this fruit crop are mango, cashewnut, pistachios and charoli (*Buchaniya lanzan)*. There are about 69 genera and 500 species belong to anacardiaceae and 6 species are reported to be found on large scale in India. Trees are distributed in Indo-Malyasian region and Australia. In India the trees are found in the sub Himalayan tract from eastward extending in the outer hills, Assam Khasi Hills, Central India, Gujarat, Konkan Southern Maharashtra, Kanara and in the deciduous forest of all district in the southern India.

MATERIALS AND METHODS

The present investigation entitled: "Study of Correlation and Index Ranging of Marking nut (*Semecarpus anacardium* L.) Genotypes in Marathwada Region" was carried out to locate superior types of Marking nut by survey and selection of marking nut trees existing naturally in Nanded, Beed and Parbhani district of Marathwada region during the year 2011-12.Markingnut can be grown under dryland without using any input. The tropical and semiarid climate of Marathwada region is best suited for growing of Marking nut. It can be grown on hills, hillocks, on bunds and the waste lands. This tree can be grown as an avenue and shade tree and can be included in social forestry programme. It is mostly grown in wild condition. In this region there is not any orchard of Marking nut. The tree is raised from seedlings.

The Statistical analysis (Correlation studies) of the superior quality Markingnuts genotypes (*Semecarpus anacardium* L.) were carried on following points.

The results were worked with four different approaches

1. Variability consisting of coefficient of variation, standard deviation and 't' values were calculated for percent variability and difference among individual strains.
2. The simple correlation between characters was worked out by the procedure suggested by Snedecor and Chochran (1989). The weight of the fruit per tree was taken as dependent (effect) and other characters as independent variables.
3. On the basis of physical characters of the fruit, which contribute to the dependent variable (yield).
4. On the basis of mean values of characters, 60 strains of marking nut were classified into various groups with specific range of units for the sake of explanation

The range value of different characters of 60 genotypes of marking nut was worked out to study the range indexing. The various growth and fruit characters were analyzed to determine the perspective range determination in marking nut. The Mean, Standard deviation and Coefficient of variation of the above characters was calculated to full fill the need of index ranging.

RESULTS AND DISCUSSION

A. Correlation Among different characters

The value of correlation coefficient among different characters in Nanded, Parbhani and Beed districts of Marathwada region ware compared with yield of tree and given in Table. 1, 2 and 3. Finding analogous to this correlation studies had also reported in charoli accession that highest significant positive association of weight of fruit, volume of fruit, size of fruit, weight of mesocarp, weight of seed, weight of seed coat, weight of kernel and panicles per tree with fruits yield per tree (Munde *et al.* 2002).

1. Volume of tree

The data presented in Tables 1, 2 and 3 revealed that positive and highly significant correlation of volume of tree with yield of tree. Highly negative and significant correlation was observed with size of Fruit, seed to hypocarp ratio and positive and significant correlation with fruit weight, fruit volume, fruit length, hypocarp weight, hypocarp length, hypocarp volume, hypocarp breadth and fruit dry weight. The weak negative and non-significant correlation was found with fruit breadth.

2. Panicle per tree

Panicle per tree showed a positive and highly significant correlation with yield of tree, fruit weight, fruit volume, fruit length, fruit dry weight, hypocarp weight, hypocarp length, hypocarp volume, hypocarp breadth, size of fruit, hypocarp dry weight, and oil content. Highly negative and non-significant correlation was observed with seed to hypocarp ratio and kernel weight. The weak negative and non-significant correlation noted with fruit breadth.

3. Fruit weight

A positive and highly significant correlation was observed between fruit weight with yield of tree, fruit volume, fruit length, fruit dry weight, size of fruit hypocarp weight, hypocarp length, hypocarp volume, and hypocarp breadth. Highly significant and negative correlation recorded with seed to hypocarp ratio and kernel weight. The weak negative and non-significant correlation was observed with fruit breadth.

4. Fruit Volume

Positive and highly significant correlation was observed between fruit volume with yield of tree, fruit length, fruit dry weight, hypocarp volume, hypocarp breadth, size of fruit, hypocarp dry weight, and oil content. Highly negative and significant correlation was observed among seed to hypocarp ratio. The weak negative and non-significant correlation was observed with fruit breadth.

5. Fruit length

According to Table 1, 2, and 3 there were positive and highly significant correlation observed between fruit length with yield per tree, fruit dry weight, hypocarp length, hypocarp volume, hypocarp breadth, size of fruit, hypocarp dry weight and oil content. Fruit length having negative and highly significant correlation was observed in seed to hypocarp ratio. The weak negative non-significant correlation was observed with fruit breadth and kernel weight.

6. Fruit breadth

According to Table 1, 2, and 3 there were positive and highly significant correlation between fruit breadth and oil content. There is negative and highly significant correlation was observed in hypocarp volume. And weak negative non-significant correlation was observed with fruit dry weight, hypocarp weight, hypocarp length, hypocarp volume, hypocarp breadth, size of fruit. And weak non-significant correlations were observed in seed to hypocarp ratio and kernel weight.

7. Fruit dry weight

Positive and highly significant correlation were observed between fruit dry weight and yield per tree, hypocarp weight, hypocarp length, hypocarp volume, hypocarp breadth, size of fruit and oil content. There is negative and highly significant

Table 1. Correlation among different characters in Nanded district.

Characters	Volume of tree	Panicle per branch	Fruit weight	Fruit volume	Fruit length	Fruit breadth	Fruit dry weight	Hypocarp weight	Hypocarp length	Hypocarp volume	Hypocarp breadth	Size of fruit	Seed to hypocarp ratio	Kernel weight	Hypocarp dry weight	Oil content	Yield kg/tree
Volume of tree	1.000	0.970**	0.989**	0.990**	0.971**	-0.282	0.936**	0.949**	0.907**	0.901**	0.932**	-0.580**	-0.760**	0.964**	0.964**	0.871**	0.742**
Panicle per branch		1.000	0.975**	0.960**	0.942**	-0.304	0.885**	0.969**	0.870**	0.848**	0.882**	0.891**	-0.588**	-0.694**	0.929**	0.666**	0.683**
Fruit weight			1.000	0.978**	0.965**	-0.253	0.923**	0.957**	0.884**	0.880**	0.900**	0.910**	-0.537**	-0.749**	0.958**	0.574**	0.707**
Fruit volume				1.000	0.985**	-0.269	0.943**	0.935**	0.933**	0.931**	0.954**	0.954**	-0.574**	0.722*8	0.981**	0.817**	0.794**
Fruit length					1.000	-0.275	0.947**	0.932**	0.944**	0.951**	0.957**	0.970**	-0.577**	-0.725**	0.978**	0.810**	0.829**
Fruit breadth						1.000	-0.186	-0.351	-0.257	-0.173	-0.386	-0.297	0.412	0.281	-0.208	0.844**	-0.311
Fruit dry weight							1.000	0.829**	0.956**	0.970**	0.913**	0.964**	-0.567**	-0.554**	0.927**	0.910**	0.859**
Hypocarp weight								1.000	0.813**	0.793**	0.859**	0.849**	-0.621**	-0.700**	0.916**	0.934**	0.618**
Hypocarp length									1.000	0.985**	0.914**	0.989**	-0.560**	0.690**	0.931**	-0.222	0.922**
Hypocarp volume										1.000	0.922**	0.986**	-0.536**	-0.684**	0.932**	0.941**	0.925**
Hypocarp breadth											1.000	0.956**	-0.553**	-0.653**	0.920**	0.760**	0.873**
Size of fruit												1.000	-0.554**	-0.695**	0.943**	0.967**	0.923**
Seed to hypocarp ratio													1.000	0.522	-0.578**	0.985**	-0.410
Kernel weight														1.000	-0.711**	0.942**	-0.727*
Hypocarp dry weight															1.000	0.979**	0.790**
Oil content																1.000	0.962**
Yield kg/tree																	1.000

**Significnat at 1 %
*Significant at 5 %

Table 2. Correlation among different characters in Parbhani district.

Characters	Volume of tree	Panicle per branch	Fruit weight	Fruit volume	Fruit length	Fruit breadth	Fruit dry weight	Hypocarp weight	Hypocarp length	Hypocarp volume	Hypocarp breadth	Size of fruit	Seed to hypocarp ratio	Kernel weight	Hypocarp dry weight	Oil content	Yield kg/tree
Volume of tree	1.000	0.970**	0.969**	0.943**	0.971**	-0.257	0.976**	0.907**	0.897**	0.855**	0.927**	0.854**	-0.765**	-0.133	0.904**	0.850**	0.812**
Panicle per branch		1.000	0.994**	0.950**	0.953**	-0.311	0.945**	0.883**	0.863**	0.793**	0.898**	0.808**	-0.753**	-0.155	0.896**	0.924**	0.743**
Fruit weight			1.000	0.935**	0.959**	-0.297	0.962**	0.896**	0.901**	0.832**	0.928**	0.850**	-0.756**	-0.131	0.877**	0.846**	0.786**
Fruit volume				1.000	0.918**	-0.352	0.903**	0.842**	0.803**	0.722**	0.807**	0.745**	-0.798**	-0.194	0.900**	0.951**	0.664**
Fruit length					1.000	-0.268	0.973**	0.966**	0.927**	0.906**	0.941**	0.910**	-0.749**	-0.212	0.902**	0.792	0.870**
Fruit breadth						1.000	-0.209	-0.264	-0.275	-0.640**	-0.086	-0.079	0.502	0.260	-0.205	0.829**	0.042
Fruit dry weight							1.000	0.920**	0.944**	0.933**	0.958**	0.936**	-0.758**	-0.077	0.847**	0.717**	0.894**
Hypocarp weight								1.000	0.917**	0.900**	0.894**	0.900**	-0.641**	-0.200	0.901**	0.903**	0.864**
Hypocarp length									1.000	0.936**	0.937**	0.950**	-0.684**	-0.111	0.763**	-0.028	0.901**
Hypocarp volume										1.000	0.943**	0.991**	-0.608**	-0.067	-0.713**	0.928**	0.988**
Hypocarp breadth											1.000	0.943**	-0.666**	-0.083	0.793**	0.888**	0.928**
Size of fruit												1.000	-0.634**	-0.114	0.707**	0.912**	0.981**
Seed to hypocarp ratio													1.000	0.315	-0.581**	0.992**	-0.568**
Kernel weight														1.000	-0.109	0.943**	-0.131
Hypocarp dry weight															1.000	0.980**	0.664**
Oil content																1.000	0.979**
Yield kg/tree																	1.000

**Significnat at 1 %
*Significant at 5 %

Table 3. Correlation among different characters in Beed district.

Characters	Volume of tree	Panicle per branch	Fruit weight	Fruit volume	Fruit length	Fruit breadth	Fruit dry weight	Hypocarp weight	Hypocarp length	Hypocarp volume	Hypocarp breadth	Size of fruit	Seed to hypocarp ratio	Kernel weight	Hypocarp dry weight	Oil content	Yield kg/tree
Volume of tree	1.000	0.965**	0.972**	0.979**	0.920**	-0.271	0.893**	0.926**	0.883**	0.876**	0.866**	0.951**	-0.366	-0.266	0.982**	0.955**	0.842**
Panicle per branch		1.000	0.988**	0.981**	0.964**	-0.391	0.908**	0.938**	0.931**	0.915**	0.903**	0.976**	-0.406	-0.283	0.979**	0.792**	0.906**
Fruit weight			1.000	0.971**	0.951**	-0.337	0.913**	0.960**	0.939**	0.921**	0.920**	0.972**	-0.347	-0.215	0.986**	0.895**	0.909**
Fruit volume				1.000	0.934**	-0.357	0.873**	0.923**	0.885**	0.873**	0.855**	0.954**	-0.397	-0.303	0.977**	0.941**	0.849**
Fruit length					1.000	-0.410	0.959**	0.944**	0.972**	0.967**	0.949**	0.970**	-0.409	-0.299	0.963**	0.946**	0.958**
Fruit breadth						1.000	-0.287	-0.191	-0.321	-0.238	-0.288	-0.301	0.318	0.346	-0.032	0.961**	-0.356
Fruit dry weight							1.000	0.937**	0.971**	0.974**	0.978**	0.940**	-0.395	-0.264	0.931**	0.933**	0.969**
Hypocarp weight								1.000	0.957**	0.965**	0.954**	0.957**	-0.246	-0.109	0.964**	0.898**	0.932**
Hypocarp length									1.000	0.990**	0.988**	0.964**	-0.390	-0.232	0.942**	0.268	0.991**
Hypocarp volume										1.000	0.982**	0.960**	-0.338	-0.187	0.934**	0.884**	0.980**
Hypocarp breadth											1.000	0.942**	-0.371	-0.210	0.923**	0.912**	0.989**
Size of fruit												1.000	-0.418	-0.266	0.980**	0.889**	0.938**
Seed to hypocarp ratio													1.000	0.948**	-0.358	0.883**	-0.387
Kernel weight														1.000	-0.244	0.885**	-0.225
Hypocarp dry weight															1.000	0.953**	0.908**
Oil content																1.000	0.867**
Yield kg/tree																	1.000

**Significnat at 1 %
*Significant at 5 %

correlation observed in seed to hypocarp ratio and kernel weight.

8. Hypocarp weight.

Positive and highly significant correlation were observed between hypocarp weight with yield per tree, hypocarp length, hypocarp volume, hypocarp breadth, size of fruit, hypocarp dry weight. Negative and highly significant correlation was observed in seed to hypocarp ratio. The weak negative non-significant correlation was observed with kernel weight.

9. Hypocarp length

The data presented in Tables 1, 2 and 3 noticed that positive and highly significant correlation were observed with yield per tree, hypocarp volume, hypocarp breadth, size of fruit, and hypocarp dry weight. Negative and highly significant correlation was observed with seed to hypocarp ratio. Weak negative non-significant correlation was observed in oil content and kernel weight.

10. Hypocarp volume

According to Table 1, 2, and 3positive and highly significant correlation was observed between hypocarp volume and yield per tree, hypocarp breadth, size of fruit, hypocarp dry weight and oil content. Negative and significant correlation was observed in seed to hypocarp ratio and kernel weight.

11. Hypocarp breadth

Positive and significant correlation were observed between hypocarp breadth and yield per tree, size of fruit, hypocarp dry weight and oil content. Negative and highly significant correlation was observed in seed to hypocarp ratio.

12. Size of fruit

The high significant strong correlation was observed between size of fruit and yield per tree, hypocarp dry weight and oil content. Negative and highly significant correlation was observed in seed to hypocarp ratio. And weak negative and non-significant correlation was observed in kernel weight.

