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CONTENTS

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Effect of microbial inoculants on physiological and biochemical characteristics in jamun (*Syzygium cumini* L. Skeels) under different propagation substrates

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ABSTRACT

The seeds of jamun (*Syzygium cuminii* L. Skeels) were sown in different propagation substrates pre-treated with different doses of microbial inoculants under shade house condition at Experimental Block of Division of Fruit Crops, Indian Institute of Horticultural Research, Bengaluru, Karnataka to obtain healthy vigorous seedlings suitable for grafting and subsequent successful establishment in field. The Arka fermented coco-peat was found better than the mixture of sand, soil and FYM as propagation substrate in terms of most of the parameters like speed of seed germination as indicated by germination vigour index (29.18% higher), polyembryony (203.06% higher), leaf chlorophyll content (13.79% higher chlorophyll a, 7.14% higher chlorophyll b and 12.03% higher total chlorophyll) and leaf total carbohydrate content (50.82% higher). Among different microbial inoculants, Arka microbial consortia (mixture of *Azotobacter tropicalis* strain PAN MC1, *Bacillus aryabhattai* strain Bel 6 and *Pseudomonas taiwanensis* Mpf2) @ 2.0% significantly improved speed of germination by 73.94% and seedling vigour by 179.70% and altered physiological and biochemical attributes in leaf such as chlorophyll a (69.23% higher), chlorophyll b (166.67% higher), total chlorophyll (87.50% higher), total carbohydrates (109.90% higher), total phenols (63.71% higher) and total antioxidants (82.95% higher), as compared to control. Thus Arka fermented coco-peat treated with 2.0% Arka microbial consortia prior to seed sowing can be used for quick raising of superior and healthy seedlings in jamun under shade house condition.

Key words: Arka fermented coco-peat, Arka microbial consortia, jamun, total phenols, total antioxidants

INTRODUCTION

Jamun (*Syzygium cumini* L. Skeels, family-Myrtaceae) is an evergreen tropical tree of many parts of Asia and Eastern Africa. It has been used worldwide in treatment of diabetes and has proven good anti-oxidant, anti-bacterial, antigenotoxic, anti-inflammatory and anti-HIV properties (Sagrawat *et al*., 2006). Seedlings are most vulnerable to mortality in their life cycle and germination determines when and where seedling growth begins (Llanes *et al*., 2005), thereby involving much cost and risk for obtaining seedlings and their subsequent maintenance till graftable stage. Nursery potting substrates influence the quality of seedlings produced (Agbo and Omaliko 2006), thereby influencing establishment in field (Baiyeri, 2006). The interaction between microbial inoculants and plant root system pave way to harness maximum benefits from microbial inoculants for improving plant growth (Raja *et al*., 2006). *Pseudomonas fluorescence* and *Trichoderma harzianum* have the potential to enhance seed germination as well as seedling vigour (Iqbal and Hasnain 2013; Priyarani *et al*., 1999). The microbial consortium, which is a group of different species of microorganisms that act together as a community, can complement functionally for plant growth promotion (Pandey and Maheshwari, 2007). The changes in total phenols and antioxidant activity induced in the host that are activated by microbial inoculation also develop resistance capacity in host against pathogens (Chakraborty *et al*., 2013). As seed germination is the first and most critical stage of plant development and the relative performance of individual plants during the early growth stage, including germination and plant establishment, can have more effects on growth and fitness (Houssard and Escarré 1991), the present study aimed to assess the potential of microbial inoculation for advancing seed germination and improving growth and antioxidant activity of jamun under different propagation substrates.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Block of Division of Fruit Crops, Indian Institute of Horticultural Research (IIHR), Bengaluru, Karnataka, India, in a shade house where availed 70% light, during May to August, 2013. The seeds were obtained from an open-pollinated seedling progeny maintained at the Experimental Farm of IIHR. The expected age of the tree was 20 years, having medium sized canopy and average fruit yield of 80 kg/tree/annum. The average fruit weight was 9.71 g with 3.87 cm length and 2.70 cm diameter, with total