13. Seed to hypocarp ratio

According to Tables 1, 2 and 3 it was observed that negative significant correlation of seed to hypocarp ratio with yield per tree. Positive and highly significant correlation was observed in oil content. Weak non-significant correlation was observed in kernel weight.

14. Kernel weight

Positive and highly significant correlation was observed between kernel weight and oil content. Negative and highly significant correlation was observed in hypocarp dry weight and yield per tree.

15. Hypocarp dry weight

From the Table 1, 2, and 3it was noticed that there were strongly positive and highly significant correlation between hypocarp dry weights with yield per tree.

16. Oil content

From the Table 1, 2 and 3 it was revealed that, there was highly strong positive and significant correlation between oil content and yield per tree.

CONCLUSIONS

The correlation studies exhibited highest significant positive association of hypocarp weight, fruit weight, kernel weight, volume of tree, fruit volume, hypocarp length, hypocarp volume and size of fruit with yield of tree.

In the study of superior types of markingnut genotypes there were wide range of variability with respect to growth and fruiting parameter and chemical characteristics. The genotypes ND-7, ND-8, ND-16, PBN-5, PBN-1, PBN-6, BD-13, BD-16, and BD-18 could be rated as most promising genotypes on the basis of the yield of different genotypes.

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Flowering and fruiting in Cape gooseberry (*Physalis peruviana* L.) as influenced by organic manures and spacing

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ABSTRACT

A field experiment was conducted to study the performance of flowering and fruiting in Cape gooseberry (Physalis peruviana L.*) as influenced by organic manures and spacing at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow, U.P. India during winter season in 2014-2015. The experiment was laid out in a factorial RBD where treatments consisted of two factors:(A) source of organic manures: farmyard manure (F_1, F_2) and vermicompost (V_1, V_2) each applied at full and half dose and (B) plants planted at two spacings: 80×75cm (S_1) and 60×75cm(S_2). The results revealed that manurial treatments had a significant effect and among those applied in the present study, vermicompost had a superior effect on maximizing plant height (45.68cm), number of branches (9.51), number of buds (31.57) number of flowers (30.86), number of fruits (29.94), fruit yield (152.93 kg/ha) fruit length (26.32mm), fruit width (25.78mm), fruit weight (25.10g), fruit volume (24.47ml), specific gravity (1.04g/ml), TSS (13.24^{0}Brix) and acidity (1.13). Since, the second factor i.e. plant spacing (60 cm x 75 cm and 80 cm x 75 cm) and their interaction did not show any significant effect on the performance of flowering and fruiting in cape gooseberry, the closer spacing (60×75cm) along with application of vermicompost may be suggested for good crop yield of cape goose berry for Lucknow condition.*

Keyword: *Cape gooseberry, Physalis peruviana, Farmyard Manure, vermicompost, spacing*

INTRODUCTION

Cape gooseberry (*Physalis peruviana* L.), belonging to family Solanaceae with 2n = 24, bears nutritionally rich fruits is still considered a backyard fruit although it has been spread widely worldwide. Native to Peru and Chile (Legge, 1974) Asia and Europe (Crawford, 2004) it is a quick growing, short duration, herbaceous, annual, at times a short perennial shrub, considered a minor tropical fruit crop of India, which has potential for use as nutraceutical (Ramadan and Morsel, 2007). However, its cultivation is restricted to a limited area in our country due to low production potential, lack of proper awareness regarding package of practices etc. (Girapu and Kumar, 2006). The fruit is a berry with smooth, waxy, orange-yellow skin (Legge, 1974), enclosed in an inflated, bladder-like calyx or husk and can be eaten fresh when ripe or in a variety of processed forms (Klinac, 2012). It has anti-ulcer activity and is effective in reducing cholesterol levels (Branzati and Manaresi, 1980; Sarangi *et al*., 1989) besides its use in treating diseases such as malaria, asthma, hepatitis, dermatitis and rheumatism.

Successful cultivation of any crop depends primarily on plant spacing and other cultivation practices which ensure proper growth and development of plant resulting in maximum yield and economic use of land. However, there is no report regarding optimum agro-techniques and spacing for the successful cultivation of cape gooseberry, especially under the agro climatic conditions of Central Uttar Pradesh (Dwivedi *et al*., 2015) although plant spacing or plant population per unit area is reported to have a decisive role with regard to optimum growth of plant and fruit yield (Ayala,1992). Composts act as a long term reserve and slow release sources of major nutrients like N, P and K (Sullivan *et al*., 2002). Additionally, they increase the microbial activity, anion and cation exchange capacity, organic matter and carbon-content of soil. Organic fertilizers increase the yield and quality of agricultural crops in ways similar to inorganic fertilizers (Arancon *et al*., 2004a, b; Heeb *et al*., 2005; a, b; Heeb *et al*., 2006; Liu *et al*., 2007 and Tonfack *et al*., 2009). Nutrient management and spacing run simultaneously in optimising proper

agrotechniques for any crop (Girapu and Kumar, 2006), for optimum plant performance. Growing consumer demand for this unique fruit is spurring a need for increased information on standard cultural techniques for Cape gooseberry, more particularly in problem soils. The present work aims to investigate the production potential of Cape gooseberry in saline soils of Central Uttar Pradesh (India) under varying levels of plant spacing and fertility.

MATERIAL AND METHODS

The experiment was conducted at Horticultural Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow during November 2014 to May 2015. The soil type of the experimental plot is reported to be saline having pH 8.2 and low organic carbon (Dwivedi *et al*., 2012). Full dose of FYM was applied @ 20 tonnes per hectare (Chattopdhyay, 1996). Since the dose of vermicompost has not been standardised for application in capegooseberry, it was applied at same dose as FYM i.e. 20 tonnes per hectare. The experiment was laid out in a factorial randomized block design with two factors: manurial application (F) and plant spacing (S) with following treatments T_1- C_0S_1 - Control and 80cm×75cm spacing, T_2- C_0S_2-Control and 60 cm ×75cm spacing, T_3- F_1S_1 - full dose of FYM + 80 cm ×75 cm spacing, T_4- F_1S_2- full dose of FYM + 60 cm ×75 cm spacing, T_5- F_2S_1 - half dose of FYM +80 cm ×75 cm spacing, T_6- F_2S_2 - half dose of FYM + 60 cm ×75 cm spacing, T_7- V_1S_1 - full dose of vermicompost + 80 cm ×75 cm spacing, T_8- V_1S_2 - full dose of vermicompost + 60 cm ×75 cm spacing, T_9- V_2S_1 - Half dose of vermicompost + 80 cm ×75 cm spacing, T_{10}- V_2S_2 -Half dose of vermicompost + 60 cm ×75 cm spacing. Seedlings were transplanted on 15thOctober, 2015 and organic manures were incorporated in the experimental plots before transplanting. The observations on growth, flowering, fruiting and yield were recorded on four and six plants each in the spacing 80 cm ×75cm and 60 cm ×75cm, respectively, selected randomly in each treatment and the average was computed. The average data was subjected to statistical analysis using Fisher's method (Chandel, 2012) and treatment means were compared at 5% level of significance.

RESULTS AND DISCUSSION

The experimental results revealed that both the manures at all doses under study improved the vegetative growth as well as fruit physico-chemical parameters of cape gooseberry significantly over the control. Among the manures applied vermicompost improved the plant performances significantly over control and some doses of FYM (Table 1). Plant height (45.68cm), number of branches (9.51), number of buds (31.57), number of flowers (30.86), number of fruits per plant (29.94), fruit yield (751.49 g/plant), average fruit length (26.32mm), fruit width (25.78mm), fruit weight (25.10g), fruit volume (24.47ml), specific gravity (1.04g/ml), TSS (13.24 ^{0}B) and acidity (1.13 %) were recorded maximum under T_7 (100% vermicompost with 80cm×75cm) (Table 2). The reason for improved vegetative performance of cape gooseberry under discussion, upon application of vermicompost, may be associated with 28% higher humic acid content over conventional compost, a neutral to alkaline pH against an acidic pH of compost and the higher degree of decomposition and mineralization due to enhancement of phosphatase activity which results in increased P and K levels in vermicompost by 20 and 38%, respectively, against the conventional compost resulting even in higher N-content (Padmavathiamma *et al.*, 2008). The available nutrient status of soil was thus, greatly enhanced by the application of vermicompost as an organic source. Vermicompost enhanced P concentration and uptake in soil, increasing the solubilisation of P either by microorganisms activation with excretion of organic acids likes citric, glutamic tartaric, succinic, lactic, oxalic, maleic and fumaric (Rao, 1982). This increase in vegetative growth may also be attributed to enhanced availability of nutrients at vital periods of growth and improved water status of plants. The inoculation of organic manure might have increased cell metabolism resulting from enhanced enzyme activity, chlorophyll content and photosynthesis process (Kumar and Singh, 2006). The increased yield is possibly due to the improved vegetative performance of the plant which increases the number of secondary and tertiary branches and subsequently the number of flowers and fruits since Cape gooseberry is an axillary bearer.

Organic manures had significant effect on maximum number of buds, number of flowers and number of fruits in comparison to control. Maximum average number of fruits (29.94 fruits per plant) was obtained with treatment T_7 (Full dose of Vermicompost, at 60cm×75cm spacing) followed by 28.59 fruits per plant under T_8 (Full dose of Vermicompost and spacing 80cm×75cm). The reason for increased number of buds and fruits per plant may be due to solubilisation effect of plant nutrients by addition of N, P, K, Ca and Mg to the crop during the vegetative as well as reproductive phase. These results are in accordance with findings of Patil *et al*. (2004). P and K are also reported to enhance flowering and fruiting in crops (Katyayan, 2001). The highest average number of flowers and fruits and fruit weight was recorded for treatment T_7 which was found to be significantly at par with the treatment T_8. The final maximum yield over control however, has been recorded upon the application of vermicompost with wider spacing however, it was non significant and close to closer spacing (Table 1). This is explainable since a larger number of plants are accommodated per hectare under the closer spacing of 60cm×75cm as compared with that of 80cm×75 cm and because the yield attributing characters *viz*., average number of flowers, fruits and average fruit weight were recorded as being statistically at par with each other for treatments T_7 and T_8. Logically, it will result in higher yield even though it is statistically at par in the yield obtained under wide spacing.

Physico-chemical characteristics of fruits of cape gooseberry (Table 2) also did not vary significantly due to planting at various spacing i.e. close or wide spacing. In all cases (fruit length, width, weight, volume, TSS and acidity except specific gravity) organic manuring had significant effect to improve the fruit quality, however, interaction effect between spacing and organic manuring were non-significant. It was seen that T_7 (Full dose of vermicompost + 80 cm×75 cm spacing) produced fruits with maximum length (26.32 mm) and width (25.78 mm). The average fruit weight and fruit volume were found maximum (25.10 g and 24.47 ml, respectively) also under treatment T_7. The fruit specific gravity depends on fruit dry matter accumulation, fruit weight and fruit volume ratio which has been recorded as non-significant due to spacing, manuring and their interaction. The fruit chemical quality in terms of TSS content was found superior under treatment T_7 (13.24 ^{0}B TSS) followed by T_8. However, T_7 increased the titratable acidity content in fruits might be due to more availability of nitrogen amount. Overall, the superior quality fruits were found under the treatment T_7 due to beneficial effect of vermicompost and wider spacing which allows better vegetative growth influencing higher accumulation of food materials resulting in better quality.

Crop physiologist, microbiologist and agronomist agree that fruit growth and development are strictly dependent on soil biological fertility factor and earthworms stimulate microbial populations, consequently increasing available nutrients and microbial metabolites release into the soil (Tomati *et al.*, 1988). Vermicompost facilitates plant growth hormones and high levels of soil enzymes, while enhancing microbial populations and tending to hold more nutrients over longer periods without adverse impacts on the environment. It can also be used as a bioremedial measure to reclaim problem soils, especially acid soils, because of the near-neutral to alkaline pH of vermicompost (Padmavathiamma *et al.*, 2008; Aksoy, 2001; Chowdhury, 2004; Maji and Das, 2008). The increase in yield and yield attributing characters may be due to application of organic manure over control and greater presence of essential plant nutrients and balanced C/N ratio for better physiological performance of the plant (Harikrishna *et al.*, 2002 and Sengupta *et al.*, 2002).

The results have further revealed that no significant variation was observed in the performance of plants planted at two spacing under study *viz*., 80cm × 75cm and 60cm × 75cm in respect of vegetative growth, fruit yield per plant and physico-chemical quality of fruits. Further, there is no significant impact of interaction of the two factors. Thus, it is clear that the performance of the crop is independent to the effect of spacing under study and has responded only to the organic manures applied. Among the organic manures, vermicompost had shown the better effect on fruit yield which is important as organic sources of

Table 1: Effect of spacing and organic manure on performance of growth and yield of cape gooseberry

Parameters Treatments	Plant height (cm)	Number of branches per plant	Number of budsper plant	Number of flowers per plant	Number of fruits per plant	Fruit yield per plant (g)
T_1- C_0S_1	27.81	7.22	16.12	15.74	15.44	317.91
T_2- C_0S_2	30.83	6.74	21.29	21.44	21.00	438.90
T_3- F_1S_1	39.08	8.37	25.39	25.69	24.39	519.26
T_4- F_1S_2	40.69	8.53	27.91	26.74	25.61	576.23
T_5- F_2S_1	31.77	7.79	24.42	24.31	24.53	536.96
T_6- F_2S_2	36.88	7.61	24.61	24.68	25.48	576.61
T_7- V_1S_1	45.68	9.51	31.57	30.86	29.94	751.49
T_8- V_1S_2	41.33	9.19	29.49	29.04	28.59	709.32
T_9- V_2S_1	38.19	8.26	28.36	26.46	25.14	594.56
T_{10}-V_2S_2	39.02	7.94	26.55	25.50	25.25	563.08
CD (P=0.05)						
Factor A	3.53	0.51	1.38	2.114	1.59	69.08
Factor B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Factor A×B	N.S.	N.S.	1.95	2.99	2.25	N.S.