soluble solids of 13.41˚B. The average weight of seed was 1.39 g. To improve seed germination and seedling growth, two factors were studied. The first one was the propagation substrates such as Arka fermented coco-peat (CP) and the mixture of sand, soil and farm yard manure (SS) in 1: 1: 1 (v/v) proportion. The preparation of CP was done at the nursery of the institute in 30 days by solid-state fermentation of raw coir pith using a consortium of the fungus *Aspergillus* having inoculum size of 20−50% (v/v) based on the volume of the mineral medium and a substrate average particle size of 375 µm. The second factor was microbial inoculants including control (T_0) such as Arka Microbial consortia 1.0% (10 g/ kg media) (T_1), Arka Microbial consortia 2.0% (20 g/ kg media) (T_2), *P. fluorescence* 1.0% (10 g/ kg media) (T_3), *P. fluorescence* 2.0% (20 g/ kg media) (T_4), *T. harzianum* 0.5% (5 g/ kg media) (T_5) and *T. harzianum* 1.0% (10 g/ kg media) (T_6). Arka Microbial consortium was a lignite based microbial product developed by IIHR that contains N fixing *(Azotobacter tropicalis* strain PAN MC1 – 2.1 x 10^9 CFU/ g), P & Zn solubilizing (*Bacillus aryabhattai* strain Bel 6 – 1.8 x 10^9 CFU/ g) and plant growth promoting microbes (*P. taiwanensis* Mpf2 – 3.2 x 10^9 CFU/ g) in single carrier. The culture of *P. fluorescence* was made in Kings B media and then raised in talc powder with spore count of 2.0 x 10^8 CFU/ g. The culture of *T. harzianum* was made in potato dextrose agar media and then raised in chalk powder having the spore count of 2.0 x 10^6 CFU/ g. Prior to seed sowing, the propagation substrates were separately treated with different doses of microbial inoculants and then filled in pro trays. Seeds were sown in those pro trays and then covered by wire net until the end of germination so as to protect the seeds from rodent attack. The experiment was laid out in a factorial completely randomized design. Each microbial treatment including control was replicated thrice with 10 seeds per replication. Watering was done with hand as when required. The seedlings were transferred after 30 days of sowing of seeds from pro trays to the poly bags of 26 x 10 cm (250 gauge) with two punch holes for drainage, filled with soil: sand: FYM (1: 1: 1) v/v. Data on seed germination was recorded regularly until no further germination upto 30 days after sowing. The germination percentage was calculated as the percent of germinating seeds in relation to the total number of seeds sown per replication per treatment. The polyembrony percentage was calculated as per cent of seeds producing multiple seedlings in relation to the total number of seeds germinated. Germination vigour index (GVI) was computed using the method as described by Hassanein (2010). Seedling vigour was calculated using the formula as given by Bewly and Black (1982). The leaf chlorophyll was estimated by the method suggested by Hiscox and Israelstam (1979). The different procedures were followed for estimation of biochemicals in leaf such as Anthrone method for total carbohydrates (Yemm and Willis 1954), Folin Ciocalteu method for total phenols (Singleton and Rossi 1965) and Ferric Reducing ability of Plasma (FRAP) assay for total antioxidants (Benzie and Strain 1996). The data obtained from the experiment were analyzed using Web Agri Stat Package version WASP2.0 (ICAR Research Complex for Goa, Ela, Goa- 403 402, India). The visual indication of data dispersion on bar and line graphs was achieved by means of standard error of the mean. Treatment difference was evaluated using least significant difference (LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Germination and growth behaviour