Factor A- Organic manures, Factor B- Spacing

Table 2 : Effect of spacing and organic manure on physico- chemical parameter of cape gooseberry fruits

Parameters Treatments	Fruit length (mm)	Fruit width (mm)	Fruit weight (g)	Fruit volume (ml)	Specific gravity (g/ml)	T.S.S. (^{0}Brix)	Acidity (%)
T_1- C_0S_1	21.40	21.83	20.59	21.46	0.97	11.62	0.97
T_2- C_0S_2	21.70	21.50	20.90	22.17	0.93	8.21	0.95
T_3- F_1S_1	24.95	23.52	21.29	21.93	0.96	12.66	1.03
T_4- F_1S_2	23.32	23.91	22.50	22.33	1.00	12.76	1.04
T_5- F_2S_1	22.87	22.15	21.89	22.68	0.96	11.92	1.04
T_6- F_2S_2	22.67	23.84	22.63	21.61	1.03	11.70	1.02
T_7- V_1S_1	26.32	25.78	25.10	24.47	1.04	13.24	1.13
T_8- V_1S_2	**25.70**	**24.86**	**24.81**	**24.35**	**1.03**	**12.93**	**1.11**
T_9- V_2S_1	23.82	23.96	23.65	23.58	1.00	12.52	1.02
T_{10}-V_2S_2	24.11	23.95	22.30	21.98	1.00	12.45	1.04
C. D. (P=0.05)							
Factor A	1.22	1.74	6.09	1.16	N.S.	2.15	0.04
Factor B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Factor A×B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

nutrition is one of the best approach for several crops (Sarath *et al.*, 2016). Therefore, it is concluded that the vermicompost application (full dose) and planting at 80cm × 75cm spacing may be beneficial for cape gooseberry cultivation. The result is as per the principle that within a given crop, the better the individual plants which are able to spread and intercept light, the lower the optimum population per unit area *i.e.* plant density does not need to be higher than that which provides full ground cover (completely shading the ground surface) at maturity (Hargreaves and Merkley, 2004).

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Effect of plant growth regulators on yield and quality of sapota (*Achras zapota* l.) through crop regulation under hill zone of Karnataka

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ABSTRACT

An experiment was conducted in the 35 year old sapota orchard at Mudigere (Karnataka) during 2014-15 to know the Effect of plant growth regulators on yield and quality of sapota (Achras zapota L.) through crop regulation under hill zone of Karnataka. Three growth regulators viz., NAA (250, 300 and 350 ppm), 2, 4-D (40, 50 and 60 ppm) and Ethephon (350, 400 and 450 ppm) at varied concentrations were sprayed at pea nut stage. The results of the experiment showed that, the foliar application of NAA at 350 ppm gave significantly maximum fruit weight (110.23 g), fruit length (6.07 cm), fruit diameter (58.30 mm), volume of fruit (106.87 ml), yield per tree (108.47 kg), yield per hectare (10.85 t) and extended shelf life (10.58 days) with minimum physiological loss in weight (6.10 %, 8.11 % and 10.22 % at 3, 6 and 9 days during storage respectively) compared to all other treatments tried. The foliar application of Ethephon 450 ppm showed significantly decrease in number of mummified fruits (40.10) with maximum per cent of thinning (35.30 %), total soluble solids (19.75 ÚBrix), reducing sugars (9.12%), non reducing sugar (6.96%) and total sugars (15.97%).

Keywords*:* Sapota, Growth Regulators, Ethephon, Crop Regulation, Mummified Fruits.

INTRODUCTION

Sapota (*Achras zapota* L.) is a native of Mexico belongs to the family Sapotaceae. India is the largest producer of sapota in the world with a production of 14.95 lakh metric tonnes. Karnataka is one of the major sapota growing states with an area of 31,700 hectares with a production of 3,73,000 metric tonnes and productivity of 11.80 metric tons per hectare (Anon, 2013). The ripe fruit is rich in sugar (12-14 %) and contains fairly large amount of minerals like calcium, phosphorous, iron and sodium besides vitamins A, B_1, B_2, B_6 and C (Joshi *et al.*, 1993). Crop regulation plays an important role in influencing the yield and quality of fruits. Among the crop regulation methods, application of chemical is cheaper than the manual thinning. Consequently, many substances like phenols, cresols, NAA, 2,4-D, MCPA, Ethephon, Carbamate, MH *etc.*, were used to regulate some of the flowers or fruitlets in different fruit crops (Auchter and Roberts, 1935). As sapota is a heavy bearing fruit crop, it suffers with the problems like enormous flowering, flower drop, less fruit set, small sized fruits with low quality and fetches less price in the market. Especially in wasteland and marginal lands, this crop suffers from a malady called mummification or stone fruit, which has been described as a nutritional or physiological disorder. This is very severe in old orchards in certain areas of hill zones. The severity leads to a loss of crop to the tune of more than 70 per cent. To overcome these problems one of the easily practicable cultural operations is crop regulation. NAA and 2,4-D enhances the early fruit drop by decreasing competition between fruits and increasing production of abscission inducing ethylene, both encouraging greater physiological drop (Mitra, 1995). Ethephon induces the biosynthesis of plant hormone ethylene which stimulates abscission (Wertheim, 1997). Keeping the above aspects in view, the present study was undertaken to know the effect of plant growth regulators on size, yield, quality, thinning per cent and incidence of mummification in sapota through crop regulation under hill zone of Karnataka.

MATERIALS AND METHODS

The present investigation was carried out at existing 35 year old sapota orchard, Zonal Agricultural and Horticultural Research Station (ZAHRS),

Mudigere, Chikamagalur district, Karnataka state during 2014-2015. The plants having uniform size were selected for the study. The treatments consisted of three different plant growth regulators with three concentrations of each namely, NAA (250, 300 and 350 ppm), 2, 4-D (40, 50 and 60 ppm), Ethephon (350, 400 and 450 ppm) and the plain distilled water sprayed on the control plants. There were ten treatments along with a control and each treatment was replicated thrice in a complete Randomized Block Design (RBD). All the treatments were applied at pea nut stage through foliar spray. The observations on physical parameters like fruit length (cm), diameter of fruit (mm), and weight of fruit (g) were recorded; further, the volume of fruit (ml) was determined by water displacement method. Yield attributes like, number of fruits per tree was physically counted when they were harvested; yield per plant (kg), yield per hectare (t), fruit thinning per cent and number of mummified fruits was also recorded. The observations on quality parameters like physiological loss in weight (%), shelf life (days), total soluble solids (ÚBrix), reducing sugar (%), non-reducing sugar (%) and total sugars (%) were recorded after harvest. Here Sugars present in the sapota fruit samples were estimated by Anthrone reagent method (Ranganna, 1977) and total soluble solids was recorded with the extracted juice using a hand refractometer at room temperature. The data obtained were statistically analysed by the analysis of variance method as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The various physical parameters were significantly influenced by application of different growth regulators (Table1). The maximum fruit volume (106.87 ml), fruit diameter (58.30 mm) and fruit length (6.07 cm) were recorded when NAA at 350 ppm was applied at pea nut stage. Application of NAA and Ethephon decreases the fruit number resulting higher accumulation and translocation of extra metabolites from other parts of the plant towards developing fruits and also due to NAA there will be a cell elongation by enlargement of vacuoles and loosening of cell wall after increasing its plasticity. This might have lead to increase in size of fruit. Similar findings were reported by Reyes *et al*. (2008), Kaur *et al*. (2005) and Taghipour *et al.* (2011).

The data revealed that the different treatments had significant effect on yield parameters of the tree (Table 2). The maximum value of fruit weight (110.23g in T_4) and reduced number of fruits per tree (964.13 in T_{10}) might be due to the elevated concentrations of Ethephon and also NAA mediated synthesis of polygalacturonase enzymes which has initiated the abscission zone, resulting in the fruit dropping, as the number of fruit decreases, the individual weight of the fruit increases due to less competition for carbohydrates. These results were in conformity with the findings of Abbas *et al.* (2014), Kaur *et al.* (2005) and Taghipour *et al.* (2011). NAA has a positive effect on yield of fruit. As a result of fruit thinning the tree did not become exhausted due to use of energy in fruit development and ripening, the prepared food remain reserved which might have helped to increase yield per tree (108.47 kg in T_4) and yield per hectare(10.85 t in T_4). These results are relevant to Abbas *et al.* (2014).

The minimum number of mummified fruit (40.10) was recorded under ethephon 450 ppm which was reduced by 1.04 per cent over the control (Table 3) and maximum number of mummified fruit (60.09) was recorded in control. This might be due to application of different concentration of ethephon, NAA and 2, 4-D decrease the fruitlet number which results in increasing the sink strength in smaller sized fruits, which leads to the more mobilization of photosynthates, moisture and mineral nutrients to the fruits and this result in proper balance of nutrients. These results were meagerly relevant to the study of Ugalat *et al*. (2013) in sapota.

There were significant differences on thinning per cent among the treatments. The maximum per cent of thinning (35.30%) was recorded in ethephon 450 ppm and minimum thinning per cent (17.63%) was recorded in control (Table 3). The result may be due to the use of ethephon enhanced the fruitlet thinning which increased the endogenous level of ethylene production leading to the abscission induction by increasing the cellulose activity in the abscission zone. The results were conformity with Moreira *et al.* (2011) in Ponkan mandarin and Sing *et al.* (2000) in Kinnow mandarin and Taghipour *et al.* (2011) in Apricot.

Table 1. Effect of foliar spray of different plant growth regulators on fruit characters of sapota

Treatment details	Fruit Volume (ml)	Fruit length (cm)	Fruit diameter (mm)
T_1- Control	59.27	4.56	43.78
T_2 - NAA 250 ppm	84.40	5.18	48.97
T_3 - NAA 300 ppm	88.10	5.38	51.67
T_4 - NAA 350 ppm	106.87	6.07	58.30
T_5 - 2,4-D 40 ppm	70.77	5.08	48.72
T_6 - 2,4-D 50 ppm	74.33	5.03	48.58
T_7 - 2,4-D 60 ppm	78.40	5.01	48.47
T_8 - Ethephon 350 ppm	89.23	5.41	52.44
T_9 - Ethephon 400 ppm	94.77	5.65	54.51
T_{10} - Ethephon 450 ppm	97.40	5.82	55.74
S. Em ±	4.21	0.18	1.60
CD @ 5%	12.51	0.53	4.75

Table 2. Effect of foliar spray of different plant growth regulators on yield parameters of sapota

Treatment details	Fruit weight (g)	Number of fruits per tree	Fruit Yield	
			kg/tree	t/ha
T_1- Control	62.59	1208.32	75.63	7.56
T_2 - NAA 250 ppm	87.17	1131.99	98.23	9.82
T_3 - NAA 300 ppm	91.53	1122.52	102.98	10.30
T_4 - NAA 350 ppm	110.23	1108.57	108.47	10.85
T_5 - 2,4-D 40ppm	74.40	1173.47	96.58	9.66
T_6 - 2,4-D 50ppm	77.20	1190.19	91.90	9.19
T_7 - 2,4-D 60ppm	81.87	1179.31	85.02	8.50
T_8 - Ethephon 350ppm	92.50	1098.22	101.68	10.17
T_9 - Ethephon 400ppm	97.74	1053.50	103.18	10.32
T_{10} - Ethephon 450ppm	99.40	964.13	94.61	9.46
S. Em ±	4.36	20.58	1.83	0.18
CD @ 5%	12.94	61.13	5.45	0.54

Table 3. Effect of foliar spray of plant growth regulators on number of mummified fruits and percent of fruit-let thinning in sapota.

Treatment details	Number of mummified fruits per tree	Fruit-let thinning (%)
T_1- Control	60.09 (4.73 %)	17.63 (24.82)
T_2 - NAA 250 ppm	46.57 (3.95 %)	22.83 (28.54)
T_3 - NAA 300 ppm	45.07 (3.87 %)	23.50 (28.99)
T_4 - NAA 350 ppm	44.57 (3.86 %)	24.43 (29.62)
T_5 - 2,4-D 40ppm	51.03 (4.30 %)	20.01 (26.57)
T_6 - 2,4-D 50ppm	48.27 (3.99 %)	18.87 (25.74)
T_7 - 2,4-D 60ppm	45.30 (3.89 %)	19.61 (26.68)
T_8 - Ethephon 350ppm	44.07 (3.85 %)	26.14 (30.74)
T_9 - Ethephon 400ppm	41.73 (3.81 %)	29.19 (32.70)
T_{10} - Ethephon 450ppm	40.10 (3.69 %)	35.30 (36.45)
S. Em ±	1.86	1.22
CD @ 5%	5.53	3.63

Table 4. Effect of foliar spray of different plant growth regulators on physiological loss in weight and shelf life of sapota fruits

Treatment details	Physiological loss in weight (days)			Shelf life
	3rd Days	6th Days	9th Days	(Days)
T_1 - Control	9.64	11.80	14.16	7.89
T_2 - NAA 250 ppm	6.29	8.69	11.16	10.43
T_3 - NAA 300 ppm	6.12	8.40	10.49	10.54
T_4 - NAA 350 ppm	6.01	8.11	10.22	10.58
T_5 - 2,4-D 40 ppm	7.64	9.87	11.99	9.68
T_6 - 2,4-D 50 ppm	7.61	9.72	11.80	9.63
T_7 - 2,4-D 60 ppm	7.49	9.55	11.66	9.26
T_8 - Ethephon 350 ppm	8.22	10.37	12.49	9.18
T_9 - Ethephon 400 ppm	8.71	10.90	13.16	8.47
T_{10} - Ethephon 450 ppm	8.88	11.12	13.39	8.02
S. Em ±	0.24	0.26	0.26	0.16
CD @ 5%	0.71	0.79	0.78	0.49

Table 5. Effect of foliar spray of different plant growth regulators on quality parameters of sapota fruit

Treatment details	TSS (^{0}B)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
T_1 - Control	14.07	7.78	4.91	13.50
T_2 - NAA 250 ppm	16.00	8.50	6.11	14.25
T_3 - NAA 300 ppm	16.13	8.53	6.17	14.53
T_4 - NAA 350 ppm	16.20	8.59	6.46	14.64
T_5 - 2,4-D 40 ppm	14.73	8.36	5.86	14.08
T_6 - 2,4-D 50 ppm	17.13	8.82	6.47	15.30
T_7 - 2,4-D 60 ppm	17.87	8.93	6.49	15.38
T_8 - Ethephon 350 ppm	18.73	9.01	6.52	15.53
T_9 - Ethephon 400 ppm	19.00	9.03	6.58	15.60
T_{10} - Ethephon 450 ppm	19.75	9.12	6.96	15.97
S. Em ±	0.35	0.10	0.16	0.13
CD @ 5%	1.04	0.29	0.46	0.40

The physiological loss in weight increased with the advancement of storage period as can be observed from Table 4. In the present investigation, the Minimum physiological loss in weight (6.01, 8.11 and 10.22%) at 3, 6 and 9 days after storage respectively with maximum shelf life of 10.58 days was recorded with NAA 350 ppm. The possible reason might be due to cause of some chemical changes within the fruits, resulting in retention of more water against the rate of evaporation, which resulted in increasing shelf life of the fruits. Further, it may be possibly due to the alteration of some proteinous constituents of the cell and thus increase in affinity towards water which resulted in lowest physiological loss in weight. Similar response was reported by Kher and Bhat (2005) in guava.

The data (Table 5) indicate that application of various plant growth regulators significantly improved the fruit quality of sapota in terms of T.S.S and sugars. The increase in total soluble solids (19.75 ÚB), reducing sugars (9.12%), non-reducing sugar (6.96%) and total sugars (15.97%) due to application of ethephon (at 450 ppm) in the present investigation might be due to its action of converting complex substances (starch) into simpler ones (sugars) through higher respiration

and carbon assimilation activity. Similar findings were observed in guava by Yadav *et al.* (2001), Jain and Dashora (2010) and also ethylene acts as a thinning agent and thinning variants, which was normal because the trees fed a smaller number of fruits, which got larger with higher amount of sugars. These results were relevant to Sarkadi (2012) in peach.

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Flower morphology and fruit maturity of four minor fruits (*Diospyros peregrina, D. discolor, Muntingia calabura* and *Careya arborea*) of Tropics and subtropics

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ABSTRACT

Floral biology and morphological features are essential for crop improvement and harvesting fruit at right time. Deshi (Diospyros peregrine Gurke) and bilatigab (Diospyros discolor Gurke), china cherry (Muntingia calabura L.) and kumbhi (Careya arborea Roxb.) are minor edible fruits of tropics and subtropics. A study was conducted at the Botanical Garden of Bangladesh Agricultural University, Mymensingh to investigate floral morphology and maturity indices of the four fruit species during 2008 to 2011. The flowers are incomplete, regular, polysepalous and poly petalous with numerous stamens and superior ovary in deshi gab; and multicarpellary ovary in bilati gab. The flowers are hermaphrodite, complete, polysepalous, polypetalous, numerous stamen with superior ovary in china cherry and inferior ovary in kumbhi. Fruit growth study revealed that maximum dry mass accumulation in seed i.e. physiological maturity (PM) was obtained when the fruit weight (dry) also reached highest in all species. Visual indices of PM were also recorded by changes in pericarp colour. These indicated the appropriate fruit harvesting stage. Results showed that fruits may be harvested at physiological maturity by observing fruit size and visual colour change of the pericarp.

Keywords: Minor fruits, floral biology, physiological and harvest maturity, 'gab', china cherry, 'kumbhi'.

INTRODUCTION

Deshi gab (*Diospyros peregrine* Gurke) and Bilati gab *(D. discolor* Gurke*)* are minor tropical edible fruits belong to family Ebenaceae. Flowers of deshi gab are small, unisexual and incomplete with persistent calyx. The sticky pulp of its fruit is extensively used to smear with fishing nets to make them durable under water. The peak flowering and fruiting season ranges from April to June (Das and Alam, 2001). The blackish cover of berries gradually disappear indicating fruit maturity. Bilati gab is originated from Philippines (Singh, 1998). This fruit is found in the district of Kushtia, Jessore, Faridpur, Rajshahi, Barisal, Pirozpur, and Chittagong Hill Tracts regions of Bangladesh. The fruit is very attractive for its beautiful reddish colour at maturity. Immature fruits are astringent, while ripe fruits have sweet smell and are eaten as table fruits (Ahmed *et al.* 2011). Fruits are nutritionally rich that contain (per 100 g of edible portion) calories 113, water 69.6 g, carbohydrates 26.6 g, fibre l.5 g, fat 0.1 g, protein 1.4 g, minerals 0.8 g, calcium 58 mg (Mondal, 2000). Mature leaves of deshi and bilati gab are reported to be edible (Sankar, Pers. comm.).

China cherry (*Muntingia calabura* L.) is another minor but well-known tropical and edible fruit that belongs to Muntingiaceae (Watson & Dallwitz, 1992). It is a very fast-growing tree, reaching 25 to 40 ft in height in 6-8 years, with spreading, nearly horizontal branches. The leaves are evergreen, alternate, lanceolate or 2's or 3's in the leaf axils with 1.25 to 2 cm wide. A 100 g edible portion of the berries contain approximately 76.3 g water, 2.1 g protein, 2.3 g fat, 17.9 g carbohydrates, 6.0 g fiber, 1.4 g ash, 125 mg calcium, 94 mg phosphorus, 0.015 mg vitamin A and 90 mg vitamin C. The energy value is 380 KJ/ 100 g (Verheij, 1992). Ripened fruits are used into jams and in tarts. Because of its ability to grow quickly on poor soils and rapid dispersal by birds and bats, the cherry tree is being considered as a candidate for reforestation for environmental protections. Although the plants bear fruits throughout the year, the pick flowering and fruiting season is mainly ranges from April to July.

Kumbhi (*Careya arborea* Roxb.), belongs to the family Lecythidaceae and sub family Planchonioideae, is also an important minor fruit trees considering its foliage, shade and windbreak properties in the tropics and subtropics (Shastri *et al.*,2002). Ripe fruits of kumbhi become juicy and the juice is reported to edible and sedative in nature. Kumbhi is traditionally used in the treatment of tumours, bronchitis, epileptic fits, astringents, antidote to snake venom and skin disease (Kirtikar and Basu, 1975). It is also used as remedy for diarrhea (Sikarwar *et al.*, 1994). Methanol extract of kumbh's barks can be used as natural antimicrobial and antioxidant (Kumar *et al.*, 2006). The plant is also investigated as feeds and fodder. As a fodder it contains 6.44% dry matter, 50.06% organic matter, 19.94% total ash, 15.57% crude protein,42.81% neutral detergent fibre, 40.41% acid detergent lignin,2.26% calcium and 0.70% phosphorus (Upreti and Shrestha, 2006).There were details information on growth of some minor fruits (fruit size, fruit and seed weight, AGR of fruits, pulp to fruit ratio etc.) in Bangladesh *viz.*, deshi and bilati gab (Hasan *et al.*, 2014); chalta (Hasan *et al.*, 2016); china cherry (Rahman *et al.*, 2010); kumbhi (Rahman 2009); and cowphal (Roy *et al.*, 2010) but little information is available on details of flower morphology and visual indices of fruit maturity for harvesting. So, the current study was carried out to investigate floral morphology (qualitative and quantitative) and harvesting maturity indices of the four fruit species, Deshi (*Diospyros peregrine* Gurke) and bilati gab (*D. discolor* Gurke), china cherry (*Muntingia calabura* L.) and kumbhi (*Careya arborea* Roxb)..

MATERIALS AND METHODS

Three each of deshi gab and bilati gab; six china cherry, and five kumbhi trees were selected in the Botanical Garden, Bangladesh Agricultural University, Mymensingh ($24^{o}26'$ and $24^{0}54'$ N and $90^{0}15'$ and $90^{0}30'$ E) to study inflorescence type, size of floral parts and fruits of china cherry from April to July of 2008, during April to July of 2008 in kumbhi, between April and June of 2011 in deshi gab, and between May and July of 2011 in bilati gab. Different coloured woolen threads were loosely fastened in the pedicel of first opening (days after tagging) to record the data. In deshi gab, tagging of flowers was started at 25th April and continued till end of May, while in bilati gab, tagging was started at 22nd May and continued up to end of June. In case of kumbhi plants, buds were tagged when the length and diameter was e"1.44 cm and e"5.12 cm, respectively. Ten opened flowers of each species were randomly collected to study the flower morphology. The flowers were carefully examined under the simple microscope and the number of sepals, petals and stamens were recorded. Cross section of the ovary was examined in the light microscope to observe the placentation and number of carpels. The length and breadth of 20 sepals and petals, stamens and styles was measured using ruler. Sepal and petal area was also estimated by L × B. At each DAT, at least 20 fruits (four replication, five in each replicate) were harvested and measured for fruit length, diameter and fresh weight of fruit. The length and diameter of fruits were measured using threads and ruler. The physiologically matured fruits were harvested by observing colour changes. The mean differences were compared by least significant difference (LSD) test (Gomez and Gomez, 1984).

RESULTS

Flower morphology

Deshi gab: The inflorescence is axillary cymes, solitary or clusters of two to seven flowers arises from the leaf axile and light green in colour. Flowers are unisexual and small, dioecious, incomplete, regular, ebracteate, hypogynus, pedicellate; female flowers are solitary and larger than male flowers, 4-5 sepal or petal, calyx persistent, stamen numerous with monocarpellary ovary. The qualitative characters of inflorescence and flower of deshi gab is shown in Table 1.

Sepal length of deshi gab varied between 0.8-0.11 cm with a mean value of 0.95±0.03 cm; sepal breadth from 0.6-0.8 cm with a mean value of 0.69±0.02 cm (Table 2). Sepal area varied between 0.48-0.88 cm^2 with a mean value of 0.66±0.03 cm^2. Petal length varied between 1.7-2.2 cm^2 with a mean value of 2.0±0.04 cm and petal breadth from 0.6-0.11 cm with a mean value of 0.0.85±0.04 cm. Petal area varied between 1.02-2.42 cm^2 with a mean value of 1.77±0.09 cm^2. Stamens number varied from 25-55 with a mean value of 41.4±2.14 and stamen length between 0.4-0.7 cm with a mean of 0.54±0.02 cm (Table 2).

Bilati gab: The inflorescence is axillary cymes, solitary or clusters of three to seven flowers arises from the leaf axile. Flowers are unisexual, dioecious, incomplete, regular, bracteate, hypogynus, 3-5 sepals, calyx persistent, 4-5 petal, stamen 3-5, stigma 4 with multicarpellary superior ovary. The qualitative characters of inflorescence and flower of bilati gab is shown in Table 3. Sepal length of Bilati gab varied between 0.8-1.3 cm with a mean value of 1.04±0.037 cm and sepal breadth from 0.8-1.2 cm with a mean value of 1.03±0.031 cm (Table 4). Sepal area varied between 0.64-1.56 cm^2 with a mean value of 1.09±0.058 cm^2. Petal length varied between 1.5 -2.0 cm with a mean value of 1.78±0.035 cm and petal breadth from 2.0-2.6 cm with a mean value of 2.32±0.041 cm. Petal area varied between 3.01-5.20 cm^2 with a mean value of 4.31±0.160 cm^2. Stigma length varied from 0.3-0.6 cm with a mean value of 0.46± 0.020 cm (Table 4).

China cherry: The inflorescence of china cherry is solitary or clusters of two rarely three flowers. Bud arises from the axile of leaf and light green in colour. Flowers are regular, pedicillate, polysepalous, hermaphorodite, epigynous, carpel: 5-7 with persistent stout capitates style. Small to medium size flower with light green sepal and creamy whitish petals. The detailed of qualitative characters of inflorescence and flower of china cherry is shown in Table 5.

Sepal length of china cherry varied between 0.7-0.95 cm with a mean value of 0.80 ±0.064 cm and sepal breadth varied between 0.20-0.25 cm with mean value of 0.216±0.040 cm (Table 6). Sepal area varied between 0.14-0.20 cm^2 with the mean of 0.173±0.039 cm^2. Petal length varied between 1.1-1.3 cm with mean of 1.14±0.083 cm and the petal breadth varied between 0.75-0.90 cm with mean of 0.86±0.086 cm. Petal area varied between 0.82-1.08 cm^2 with a mean of 0.98±0.11 cm^2. Number of stamens/flower varied between 102-151 with a mean value of 121.2±1.95 the stamen length varied between 0.4-0.6 cm with a mean value of 0.481±0.09 cm (Table 6).

Kumbhi: The inflorescence of kumbhi appears at the end of March when the tree more or less leafless. Spike inflorescences appear clustered at the end of branches. Buds are dark green color. Flower does not open completely and some shed shortly after opening. Flowers are medium to large, pinkish, hermaphrodite, regular, polysepalous, polypetalous, ovary inferior, carpels 4-5, placentation axile with thick and persistent calyx and possess a bad smell. The flower morphology is shown in the Table 7.

Sepal length varied between 0.8-1.3 cm with mean of 1.03 ± 0.09cm and the sepal breadth varied between 1.2-1.5 cm with mean of 1.34 ±0.07 cm (Table 8). The sepal area varied between 0.96 and 1.82 cm^2 depending on the sepal length and breadth with mean value of 1.39 ± 0.13 cm^2. Petal length varied between 1.4-5.4 cm with mean of 4.68 ±0.18 cm and the breath varied between 1.7-2.5 cm with mean of 2.14 ±0.12 cm. The petal area varied between 6.12-4.31 cm^2 with mean of 10.04 ±0.33 cm^2. Number of stamens/flower varied between 510-615 with mean of 566.5 ±1.86 and stamen length varied between 3.0-3.8 cm with mean of 3.51 ±0.11 cm. The style is persistent and the length varied between 4.9 and 6.1 cm with mean of 5.84 ±0.19 cm (Table 8).

Fruit growth and visual colour change

In Deshi gab, fruit size (length and diameter) increased with increasing ages (DAT). The fruit length was 5.45 cm at 49 DAT, then grew rapidly and reached a steady state between 60 and 63 DAT (average 5.78 cm) (Table 9). The diameter followed similar pattern of length and remained constant between 60 and 63 DAT (average 4.58 cm) (Table 9). Near physiological maturity (63 DAT), seed and fruit weight reached 3.22 and 11.25 g, respectively (Table 9). Around two months from flowering, a berry of deshi gab turn yellowish green with the loss of blackish hairs, which is developed earlier on fruit surface (Fig. 1 A, B, C). Like deshi gab, fruit growth increased with increasing ages (DAT) in bilati gab. The fruit length and diameter also increased gradually and reached a steady state at 85 DAT (9.10 and 7.60 cm, respectively) (Table 9). At 85 DAT (PM stage), seed and fruit weight reached 9.13 and 35.78 g, respectively. After three months from flowering, fruits turn into dark red colour indicating visual index of fruit harvest (Fig. 1 D, E, F).In case of china cherry, fruit length and diameter was almost similar at 35 DAT (average 0.53 cm) followed by gradual increase and reached

steady at 55 DAT (at PM) (1.00 and 1.17 cm, respectively) with an average fruit dry weight of 0.53 g (Table 9). Harvest maturity of china cherry was attained around 53 DAT when the deep green berries turned into yellowish pink (Fig. 1 G, H, I). The fruit diameter of kumbhi increased twice than length at different ages and at 67 DAT (harvesting stage) fruit size attained about 7.48 and 19.72 cm, respectively (Table 9). Seed and fruit dry weight was recorded the maximum at 67 DAT and obtained 3.22 and 30.42 g, respectively (Table 9). Slight colour development on the shoulders and falling of one or two ripe fruits naturally from the plant was considered as the harvesting index of kumbhi (Fig. 1 J, K, L).

DISCUSSION

Deshi gab is a fast growing tree reaches 3-10 m in height, with spreading nearly horizontal branches. Flower characteristics were investigated by closely observing the flower. The flowers are small, whitish brown axillarycymes, solitary or clusters of 2-7, unisexual and small, dioecious, incomplete, regular, ebracteate, hypogynus, pedicellate, female flowers, solitary, larger than male flowers (Table 1).