The microbial inoculants significantly influence the seed germination of jamun under different propagation substrates. The germination was significantly initiated by 3.29 days earlier and completed by 4.00 days earlier in CP than SS. The speed of germination was significantly higher in CP, as indicated by 29.18% higher GVI over SS, although there was no significant difference for germination percentage (Figure 1A & 1B). The earliness in seed germination might be due to the use of fermented coco-peat, which is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes (Awang *et al*., 2009). Among different microbial treatments, T_6 significantly took minimum days to initiate and complete germination (7.00 and 8.33 days earlier, respectively) and also recorded 73.94% higher GVI, as compared to control (T_0), though germination percentage was non-significant among the treatments. The results indicated the beneficial effects of microbial consortia over single inoculation (Raja *et al*., 2006). The interaction study revealed minimum days for initiation and completion of germination in T_6 treated seeds sown in CP, which were statistically at par with T_5 and T_3 treated seeds sown in CP for completion of germination. The GVI was also significantly higher in T_6 treated seeds sown in CP. Thus the improvement in seed germination rate due to interaction effect of T_6 and CP depicted higher magnitude of plant growth promoting activities in the case of consortia or mixed microbial cultures than single strain under CP.

Table 1. Response of jamun to microbial inoculants on chlorophyll content under different propagation media

Treatment	Chlorophyll a (mg g^{-1} f.w.)			Chlorophyll b (mg g^{-1} f.w.)			Total Chlorophyll (mg g^{-1} f.w.)		
	Different propagation media								
	CP	SS	Mean	CP	SS	Mean	CP	SS	Mean
T_0	1.18	0.64	0.91	0.17	0.25	0.21	1.34	0.89	1.12
T_1	1.13	1.20	1.16	0.41	0.44	0.42	1.53	1.64	1.59
T_2	1.25	1.07	1.16	0.47	0.41	0.44	1.72	1.48	1.60
T_3	1.29	1.30	1.29	0.43	0.46	0.45	1.72	1.76	1.74
T_4	1.18	1.42	1.30	0.49	0.48	0.49	1.67	1.90	1.79
T_5	1.46	1.15	1.31	0.55	0.42	0.48	2.01	1.57	1.79
T_6	1.75*	1.33	1.54*	0.63*	0.49	0.56*	2.38*	1.82	2.10*
Mean	1.32*	1.16		0.45*	0.42		1.77*	1.58	
For comparing the means of	S.Em±	LSD at 5%		S.Em±	LSD at 5%		S.Em±	LSD at 5%	
Propagation substrate (P)	0.06	0.02		0.01	0.02		0.09	0.05	
Treatment (T)	0.07	0.04		0.04	0.02		0.11	0.05	
Interaction (P × T)	0.07	0.05		0.03	0.04		0.09	0.08	

'*' indicates significance at LSD (0.05), n= 3.

Table 2. Response of jamun to microbial inoculants on biochemical changes under different propagation media

Treatment	Total Carbohydrates (mg g^{-1} f.w.)			Total Phenols (mg GA equivalent g^{-1} f.w.)			Total Antioxidants (mg ascorbic acid equivalent g^{-1} f.w.)		
	Different propagation media								
	CP	S	Mean	CP	S	Mean	CP	S	Mean
T_0	30.024	21.244	25.634	13.14	23.78	18.46	3.39	4.47	3.93
T_1	42.463	24.902	33.683	19.58	25.29	22.44	4.63	7.68	6.16
T_2	44.659	37.098	40.878	16.94	23.67	20.30	3.38	6.01	4.69
T_3	58.073	45.878	51.976	13.33	30.01	21.67	4.42	5.69	5.05
T_4	54.902	37.829	46.366	17.71	31.01	24.36	4.62	8.44	6.53
T_5	68.317*	32.463	50.390	25.76	25.66	25.71	5.93	7.48	6.71
T_6	65.634	41.976	53.805*	26.26	34.18*	30.22*	5.87	8.51*	7.19*
Mean	52.010*	34.484		18.96	27.66*		4.61	6.90*	
For comparing the means of	S.Em±	LSD at 5%		S.Em±	LSD at 5%		S.Em±	LSD at 5%	
Propagation Media (P)	8.763	0.003		4.35	0.05		1.15	0.02	
Treatment (T)	3.951	0.004		1.47	0.09		0.45	0.03	
Interaction (P × T)	3.834	0.005		1.72	0.14		0.46	0.03	

'*' indicates significance at LSD (0.05), n= 5.