The present findings are similar to the results reported by Sasidharan (2004) and Das and Alam (2001). They reported that the flowers of deshi gab are borne singly or in cluster, unisexual, small and dioecious. Sepal length varied between 0.8-0.11 cm and that of breadth between 0.6 and 0.8 cm, respectively. Petal length varied between 0.48-0.88 cm and that of breadth from 1.7-2.2 cm, respectively. Stamen number/ flower varied between 25 and 55 and that of stamen length varied from 0.4-0.7 cm.

Previous researchers (Sashidaran, 2004; Das and Alam, 2001) described a few features of flower. In the present study, detailed qualitative and quantitative floral characters are described (Tables 1 and 2). Fruit growth was investigated by measuring length, diameter and weight from 7 DAT to full maturity with a duration 60-65 days after flowering in deshi gab. Fruit length and diameter became greater (5.75 cm and 4.57 cm, respectively) at 60 DAT with an approximate weight of 60 g/ fruit and remained more or less unchanged till 63 DAT indicating maximum fruit size at maturity stage. This signifies that when the berry reaches to approximately 5.8 cm in length or 4.6 cm in diameter, berries can be harvested. Around two months age from DAT, a berry of deshi gab turn yellowish green colour and devoid of blackish hairs on fruit surface indicating visual index of fruit harvest. These indices are important for harvesting berries at right time.

Flower characteristics of bilati gab were investigated by closely observing the flower. The flowers are small, whitish, axillary cymes, solitary or clusters of 2-7, unisexual and larger than deshi gab, dioecious, incomplete, regular, bracteate, hypogynus, sessile, female flowers, solitary, larger than male flowers (Table 1). The present findings are similar to Chong *et al*. (2009) and Morton (1987). They reported that the flowers of bilati gab are borne singly or in cluster, unisexual, small and dioecious. Sepal length varied between 0.8 and 1.3 cm and that of breadth from 0.8-1.2 cm, respectively. Petal length varied between 1.5 and 2.0 cm and that of breadth between 2.0 and 2.6 cm, respectively. Stamen length varied from 0.3-0.6 cm.

Previous researchers (Chong *et al*., 2009; Morton, 1987; Das and Alam, 2001) described a few features of flower excluding growth study. In the present study, qualitative and quantitative floral characters and fruit growth were studied (Tables 3 and 4). Fruit growth was investigated by measuring length, diameter and weight from 35 DAT to full maturity with a varied duration. Fruit length and diameter became greater (9.08 cm and 7.59 cm, respectively) at 83 DAT with an approximate weight of 220 g/fruit and remained more or less unchanged till 85 DAT indicating maximum fruit size at maturity stage. This signifies that when the fruit reaches to approximately 9.1 cm in length or 7.6 cm in diameter, fruit can be harvested. Around at three months age from DAT, a fruit of bilati gab turn dark red colour indicating visual index of fruit harvest. These indices are important for harvesting fruit at right time.

The flowers of China cherry are small, white, borne singly or cluster of 2 or 3.Flowers are regular, sepal and petal 5-6, polypetalous, stamen numerous, syncarpous ovary superior with 5-7 carpels(Table 5). The present findings are similar to Morton

Table 1. Morphological characters of flower of Deshi gab (Diospyros peregrina)

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
Axillary, cymes, solitary or cluster of 2-7	Unisexual and small, dioecious, incomplete, regular, ebracteate, hypogynus, tri or pentamerous, pedicellate, female flowers larger than male ones	Sepal 3-5, light green, polysepalous, persistent, aestivation imbricate	Petal 3-5, yellowish, polypetalous, aestivation imbricate	Stamen numerous (25-55), free, anther lobed, light blackish in colour	Ovary superior, globose, glabrous or hairy, monocarpellary, ovule 2-8, placentation axile	Berry, slightly longer than wide, green when immature, yellowish green at maturity	Seeds 4-8, elliptical, smooth compressed, embedded in the gelatinous pulp

Table 2. Floral morphology of *Deshi* gab (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm^2	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm^2	Stamens/ flower (No.)	Stamen length (cm)
Mean	0.95	0.69	0.66	2.0	0.85	1.77	41.4	0.54
Range	0.8-0.11	0.6-0.8	0.48-0.88	1.7-2.2	0.6-0.11	1.02-2.42	25-55	0.4-0.7
Standard error mean	±0.03	±0.02	±0.03	±0.04	±0.04	±0.09	±2.14	±0.02

Table 3. Morphological characters of flower of Bilati gab (*D. discolor*)

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
3-7 flowered cymes, creamy white flowers, flowers arise from leaf axile	Flower unisexual, larger than deshi gab, dioecious, incomplete, regular, bracteate, 3-4 bracts, hypogynus, 3-5 merous, sessile, creamy white in colour, female flowers are solitary, larger than male flowers	Sepal 3-5, light green, polysepalous, persistent, aestivation valvate	In male flower petal 5, polypetalous, in female flower petal 4 and gamopet-alous, creamy white in colour	Stamens 3-5, free	Stigma 4, united, covered by hairs, ovary superior, carpel 4, syncarpous	Round berry, globose, velvety, brownish red and densely covered with short, golden brown hairs, dark red at maturity	Seed 2-8, dark or blackish brown, elliptical

Table 4. Floral morphology of Bilatigab (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm^2	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm^2	Stamens/ flower (No.)	Stamen length (cm)
Mean	1.04	1.03	1.09	1.78	2.32	4.31	0.46	
Range	0.8-1.3	0.8-1.2	0.64-1.56	1.5-2.0	2.0-2.6	3.01-5.20	0.3-0.6	
Standard error mean	±0.037	±0.031	±0.058	±0.035	±0.041	±0.160	±0.020	

Table 5. Morphological characters of flower of China cherry

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
Solitary or cluster of two, arises from leaf axile.	Hermaphrodite, regular, pedicellate, bud green, 1.25-2 cm wide.	Sepal 5-6, light green, polysepalous, aestivation valvate	Petal 5-6, whitish, polypetalous, arises from the join of two sepals, aestivation valvate, last only one day,	Stamen numerous, free, filament long, anther lobed yellow in colour, glabroous at the base from where the stamen arise.	Carpel 5 – 7, syncarpous, ovary superior, style short or reduced. stigma capitates, 5 – 7 lobed, persistent, placentation axile.	Edible berry, numerous tiny seeded, green when immature but red or pink when ripe, juicy pulp sweet in taste.	Numerous, minute, round, tiny, embedded in the pulp.

Table 6. Floral morphology of China cherry (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm^2	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm^2	Stamens/ flower (No.)	Stamen length (cm)
Mean	0.80	0.216	0.173	1.14	0.86	0.989	121.2	0.481
Range	0.7 – 0.95	0.2 – 0.25	0.14–0.20	1.1–1.3	0.75–0.90	0.82–1.08	102–151	0.4–0.6
Standard error mean	±0.064	±0.040	±0.039	±0.083	±0.086	±0.11	± 1.95	± 0.09

Table 7. Morphological characters of flower of Kumbhi

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
Spike, clustered at the terminal of the stem when the tree is more or less leafless.	Hermaphrodite, regular, bud green.	Sepal 4 or 5, green, thick, triangular, polysepalous, aestivation valvate, persistent.	Petal 4 or 5, pinkish, green, oval shaped, polypetalous, aestivation valvate.	Stamen numerous (>500), free, outer ones long and pinkish, inner ones short and whitish, filament long, anther bilobed, basifixed base of the stamen.	Carpel 4, rarely 5, syncarpous, ovary inferior, style long and persistent. stigma 4 lobed, placentation axile.	Berry, green, few (1-9) or no seeded, become juicy and light green when ripe.	Round or oval, brown in colour, cotyledon absent.

Table 8. Floral morphology of Kumbhi (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm^2	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm^2	Stamens/ flower (No.)	Stamen length (cm)	Style length (cm)
Mean	1.03	1.34	1.39	4.68	2.14	10.04	566.5	3.51	5.84
Range	0.8-1.3	1.2-1.5	0.96-1.82	3.4-5.4	1.7-2.5	6.12-14.31	510-615	3.0-3.8	4.9-6.1
Standard error mean	±0.09	±0.07	±0.13	±0.18	±0.12	±0.33	± 1.86	± 0.11	± 0.19

Table 9. Fruit size and seed and fruit dry weight (DW) at different ages (days after tagging, DAT) in four minor fruits of Bangladesh

Age (DAT)	Fruit size Length x Diameter (cm)	Seed DW (g Fruit^{-1})	Fruit DW (g Fruit^{-1})
Deshi gab			
49	5.45×3.88 c	2.65 b	10.24 b
56	5.62×4.27 b	3.06 a	10.68 b
60	5.77×4.56 a	3.17 a	11.02 a
63	5.80×4.61 a	3.22 a	11.25 a
Bilati gab			
70	8.34×6.24 c	8.89 b	33.85 b
77	9.03×6.78 b	9.02 a	35.23 a
83	9.08×7.59 a	9.11 a	35.68 a
85	9.09×7.62 a	9.13 a	35.78 a
China cherry*			
35	0.53×0.52 c	-	0.14 c
45	0.74×0.79 b	-	0.23 b
53	0.99×1.17 a	-	0.33 a
55	1.00×1.17 a	-	0.35 a
Kumbhi			
45	6.64×15.74 c	2.21 c	26.45 c
55	7.25×18.57 b	2.59 b	28.77 b
65	7.45×19.71 a	3.15 a	30.25 a
67	7.48×19.72 a	3.22 a	30.42 a

In a particular fruit, figures within in a column with uncommon letter(s) differ significantly at Pe”0.05. *: Seeds were very minute, hence, inseparable from fruit.

(1987) who also reported that the flowers of china cherry borne singly or in group of 2’s or 3’s in the leaf axils and 1.25-2 cm wide with many prominent stamens. Rahman *et. al.*, (2009) reported that the flowers borne singly or in groups of two in leaf axils with 5-6 green sepals and5-6 white petals and many(>100) prominent yellow stamens, ovary superior with 5-7syncarpous carpels and axile placentation. Sepal length varied between 0.70 and 0.95 cm and that of breadth between 0.2 and 0.25 cm respectively. The petal length varied between 1.1 and 1.3cm and that of breadth between0.75 and 0.90 cm, respectively. The length of stamen varied between 0.4 and 0.6 cm with mean of 0.48 ± 0.09 cm.The present result is similar to the report of Stone (1970) who reported that the petal is about 1.2 - 1.3cm long and the stamen is about 0.6 cm long.

Previous researchers (Stone, 1970; Morton, 1987; Verheij, 1992) described a few features of flower. In the current study, detailed qualitative and quantitative floral characters are described in Table 5 and 6. Fruit growth was investigated by measuring length, diameter and weight beginning from fruit set to full maturity with a duration about 2 months. Fruit length and diameter became greater (0.99 cm and 1.17 cm, respectively) at 53 days after tagging (DAT) and remain more or less unchanged till 55 DAT indicating maximum fruit size at maturity stage. This signifies that when the berry reaches to approximately 1.0 cm in length or 1.17 cm in diameter, berries could be harvested. The present result is similar to the report of Rahman *et al.* (2009) who also observed that matures berries of china cherry is 1.0- 1.2 cm in length or diameter.

Flowers of Kumbhi are medium to large; pink clustered at the end of branches and had a bad smell. Sepal and petals 4 or 5, polysepalous, sepals thick and dark green, petals pinkish green, stamen numerous, pink or white, ovary inferior,

Figure 1. Changes in fruit size and colour at different ages: (A, B& C at 49, 56 & 63-65 DATs, respectively) in deshi gab;(D, E,& F at 70, 77 &83-85 DATs, respectively) in bilati gab; (G, H,&I at 35, 45,& 53-55 DATs, respectively) in china cherry; and (J, K, L at 45, 55, & 65-67 DATs, respectively) in kumbhi.

placentation axile, style long and persistent (Table 7). Rahman *et al.* (2009) also described the flower of kumbhi borne in a cluster of raceme, bisexual, large, sepals 4-5, petals 4-5, free, stamen long and many (500), stigma long, ovary 4-5 locular inferior with many ovules. Das and Alam (2001) also reported that flowers are large, 5-10 cm across, white and pink, with an unpleasant smell in few flowered clustered at the end of branches. Das and Alam (2001) and Rahman *et al.* (2009) described a few floral characters but in the present study the detailed qualitative and quantitative floral characteristics had been studied in Table 7 and 8. Locally juices from light green fleshy ripe fruits are reported to edible but sedative in nature. Like the china cherry, fruits of kumbhi also required around 2 months (65 DAT) to mature. The length and diameter of fruit reached maximum (7.45 cm and 19.71 cm for length and diameter, respectively) at 65 DAT. The fresh and dry weights of fruits and seeds also reached maximum at 65 DAT. The present result is similar to Rahman *et al.* (2009) who reported that berry of kumbhi was 7.48 cm long 19.71 cm diameter and attained maturity around 65 DAT.

In summary, inflorescence is axillary cyme, solitary or cluster of 2-7 in deshi and bilati gab; solitary or cluster of two in china cherry, and spike in kumbhi. Flowers are monoecious in deshi and bilati gab, and hermaphrodite in china cherry and kumbhi but fruits are berry in all species. In deshi gab, floral parts consist of 3-5 sepals and petals in both male and female flowers, 25-55 stamens in male and monocarpellary ovary in female; in bilati gab, sepals and stamens are 3-5 in either sex, petals are 5 in male flower but 4 in female flower, syncarpous ovary with 4 carpels; in china cherry, sepals and petals are 5-6, stamen numerous with 5-7 carpels; and in kumbhi, sepals and petals are 4 or 5, stamen numerous with 4 carpels. In deshi gab, average size of sepal was 0.95cm x 0.69 cm (length x diameter), petal was 2.0 cm x o.85 cm, and stamen was 0.54 cm long; in bilati gab, sepal was1.04 cm x 1.03 cm (length and diameter), petal was 1.78 cm x 2.32 cm and stamen was 0.46 cm long; in china cherry, sepal was 0.80 cm x 0.216 cm (length and diameter), petal was 1.14 cm x 0.86 cm and stamen was 0.481 cm long; and in kumbhi, sepal was 1.03 cm x 1.34 cm (length and diameter), petal was 4.68 cm x 2.14 cm and stamen was 5.84 cm long. Results also show that all the morphological characters of fruits were increased gradually with increasing ages (days after tagging) and fruits may be harvested at physiological maturity by observing fruit size (11.2, 35.33, 0.33and 30.25 g fruit^{-1} at 60, 83, 53 and 65 DAT in deshi gab, bilati gab, china cherry and khumbi, respectively) and visual colour change.

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Root-knot nematode - a threat to brahmi (*Bacopa monniera)*

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ABSTRACT

Generally leaves, roots, flowers, barks of brahmi are most commonly used raw materials and interestingly these parts of the plants are more susceptible to the attack of insect-pest, diseases and nematodes and as a result quality of the raw materials which ultimately lead to the economic losses. During a survey programme this brahmi plant was found to be susceptible for root-knot nematode. The infected plants show the characteristics symptoms of stunted growth in patches, yellowing and drying of the plants from the tip and when infected plants uprooted small galls were observed in the roots. The small knot like galls were appeared in the main as well as on the lateral roots, the size of the galls was about 0.25-0.5 cm in size. Histopathology of the infected roots revealed that the second stage juvenile (J_2) initially penetrated in the root cortex and then move to the cortical layer of the cells and started feeding. During the feeding process they developed metabolically highly active permanent feeding cells in the vascular system of the plant by the hyperplasia and hypertrophy of the parenchymata cells and thus thereby affecting the translocation of the nutrient to different parts of the plants and leading to the collapse of the plants.

Keywords: Brahmi, root-knot nematode, histopathology, feeding cell,

INTRODUCTION

North-east India which is ecologically represented by the Eastern Himalayan biome and one of the biodiversity hotspot which harbours numbers of endemic and extinct flora and fauna (Schedule I species) as compared to other parts of India. According to an estimate, medicinal and aromatic plants occupy an area of about 2,50,000 hectares producing raw materials worth Rs. 500 crores, generating business opportunities of more than Rs. 5000 cores. According to WHO the global market of medicinal and aromatic plants as herbal product is estimated to be US $ 62 billion and it is expected to reach to the tune of US $ 5 trillion by 2050 (Anon, 2009). With the increasing interest in the use of natural products of plant origin for pharmaceutical industries there is also concerned on quality of the raw materials. Generally leaves, roots, flowers, barks are most commonly used raw materials and interestingly these parts of the plants are more susceptible to the attack of insect-pest, diseases and nematodes and as a result quality of the raw materials which ultimately lead to the economic losses.

Bacopa monniera commonly known as "brahmi", is an annual succulent, creeping plant with numerous branches, rooting at the nodes belonging to family Scrophulariaceae and grows naturally throughout the North-eastern states of Indian subcontinent in wet soil, shallow water, damp and marshy areas. The literal meaning of the word "Brahmi" is "energy or shakti of Brahman". Brahmi was used in traditional medicine from centuries ago and presently it is used as a brain and mental tonic to treat Alzheimer disease, memory loss, insanity, insomnia and other mental illness. It has great value in Ayurvedic medicine due to the present of active constituents such as alkaloids, sterols, saponins, betulic acid, stimastorol, betasitosterol, bacoside and bacopa saponins. The active constituent bacoside has released the naturally occurring nitric oxide which relaxes the aorta and vein allowing smooth blood flow that nourishes the nerve cells, improving cognitive capability; promote mental clarity and focus and thus this plant become most important in pharmaceutical industry.

These medicinal plants are highly susceptible to number of insect pest, diseases and nematodes. A very few information are available on the nematode pest of medicinal plants particularly on Brahmi. Deuri *et.al.* (2013) reported the present of root-knot nematode from the roots of Brahmi plant from Jorhat district. Since the Brahmi is the second in the list of most traded medicinal plant, therefore

an effort was made to study the morpho-anatomical changes in the roots of Brahmi due to the infection of *Meloidogyne incognita*.

MATERIALS AND METHODS

Histopathology

During a random survey programme, roots of *M. incognita* infected Brahmi plants were collected from cultivated as well as non cultivated areas of Jorhat district. The roots were cut into bits of 1-2cm length and fixed in F.A. A. (Formalin Acetic-Alcohol) and processed for histological studies according to standard procedure given by Sass (1964). Dehydration was carried out in a serial concentration of ethanol (50, 60, 70, 80, 90 and 100) per cent for 2-3 hrs in each solution. Then it was cleared in a mix of absolute ethanol and xylol (3:1) for 3 hrs and subsequently passed through 2:2 and 1:3 ethanol and xylol. The dehydrated root tissues were infiltrated with paraffin wax (60°C) to replace alcohol and then embedded in clear paraffin and made into blocks which were turned into turned after hardening. Sections of 10-15µm thickness were cut with a rotary microtome on a clean glass slide smeared with 'Mayer's albumin'. The ribbon sections were placed on 2-3 rows on clean glass slide. A few drops of water were added and the ribbon was stretched by passing the slide on the flame of a spirit lamp. The slide was dried overnight in an incubator at 40°C.

Processing of slide

The wax of the ribbon in the slide was dissolved by dipping in xylol for 2-5 minutes. The slide is then passed through absolute ethanol (95, 70, 50, 30) per cent and distilled water for 2-5 minutes in each solution. The slide was stained for 1-2 hrs in 1 percent Saffranin solution. The excess of stain was washed in distilled water until the slide was then passed through (30, 50, 95) per cent ethanol for 5 minutes in each solution. It was then counterstained with fast green for 5-30 second. Then the slide was passed through absolute ethanol and was cleared in cloved oil for 5-10 minutes and then the slide was mounted in DPX mounting. DPX mounting is a chemical used to observe a nematode finally in the microscope.

RESULTS AND DISCUSSION

The brahmi plants were found to be susceptible for root-knot nematode during the survey programme. The infected plants show the characteristics above ground symptoms of stunted growth in patches, yellowing and drying of the plants from the tip and when the infected plants were uprooted small galls were observed in the roots (Fig. A, B, C), which is the typical symptom of root-knot nematode infected plant.

The second stage juvenile is the infective stage of root-knot nematode. At this stage, juveniles of *M. incognita* initiated the penetration by puncturing action of stylet and entered into the roots (Fig. D). The transverse sections of roots exhibited severe infestation of nematode. After penetration, the 2nd stage juveniles were seen migrating towards vascular zone and then slowly settled down near the cortex (Fig. E). After settling down, the J_2 stage moults to J_3 and J_4 stages in feeding site and finally to adult females. Voracious feeding by females in adjacent cells caused cell damage.

After settling down, the J_2 stages moulted to J_3 and J_4 stages and were seen at one feeding site. These were finally developed into adult females. Females feeding in adjacent cells and caused cell damage thereby disintegrating cortical and vascular tissues.

The nematodes in vermiform stage remained oriented parallel to the vascular strands after development into mature females and then became perpendicular to the vascular strands. Development of nematode, formation of giant cells, hyperplasia and hypertrophy affected all kinds of tissues and apparently, it became difficult to locate endodermis, pericycle and structures of normal xylem and phloem. The findings are in conformity with Khan *et al*, (2010) on apple roots, Sayed *et al.* (2010) on mango roots and Robab *et al.* (2010) on soybean roots infected by *M. incognita*. The giant cell complex was induced near the nematode head but hypertrophied and hyperplasia cells were observed at a little distance surrounding the body of nematodes. The shape and size of giant cells were not uniform, some were ovoid, elongated or irregular shaped with dense cytoplasm and multinucleated condition (Fig. F). Occasionally the common cell wall between a giant cell and parenchyma cells was dissolved and this acts as

Fig. A Patchiness of the infected plants

Fig.B Chlorosis and yellowing of infected plant

Fig.C Galls form in the root of Brahmi plant

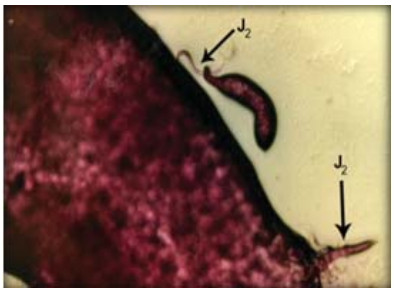

Fig. D Transverse section of brahmi roots showing partial penetration of second stage juvenile (J_2) of *M. incognita* **into the root**

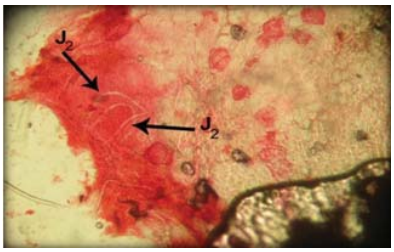

Fig. E Transverse section of brahmi roots showing partial penetration of second stage juvenile (J_2) of *M. incognita* into the root

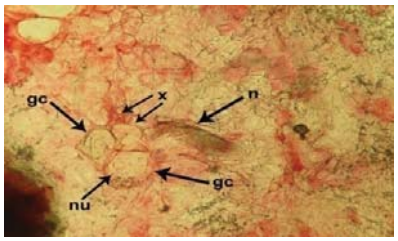

Fig. F Transverse section of brahmi roots showing *M. incognita* (n), Giant cell (gc), nucleus (nu) and broken cells (x)

feeding sites for adult female nematode. Deformation of vascular tissues at and near the feeding sites was a common observation. Hypertrophy and hyperplasia was commonly observed in both the cortical and epidermal cells. The adult females were seen laying egg masses in gelatinous matrix embedded in cells. Fully developed females with egg mass were usually surrounded by necrotic tissues causing onset of necrosis in the roots. The eggs and hatched juveniles were found within the necrotic rings and J_2 were found moving out of the necrotic ring in the starch of healthy tissue. These observations are supported by the findings of Dipali *et al.,* (2014) with similar developments in brinjal roots infested by root-knot nematodes.

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Ethnobotanical uses of wild fruits of Santal paraganas (Jharkhand)

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ABSTRACT

Santal Paraganas of Jharkhand harbours a wide range of forest cover including several significant trees, shrubs and herbs species. The indigenous and tribal communities like Mahalis, Santals, Paharias, Koras, Karmalis, Bhumijs, Kols etc. living in and around these forest areas use their traditional wisdom to meet their requirements utilizing various forest products in a sustainable way. Present study aims to analyse and record ethnobotanical uses of different wild fruits being used by these communities. Data was collected using participant observations and in-depth interviews. Intensive survey conducted in the area revealed a total of 30 different wild fruits species belonging to 29 genera and 21 families serving both as nutritional supplement and ethno-medicines, treating different ailments. Most of the species among these have the potential to contribute to future food and nutrition security, dietary and culinary diversification. There is an immediate need for further critical phyto-chemical analysis of these plant species and exploring new valid drugs for common use, before the extinction of this precious traditional knowledge.

Keywords : Wild Fruits; Ethnobotanical uses; Traditional; Nutrition etc.

INTRODUCTION

Santal Paraganas, derives its name from two words: "*Santals",* a major tribe of India and "*Paraganas*" a Persian word meaning district. It is being provided to the *Santals* by the British government. Presently, this administrative division comprises six districts of Jharkhand: Godda, Deoghar, Dumka, Jamtara, Sahibganj and Pakur (**Fig. 1**). The division is gifted by rich phyto-diversity of dry deciduous tropical forests and a vast range of topographic conditions with significant potential for health security, in the form of abundant ethnomedicinal plants, for nutrition security as various wild-edibles and other Non-Timber Forest Products like fibres, gums, resins, latex etc. Apart from the rich phyto-diversity it also has a rich cultural diversity of different indigenous and tribal communities as *Mahalis, Santals, Paharias, Koras, Karmalis, Bhumijs, Kols* etc. living in and around the forest areas. The region is the abode of mainly two tribal communities *Santals* and *Paharias,* with a mixed Bengali culture, being close to West Bengal. Apart from their primary occupation of cultivation (either settled or Shifting locally called *Jhum* Cultivation), they use to collect diverse forest products.

Of diverse forest produces, fruits are also one of the significant forest products growing wild in the region. By definition, a fruit is the seed bearing structure in flowering plants formed from ovary after flowering. Fruits are generally rich in fibres, vitamins and of course water. Regular consumption of various seasonal, either wild or cultivated, fruits are associated with reduced risks of several diseases and age related various functional disorders. These wild fruits not only satisfy the nutritional supplements rather are also used by these communities to treat various ailments.

The herbal medicines are considered significant among different rural or indigenous communities in many developing countries like India (Ghosh, 2003). People all around the world prefer herbal medicines than other system of treatments. According to the World Health Organization as many as 80% of the World's population depends on traditional medicine and in India 60% of the people in rural areas use herbal medicines (WHO, 2002). Plant based traditional medicine in India is as old as human civilization and has been documented in ancient literatures (Charak, 1996). This age old ethnic knowledge or folklore of these communities has evolved out of extensive trial and error methods to meet their daily needs including health care, nutrition supplement, religious and cultural activities, etc. from different forests produces. But, unfortunately, it is handed over verbally from their ancestors to the successive

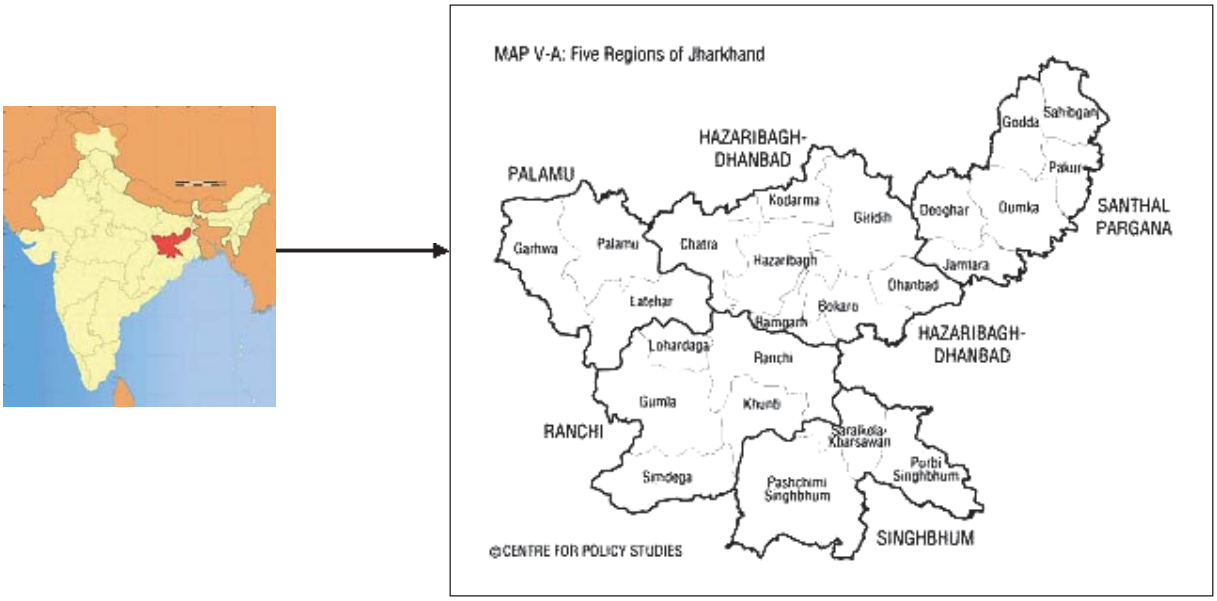


Fig. 1. Map representing the study area Santal Paraganas of Jharkhand.

generations, without any scientific documentations, compilations, standard pharmacopoeia preparations, etc. Moreover, rapid economic and cultural changes is increasingly threatening the traditional lifestyles of these peoples, gradually they are migrating to their neighbouring state to earn their livelihood and working there as labourers on daily wages. Hence we seek to conserve this knowledge along with these communities before their extinction.