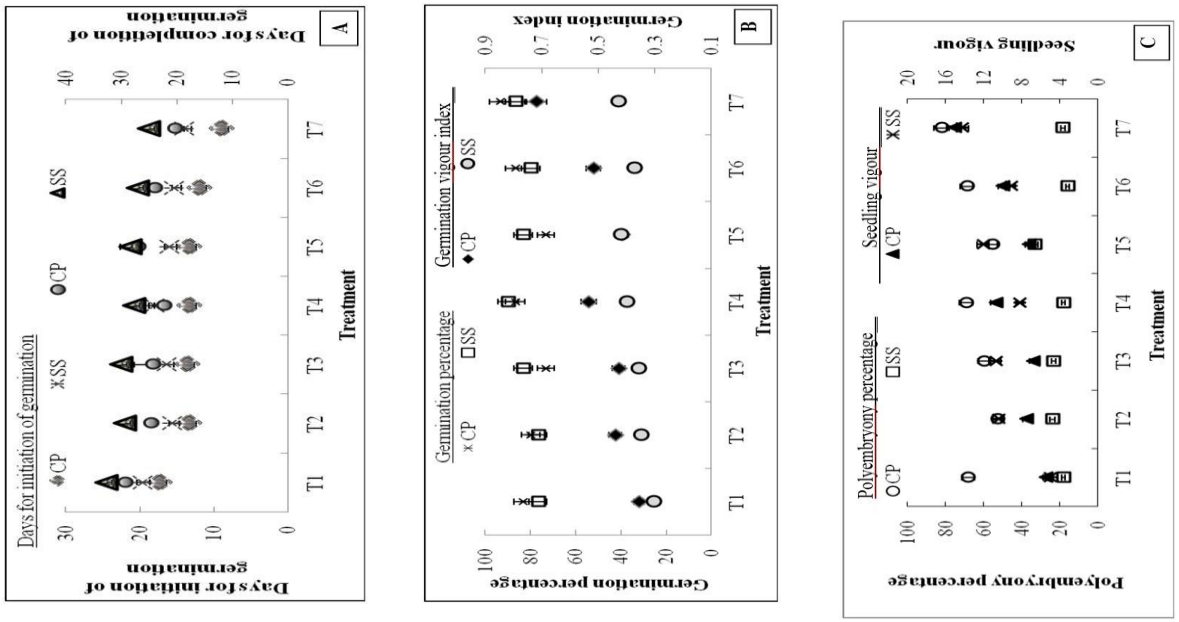

Figure 1. Response of jamun to microbial inoculants on (A) days taken for seedling emergence and completion of germination; (B) germination percentage and germination index; and (C) polyembryony percentage and seedling vigour under different propagation media.

The emergence of more than one seedling from a single seed due to polyembryony has been reported in jamun (Sivasubramaniam and Selvarani 2012). However, to our knowledge, this is the first report where we found significant effect of propagation substrate on emergence of multiple seedlings from a single seed (Figure 1C). The polyembryony was increased by 203.06% in CP than SS. Thus fermented coco-peat might have created favourable micro-climate for the germination of multiple embryos, resulting in emergence of multiple seedlings from single seed. However, application of microbial culture in propagation substrate did not have any significant influence on polyembryony.

The seedling vigour was non-significant among the seedlings raised in different propagation substrates (Figure 1C). However, among different treatments, it was significantly higher in T_6 over T_0 by 179.70%. The results indicated that microbial consortia prepared by mixing of different rhizobacteria produced a more pronounced influence while inoculation alone showed a lower effect on seedling vigour, as suggested by Stefan *et al.* (2013). Thus different bacteria present in consortia can act synergistically to stimulate the growth of host plant *via* production of plant growth promoters like auxin, gibberellins and cytokinins (Glick, 1995).