Although several ethno-botanists like Bodding (1925); Roy Chaudhary (1957); Hembrom (1991); Jain (1998); Verma *et al.* (1999); Kumar (2014); etc. have worked in this field, still a major portion of the region is still unexplored. Many ethno-botanical studies (Borthakur and Gogoi (1994); Rao (1996); Jain (1998); Pei Shang-Ji (2001) have also showed that inventory preparations of indigenous knowledge through ethno-botanical studies are important for the conservation as well as sustainable utilization of the bio-resources. Present study is an endeavour in this direction.

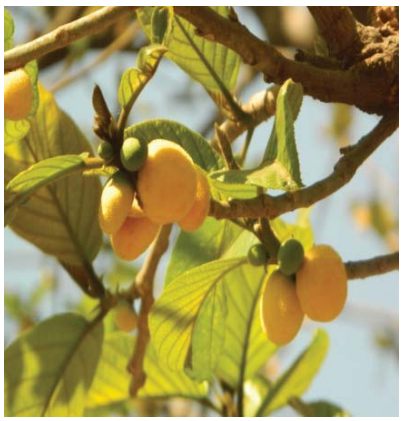
MATERIALS AND METHODS

For the purpose different tribal areas located in the different districts of Santal Paraganas were surveyed regularly since 2012-2017. The first hand data were collected through interviews and with the help of local guides, villagers, local herbal practitioners and tribal persons, women who had the traditional knowledge of plants. They have quite deep knowledge about the herbal medicines. The tribal herbal practitioners locally called *Jangurus, Ojhas, Kavirajs, Vaidyas, Pahans, Manjhis, Horopaths,* etc. were interviewed to collect information about the description of the plants of different wild fruits and their medicinal uses. At the same time, field visit were also undertaken along with the villagers in the local markets called *Haats* or *Hatias*. Following the first hand data given by these people, a total of 30 wild fruits species were collected and properly tagged with their local names, from this region. Plants species were visited regularly in different seasons in order to observe the species in their natural flowering and fruiting condition. Collected plants were processed and herbarium specimens were prepared following standard herbarium techniques (Jain and Rao, 1977) and identified consulting available literatures (Haines,1921-1925; Kirtikar & Basu, 1935; Anonymous, 1948-72; Chopra *et al.*,1956; Nayar *et al.,* 1989 and Jain and Mudgal, 1999).

RESULTS AND DISCUSSIONS

Ethnobotanical survey of the area revealed that this area has been gifted with rich phyto-diversity. A large number of plant species are growing in the wild enriching the floristic diversity of this region. Different plant species though uncommon contribute to the nutrition of these tribal and indigenous communities significantly.

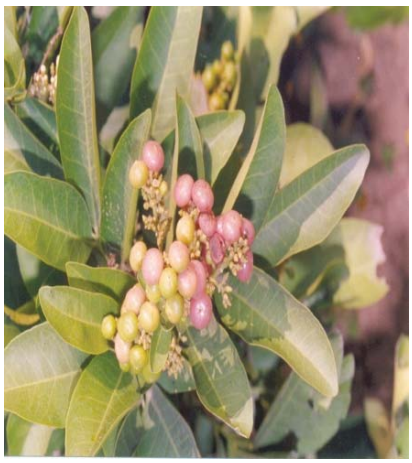
A. *Alangium salvifolium* (L.*f*.) Wang.



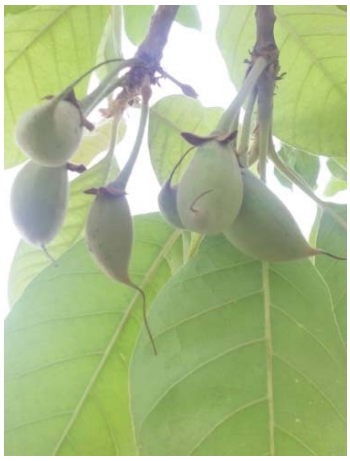
B. *Artocarpus lacucha* Buch.- Ham.

C. *Cordia dichotoma* G. Forst.

D. *Diospyros melanoxylon* Roxb.



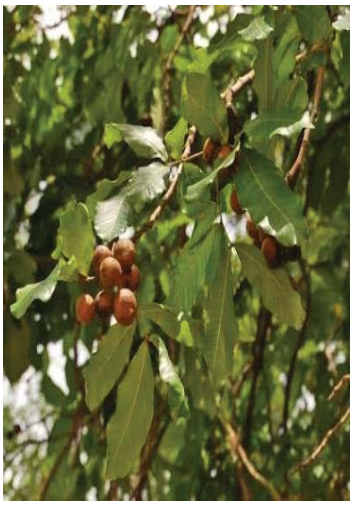
E. *Glycosmis pentaphylla* (Retz.) DC.



F. *Madhuca longifolia* (Koen) Mac Br.

G. *Neolamarckia cadamba* (Roxb.)

H. *Pithecellobium dulce* (Roxb.) Benth.



I. *Schleichera oleosa* (Lour) Merr. Bosser

All together, a total of thirty wild edible fruits belonging to 29 genera and 21 different families have been enumerated. These species have been enumerated depicting their scientific names arranged alphabetically along with their voucher specimen number in parentheses, followed by local names, families and their actual therapeutic uses (Table 1.).

Most of the species (25) are trees with two (2) shrubs species like *Carissa spinarum* L., *Glycosmis pentaphylla* (Retz.) DC, two (2) herbaceous species like *Physalis minima* L., *Solanum nigrum* L. and a single climber species *Cucumis melo ssp. agrestis var. Agrestis* Naud. Most frequent families are Sapotaceae and Anacardiaceae (3 species),

Table 1. List of ethnobotanical uses of wild edible fruits of Santal Paraganas of Jharkhand

Sl. No.	**Scientific Name** (Voucher Specimen number)	**Local Name**	**Family**	**Therapeutic uses**
1	*Alangium salvifolium* (L.*f*.) Wang. (AD- 239)	Dhela (S), Akola (IC)	Cornaceae	Fruit pulp is effective in controlling mucus and relieves constipation.
2	*Annona reticulata* L. (AD- 305)	Gom(S), Ramphal (IC)	Annonaceae	These are used to treat diarrhoea and dysentery.
3	*Artocarpus lacucha* Buch.-Ham.(AD- 692)	Barhal (S), Dahua(IC)	Moraceae	Jams and pickles are prepared out of these fruits. These are good for liver.
4	*Borassus flabellifer* L. (AD-699)	Tal (S), Tar (IC)	Arecaceae	Ripened fibrous outer layer of the fruits contain sweet juice which is either eaten raw, boiled, or deep fried to prepare sweet dishes.
5	*Buchanania lanzan* Spreng. (AD-569)	Piyar, Chironji (IC)	Anacardiaceae	The kernels as a whole are eaten as a substitute for almond kernels. Seeds treating skin infections. A face pack made with the seeds and milk brings extra glow to the face.
6	*Carissa spinarum* L. (AD- 612)	Jangli Karaunda(IC)	Apocynaceae	Useful in headache and vomiting. It is also eaten raw or as pickles.
7	*Cordia dichotoma* G. Forst. (AD- 701)	Lasora (IC)	Boraginaceae	Immature fruits are pickled. Seeds of the fruits are used to expel intestinal worms.
8	*Cucumis melo ssp. agrestis var. Agrestis* Naud. (AD- 606)	Kachri (IC)	Cucurbitaceae	Fruits are edible and are also called wild melon due to similar appearance. The fine powder of the fruits is the best natural meat tenderizer. Chutney of the fruits has a tangy taste.

Sl. No.	**Scientific Name** (Voucher Specimen number)	**Local Name**	**Family**	**Therapeutic uses**
9	*Diospyros melanoxylon* Roxb. (AD- 394)	Kend (IC), Terel (S)	Ebenaceae	Cures dysentery, Paste of unripe fruits is applied as poultice over the fractured bones. Enhances healing process.
10	*Ficus racemosa* L. (AD- 388)	Dumbari (IC), Loa (S), Gular	Moraceae	The fruits are given in menorrhagia, bronchitis, dry cough and diseases of kidney. Urinary troubles & Diabetes are also treated.
11	*Flacourtia indica* (Burm. *f*.) Merr. (AD- 298)	Boichi (IC), Serali (S, P)	Salicaceae	Cures liver disorders
12	*Glycosmis pentaphylla* (Retz.) DC. (AD- 307)	Ansh sheora (S)	Rutaceae	Edible translucent pink sweet and fleshy fruits are eaten raw.
13	*Holoptelea integrifolia* (Roxb.) Planch. (AD- 702)	Chilbil, Papri (IC)	Ulmaceae	Fruits edible. Paste of the seeds is useful in treating ringworm.
14	*Limonia acidissima* L. (AD- 314)	Kath bel (IC), Kainta	Rutaceae	Pulp of the fruits with honey and 'Pipli' (*Piper longum*) is given to cure hiccup and difficulties in breathing. Pulp is also used for curing infections of gums and to tone the breast. It also cures diarrhoea & dysentery.
15	*Madhuca longifolia* (Koen) Mac Br. (AD- 626)	Mahua	Sapotaceae	Fruits are eaten either raw or after cooking.
16	*Manilkara zapota* (L.) P. Royen (AD- 291)	Sapatu (IC), Chikoo	Sapotaceae	Eaten both raw and after ripening. These taste delicious.
17	*Mimusops elengi* L. (AD- 646)	Bakul (IC)	Sapotaceae	Helpful for dental ailments such as bleeding gums & dental carries.
18	*Neolamarckia cadamba* (Roxb.) Bosser (AD-270)	Kadam (IC)	Rubiaceae	Fruits are edible and are eaten either after cooking or even raw. These fruits quench excessive thirst in fevers. These also reduce excessive burning sensation and increase lactation in nursing women.
19	*Phyllanthus emblica* L. (AD- 343)	Amla (IC), Meral (S)	Phyllanthaceae	Ripened fruits are eaten to stimulate appetite. Of great medicinal potential. It conditions stomach, one of the ingredients of "Triphala", in Ayurveda.

Sl. No.	**Scientific Name** (Voucher Specimen number)	**Local Name**	**Family**	**Therapeutic uses**
20	*Phoenix sylvestris* (L.) Roxb. (AD- 399)	Khajuri, Pin-khajur(IC)	Arecaceae	The fruits are good in heart complaints, vomiting and constipation.
21	*Physalis minima* L. (AD- 661)	Bantapari (IC)	Solanaceae	Fruits are roasted in coconut oil and given to treat spleen disorders. Also improves appetite.
22	*Pithecellobium dulce* (Roxb.) Benth. (AD- 582)	Jangli jalebi (IC)	Fabaceae	The pulpy ripened fruits are sweet in taste. These also cure ulcers.
23	*Schleichera oleosa* (Lour) Merr. (AD- 709)	Kusum (IC)	Sapindaceae	Unripe fruits are pickled. These also improves appetite
24	*Semecarpus anacardium* L. *f.*, (AD- 570)	Bhelwa (IC), Soso(S), Bale(P)	Anacardiaceae	Red-Orange part of the fruits are eaten and is considered good for female reproductive system
25	*Spondias pinnata* (L.*f.*) Kurz. (AD- 371)	Amra (IC)	Anacardiaceae	The fruits are fabulous in taste. These are eaten both as vegetable and as fruits after ripening. These are used in treating indigestion and nausea.
26	*Solanum nigrum* L. (AD- 231)	Makoi	Solanaceae	Fruits edible and fruit juice is used in gastritis and acidity.
27	*Syzygium cumini* (L.) Skeels (AD- 114)	Sokod (S), Jam (IC), Jamun, Nudgey(P)	Myrtaceae	Decoction of the fruits and seeds is given to control diabetes and urinary troubles.
28	*Terminalia catappa* L. (AD- 695)	Badam (S) (IC)	Combretaceae	The kernel of the fruits eaten fresh and also relieves constipation but high doses can cause diarrhoea.
29	*Ziziphus mauritiana* Lam. (AD- 397)	Kul, Ber (IC)	Rhamnaceae	Used as a cooling agent. Fruits are eaten fresh, dried, candied or stewed. Kernels are used in the treatment of nausea, vomiting and for abdominal pain in pregnancy.
30	*Ziziphus oenoplia* (L.) Mill. (AD- 592)	Makora, Mahkoa, Jangli Ber, Siakul (IC)	Rhamnaceae	Used as a cooling agent. Fruits are used in the treatment of dysentery.

*(S)- *Santal* Community, **(P)- *Paharia* Community, ***(IC)- Indigenous Communities like *Mahalis, Bhumijs* etc.

followed by Moraceae, Arecaceae, Rutaceae, Solanaceae (2 species each) followed by single species of each of the rest families.

These wild edibles including various fruits are the natural, low calorie content, vitamins, minerals and fibres rich diet. These are easily available to them in natural and fresh condition without any chemicals and preservatives, enriching their nutrition more than that are found in urban areas (Das and Bondya, 2016). Some of these are quite tasty and fabulous in appearance too. These wild fruits can withstand harsh climatic condition and also these do not need much care to grow. After collecting, these fruits are also sold in the local markets called "*Hatias* or *Hats*" for earning their livelihood.

The plant species like the *Borassus flabellifer* L., *Phoenix sylvestris* (L.) Roxb. etc. are also used in the preparation of typical cultural alcoholic beverages known as *Tadi*. The latter is often taken by them for celebrating different festivals. *Cordia dichotoma* G. Forst. yields a natural gum used in different purposes as adhesives. So, these in turn add values to the under- utilized wild edible species. Plants like *Madhuca longifolia* (Koen) Mac Br. yield different useful products from its flowers, fruits and seeds. *Mahua* (*Madhuca longifolia* (Koen) Mac Br.) oil and *Kusum* (*Schleichera oleosa* (Lour) Merr.) oil are also edible and can be used variously. These people have esteemed their surrounding phyto-diversity in their culture and tradition. It is a matter of fact that the ritualistic, symbolic & religious associations with bio-resources are deeper rooted than the material uses of bio-resources (Ford, 1994). This healthy blending of the bio-resources and their cultural attachment is also a crucial approach of sustainable utilization and conservation of these bio-resources in this region.

Although these plant species do have significant medicinal potential in addition to their edible and other miscellaneous values yet these are neglected in terms of their utility. Ethno-medicines utilized by these indigenous and tribal communities including the herbal healers can no doubt prove the best medicines to discover new drugs or escort active bio-molecules for the development of new drugs, provided the formulations and data should have integrated scientific approaches. Intensive pharmacological, phytochemical, nutritional analysis of different plants species utilized by these tribal communities is the need of the hour. Also, approaches towards the large scale cultivation, sustainable utilization and conservation of the important plant species are equally needed. This will in turn lead to future food and nutrition security, dietary and culinary diversification and ultimately resulting in better health and income generation of the society.

In addition, efforts should be made to recognize IPR (Intellectual Property Rights) of these ethnic communities to sustainably utilize their precious knowledge and conserve this for our future generation **(**Borathakur & Gogoi, 1994**)**.

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SHORT COMMUNICATION

Study on performance of three fig cultivars in laterite zone of West Bengal

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ABSTRACT

A study was made with three exotic figcultivas viz., Deanna, Excel and Conadria to know their performance in laterite zone of West Bengal. The study was made on 3rd, 4th and 5th year old plants. Preliminary results indicated that Deanna showed lowest plant growth in terms of growth increment in plant height, basal girth and plant spread with maximum branch production which ultimately resulted in highest fruit production. Fruit weight was highest in Deanna (44.0 g) and lowest in Conadria (33 g). Fruit quality in terms of TSS, total sugars and reducing sugars were not in acceptable range but acidity in all the three cultivars was low. From the initial study, it was concluded that Deanna can be recommended for commercial cultivation in laterite zone of West Bengal. But fruit quality should be improved by agronomical manipulation.

***Keywords*:** Exotic Figs, performance, laterite soil.

The edible fig (*Ficus carica* L.), belongs to the family Moraceae, is growing in India mainly some localized areas like western part of Maharashtra (adjoining areas of Pune and Aurangabad), Gujarat, Uttar Pradesh (Lucknow and Saharanpur), Karnataka (Bellary, Cnitradurga and Srirangapatna) and Tamil Nadu (Coimbatore) (Dalal *et al*., 2017). The fresh fruits are delicious and have a luscious taste. The fig fruits are important for both as food and traditional medicine. In most of the areas in India the fig varieties viz., Poona fig and Dinkar are grown and these varieties are not found to be suitable for preparation of dried fig for various seasons such as low TSS, high acidity, lathery appearance and poor taste of final product (Gawade and Waskar, 2002). Introduced exotic figs like Deanna, Conadria and Excel are reported to be remunerative and suitable for preparation of dried figs (Jalikop and Sampath Kamar, 2000; Gawde and Waskar, 2002). Performance of these 3-exotic fig varieties have been studied under Bangalore condition (Jalikop and Sampath Kumar, 2000) and Rahuri (Maharastra) condition (Gawade and Waskar, 2002) and reported to be good in both the condition. Considering their well performance in varied agro-climatic condition and having various good horticultural traits, there cultivars were taken for study in the laterite zone of West Bengal where soil is porous and rainfall is low as compared to other parts of the state.

Three fig cultivars namely Deanna, Excel and Conadria were collected from Indian Institute of Horticultural Research, Bangalore and planted in a filed at Jhargram, Paschim Medinipur during 2007 at a spacing of 3m x 3m. In each variety there was six plants and planted in a row. The soil of experimental site was laterite, having pH 5.8. The area receives annual rainfall about 1100 mm to 1600 mm mainly during June to September. Growth parameters like plant height, basal girth, plant spread, number of primary and secondary branches were recorded at the plant age of 4th to 5th year (2011 and 2012). Number of fruits/plant was recorded at the plant age of 3rd (2010), 4th (2011) and 5th year (2012). Fruit weight, fruit length, fruit diameter, TSS, acidity, total sugar and reducing sugars were recorded in all three years and average of the parameter have been presented.

It is clear from the data in Table 1 that plant height was minimum of 240 cm (Conadria) and maximum of 280 cm (Excel) at the age of 5th year. Plant height of these varieties as noted under Bangalore condition was 90 cm in Conadria; 138 cm in Excel and 156 cm in Deanna at the age of 30 month (Jalikop and Sampath Kumar, 2000). Growth in terms of increase in plant height was maximum in

Table 1 : Plant growth of three Fig cultivars under Jhargram Condition

Cultivars	Plant Growth												Number of primary branches/ plant	Number of secondary branches/ plant
	Height (cm)			Basal girth (cm)			Plant spread towards East-West (cm)			Plant spread towards North-South (cm)				
	2011	2012	% of increase	2011	2012	% of increase	2011	2012	% of increase	2011	2012	% of increase		
Deanna	200	250	25.0	21.8	30.8	41.3	220	260	18.2	130	280	115.4	4	48
Excel	200	280	40.0	17.5	27.5	57.1	250	330	24.2	120	270	125.0	2	25
Conadria	160	240	50.0	15.0	23.3	55.3	180	230	27.7	110	240	118.2	2	35

Table 2: Fruit yield and physico-chemical characteristics of fruits of three fig cultivars

Cultivars	Number of fruits/plant				Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	TSS (^{0}B)	Acidity (%)	Total sugar (%)	Reducing sugar (%)
	2010	2011	2012	Average							
Deanna	28	62	19	39.8	44.0	5.1	5.5	9.9	0.14	6.7	5.1
Excel	26	10	13	17.3	38.0	5.0	5.2	8.3	0.17	7.0	3.1
Conadria	40	14	09	31.0	33.0	4.8	4.8	11.1	0.15	6.4	4.8

Conadria (50%) and lowest in Deanna (25%) in terms of increment in 5th year. Growth in basal girth was maximum in Excel (57.1%) and minimum in Deanna (41.3%). Growth in plant spread was also lowest in Deanna (18.2% towards East-West and 115.4% towards North-South) and can be considered as dwarf growth habit as compared to other two varieties. However branch production in terms of primary (4.0) and secondary branches (48) was highest in Deanna and lowest in Excel (2 and 25).

Fruit production in terms of number of fruits / plant was highest in Deanna in all the year (28 in 3rd year, 62 in 4th year and 19 in 5th year with on average of 39.8) and lowest in Excel (Average 17.3) (Table 2). Higher fruit production in Deanna may be explained from the fact that it had lowest plant growth but had maximum number of fruit bearing branches. It was noted that fruit production in different years was drastically varied irrespective of the cultivars which may be due to younger age of the plant.

The fruit weight and size were highest in Deanna (44 g weight, 5.1 cm x 5.5 cm size) and lowest in Conadria (31.0 g weight, 4.8 x 4.0 cm size) (Table 2). Fruit weight as observed by Jalikop and Sampath Kumar (2000) was 61.5 g in Deanna (highest) 34.0 g in Excel (lowest under Bangalore condition. From this comparison of results, it can be conferred that Deanna is performing well on under West Bengal condition also.

Highest TSS was recorded from Conadria (11.1 ^{o} B) and lowest from Excel (8.3 ^{0}B). Total sugar content varied between 6.4% and 7.0% and reducing sugar 3.1% and 5.1% in different cultivars. Fruit quality in terms of TSS and sugars in the cultivars was in the cultivars was not good as reported by Gawade and Waskar (2002). Fruit acidity was minimum in Deanna (0.14%) and maximum in Excel (0.17%) and result is agreement with the findings of Gawade and Waskar (2002) who also recorded fruit acidity 0.15% in Deanna and 0.19% in Excel.

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SHORT COMMUNICATION

Medicinal plants- *Simarouba glauca* and *Dillenia indica*

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Simarouba glauca

Simarouba is an attractive, exotic and versatile medicinal plant with numerous properties. Popularly known as *Lakshmitaru* in India and as *Paradise Tree, Aceituno, and Bitterwood* in its original home-Central and South America. Simarouba was introduced to India in 1960 by NBPGR in Amaravathi, Maharashtra. Later, during 1986 the scientists Dr Syamasundar Joshi and Dr Shantha Joshi at University of Agricultural Sciences, Bangalore made extensive studies and developed technologies for its uses and cultivation.

The Plant

Simarouba glauca is a medium-sized tree and at full grown stage attains 20 m high, with a trunk 50 to 80 cm in diameter. It produces bright green leaves 20 to 50 cm in length, small white flowers, and small blackish purple or yellowish green fruits. It is indigenous to the Amazon rainforest and other tropical areas in Mexico, Cuba, Haiti, Jamaica, and Central America.

Uses

All the parts of Simarouba are useful. Timber from Simarouba is light, moderately strong, attractively grained and can be used to manufacture household furniture and other products. Its leaf litter can be used for vermicompost making. The organic manure produced from one tree is 20 kg from leaf litter and pulp waste, apart from the de-oiled seed cakes.

Seed usage

The seeds contain 60-75 per cent oil, the highest from any plant which means a yield of around 2,000 kg of oil per hectare may be obtained.. The edible seed oil from *Lakshmitaru* tree is the only plant source of top quality vegetable oil.

Seeds can also be used to generate bio-diesel and various oil-based industrial products. The bio-fuel from *Lakshmitaru* is far superior bio-fuel plants like *Neem*, *Pongamia* and *Jatropha.*

The de-oiled cake makes for a nitrogen-rich manure.

Health benefits

Anti-luekemic and anti-cancerous properties: Simarouba has 11 medicinally important quassinoids, the active principles in the tree, that have antimicrobial properties and quassinoids namely ailanthinone, glaucarubinone, dehydroglaucarubinone and holacanthone that are anti-luekemic and anti-cancerous. Cancers of the mouth, lungs, ovaries and breast may be cured using Simarouba.

- The anti-cancerous properties of the leaf and bark extract can cure I and II stage cancer and improve the quality of life in the III and IV stages.
- All illnesses caused by microbes like bacteria, viruses, protozoa like Chikungunya, hepatitis, herpes, malaria, viral coughs and colds, dental caries can be effectively cured by consumption of a decoction made from leaves and bark of the tree.
- *Lakshmitaru* can make a complete recovery or drastic improvement from various conditions such as gastritis from *Helicobacter pylori*, acidity, rheumatoid arthritis as well as various menstrual problems of women. Simarouba can expel worms.
- The fruit pulp contains 11-16 per cent sugars which can be used for healthy drink or can be used to produce ethanol. Waste fruit pulp can be used in vermicompost.

Table 1: Various part of plant of Dillenia indica having various chemical constituents

Parts	Chemical constitution
Stem, Bark	Tannin, sitosterol, dillenetin, betunaldehyde, betulinic acid, lupeol and stigmastero, betulin, kaempferol, rhamnetin, dihydro-isorhamnetin, myricetin, naringenin and quercetin.
Fruits	Arabinogalactan, Fixed oil, colouring matter, sterols, glycosides, saponins, proteins, free amino acids, sugars, free acids, anthraquinone and tasnnins.
Leaves	N-hentriacontanol, ?-sitosterol, betulin, betulinic acid and kaempferol.

Table 2: Various parts of Dillenia indica used in curing ailments

Parts	Uses
Leaf	Hydrocele and contraceptive: A handful of root is tied around the waist for hydrocele. For contraceptive uses, 1 young leaf of the plant is mixed with 1 handful of rice and soaked in water overnight. In the morning, rice and leaf is macerated and pithas (flattened and steamed food item) are made of the mixture and they are taken on empty stomach. Dysentery, promeho: One cup of juice obtained from squeezed young leaves is taken twice daily for 7 days. Juice of leaves and decoction are used in curing fever, cough, constipation, chest pain and for women having breast cancer. It is also used in defeating malaria like symptoms. The alcoholic extract of leaves is reported to have CNS depressant activity and also exhibits antioxidant activity due to presence of phenolics constituents. The leaves are used as laxative, tonic and astringents. It is used in treatment of gastrointestinal disorders including diarrhea, indigestion, colic, acidity, constipation, bloating, anorexia, stomachache and Respiratory tract disorders including asthma, bronchitis, pneumonia, cold, influenza, mucus, tonsillitis and sore throat
Seed	To enhance digestion: 1 teaspoonful of dried and powdered seed is taken to ensure better digestion
Fruit	This fruit is beneficial for assessing better appetite, to tackle weakness and rheumatic pain and used for garnish in indigenous ayurvedic medicine for nervousness. In addition to this, it is also used as a cosmetic for preventing dandruff.
Bark	Paste is applied on skin for dealing with dermatological problems. On the other hand bark is also used for production of charcoal. Bruised bark is applied as a cataplasm for patients with arthritis.

How to use?

Leaf and bark decoction as drinks are prepared in simple methods for use 2 to 3 times daily. Three mature and shade dried leaflets or dried 1.5 cm^2 bark pieces are cut into small pieces and place them in a stainless steel saucepan containing 200 ml water. The mixture is boiled in low flame for 3 minutes preferably at night. The saucepan is covered with a stainless steel plate and left as such overnight. In the morning, decoction is warmed and a teacup full is slowly swallowed in empty stomach. There should be a gap of 30 minutes for consumption of other foods. In the evening, the left over cut pieces of *Lakshmitaru* may again be used in a similar manner to prepare the decoction and may be consumed another cup 30 minutes prior to dinner.

Health hazards for contraindication

It is practically negligible. Consumption of high dosages would result in side effects like increased

Picture 1: Leaf and fruits of *Simarouba glauca*

Fruit

Leaf

Bark

Fruiting habit

Picture 2: Fruit, leaf, bark and fruiting habit of *Dillenia indica*

perspiration and urination, nausea, and/or vomiting.

Dillenia indica

Dillenia indica f. *elongata (Miq.)* Miq has originated from Indonesia and belongs to family Dilleniacea. It grows widely in tropical forests in western peninsula and evergreen forests of the sub-Himalayan tracts from Uttrakhand to eastwards Assam and southwards to central and southern India and also found in Bangladesh, Nepal, China, Sri Lanka and Vietnam.

It is an evergreen large shrub or small to medium-sized tree growing to 15 m tall. The leaves are 15-36 cm long, with a conspicuously corrugated surface with impressed veins. The flower is large, 15-20 cm diameter, with five white petals and numerous yellow stamens. The fruit is a 5-12 cm diameter aggregate of 15 carpels. Each carpel containing five seeds embedded in an edible but fibrous pulp.

The fruit is used in treating laxative problems, abdominal pain. Bark and leaves possess astringent properties, the alcoholic extract of leaves of this fruit had been reported to impact CNS depressant activities, seed have been reported to possess antimicrobial activity and fruits of *Dillenia indica* f. *elongata (Miq.)* Miq have been found to be rich in showing anti-oxidant activity.

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