Physiological changes

The leaf chlorophylls (a, b and total) were significantly increased in CP over SS by 13.79, 7.14 and 12.03%, respectively (Table 1). Irrespective of propagation substrate, the leaf chlorophylls significantly recorded more in T_6 than T_0 by 69.23, 166.67 and 87.50%, respectively. The interaction effect revealed that CP and T_6 significantly interact to enhance the formation of leaf chlorophyll which might be attributed to their action on increasing availability of water and minerals due to improvement in plant growth mediated by microbial inoculants and coco-peat (Berg, 2009; Evans and Iles 1997).

Biochemical changes

The accumulation of total carbohydrates in jamun leaves was recorded 50.82% more in CP than SS (Table 2), which might be attributed to improved photosynthetic rate of seedlings under fermented coco-peat, due to improvement in hydraulic conductivity, porosity, water holding capacity, nutrient retention capacity and formation of humic substances in the rhizosphere having hormone-like activity (Prabhu and Thomas 2002). This parameter was also enhanced by microbial inoculation, regardless of propagation substrate, and the increase was 109.90% more in T_6 over T_0, which might be attributed to enhanced photosynthetic activity by microbial consortia (Stefan *et al.*, 2013). The interaction effect revealed significantly higher content of total carbohydrate in T_5 followed by T_6 under CP substrate.

The production of secondary metabolites like phenolics in plant is related to its growing condition (Saikia and Upadhyaya 2011). The accumulation of phenolic compounds in seedlings raised in CP than SS was lesser by 45.89% (Table 2), which might be due to better growing condition of plant as a result of better water maintenance ability of fermented coco-peat. The T_6 had significant effect on level of total phenols in leaf cytoplasm, regardless of any propagation substrate, and it was 63.71% more than that of T_0. The result is in agreement with that of Thiruveni *et al*., 2012). Thus increased level of total phenols among plants with more dose of microbial consortia inoculation could be due to reaction of host plants against microbial colonization, which thereby induced systemic resistance against pathogens (Chakraborty *et al*., 2013).

Total antioxidants in leaf was increased by 82.95% in SS than CP, as observed in Table 2, which might be associated with enhanced phenolics content in seedlings grown in SS (Vignesh *et al*., 2012). The T_6 had significant effect on production of total antioxidants, as compared to other treatments including T_0, regardless of propagation substrate. The elevated antioxidant activity due to microbial consortia could be correlated with increased stress tolerance (Stefan *et al.*, 2013). Similar results concerning antioxidant protective effects of microbial culture were previously reported by other authors (Vignesh *et al*., 2012). The interaction study revealed highest content of total antioxidants in T_6 under SS.

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Morphological variation of cinnamon (Cinnamomum verum Persl) germplasm in Matara District of Sri Lanka

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ABSTRACT

Forty seven representative cinnamon accessions were collected from Matara District of Sri Lanka to analyze the morphological variation of *Cinnamomum verum* germplasm. Morphological characters viz. Leaf length, Leaf width, Leaf length-width ratio, Petiole length, Leaf arrangement, Leaf shape, Leaf apex, Leaf base, Leaf texture, Upper surface leaf color, Flush color, Bark color, Bark surface, and Bark fragrant were recorded. Principal component analysis (PCA) using four quantitative morphological characteristics, indicated that the first two principal components (PCs) with Eigen values of more than one and accounted for 88.88% of the total variance. Cluster analysis classified 47 accessions into nine groups. The present study demonstrates a considerable diversity of morphological characters among the accessions that can be useful in germplasm management and future crop improvement programs.

Key words: *Cinnamomum verum* germplasm, morphological characters, Principal component analysis, Cluster analysis

INTRODUCTION

The genus *Cinnamomum* belongs to the family Lauraceae and consists of about 110 species of evergreen trees and shrubs (Purseglove *et al.*, 1969). Out of nine *Cinnamomum* species, *Cinnamomum verum* is one of the most important species in Sri Lanka which contributes to 70% of the world true cinnamon bark production (Abeysinghe *et al.*, 2009). The export volume of cinnamon and earning for 2012 was 14,435 metric tons and16,654.7 million rupees respectively (Sri Lanka Custom, 2012). Cinnamon is endemic to Sri Lanka and it had been found in central hilly areas of Sri Lanka and also in Sinharaja and Knuckles forest reserves. The ideal environmental condition for cinnamon is available in wet zone of Sri Lanka. However commercial cinnamon cultivation is carried out in intermediate zones of mid and low country, where annual rainfall is more than 1750 mm. Cinnamon is mostly cultivated along the coastal belts of Kalutara, Galle, Hambantota at an elevation of about 250 m above mean sea level. The most suitable temperature is between 25°C- 32°C (Department of Export Agriculture, 2013). Cinnamon bark is mainly used as a spice for flavoring food product and leaf oil is used as flavor ingredients and also in cosmetics and pharmaceutical industries (Paranagama *et al.*, 2001). Different biological activities including anti-diabetic, anti-inflammatory, astringent and diuretic effects have been popularized cinnamon in folk medicine (Lee *et al.*, 2010). In modern medicine, cinnamon is combined with other ingredients to treat diarrhea, internal hemorrhage, impotency, typhoid, halitosis, checking nausea and vomiting and for restoring normal skin color on the face (Warrier *et al.*, 1994).

According to Ravindran *et al.*, (2004) leaf shape of cinnamon varies from oval or elliptic to lanceolate-oval or narrowly elliptic, $3 \times 7 - 8 \times 25$ *cm, leaf apex shortly or broadly acuminate and leaf base acutish or cuneate.* A study by Wijesinghe and Gunarathna, (2001) showed correlation between leaf size and shape with yield in seven different types of true cinnamon. According to this observation trees with large round leaves and big leaves had high bark yield. Moreover bark oil (cinnamaldehyde %) quality is higher in the variety of inwardly curved leaves and high quality leaf oil was obtained from the small round leaves.

Cinnamon flower exhibits protogynous dichogamy and it is cross pollinated (Joseph, 1981). Thus, vegetative propagation is necessary for producing uniformly high yielding populations and for propagating elite lines (Rema *et al.*, 1997). A core collection is a representative subset of a large number of populations which intends to improve management

and use of a germplasm collection (Diwan *et al*., 1995). It is also a powerful material for evaluation of germplasm, identification of trait-specific accessions, gene discovery, allele mining, genomic study, marker development, and molecular breeding (Qiu *et al*., 2013). Cluster analysis followed by Principal component analysis had been used to cluster *Cinnamomum* spp. into groups and to show relationship among the species on the basis of morphological characters (Ravindran *et al*., 1991).

Morphological variation of a crop indicates the genetic diversity and effect from environment. Both environmental and genetic effects contribute to phenotypic variation within and among populations (Allard and Bradshaw, 1964; Andrew *et al*., 2010). Some molecular study has been conducted to evaluate genetic differences on *Cinnamomum* species (Ho and Hung, 2011; Joy and Maridass, 2008; Lin *et al*., 1997; Kameyama, 2012; Soulange *et al*., 2007; Lee *et al*., 2010; Kojoma *et al*., 2002; Sandigawad and Patil, 2011; Kuo *et al*., 2010). A molecular research has been done on the genetic analysis of *Cinnamomum* species by sequencing *Trn*L intron region, intergenic spacer between *trn*T-*trn*L, *trn*L-*trn*F, *trn*H-*psb*A and nuclear ITS (Abeysinghe *et al*., 2009). Another work has been carried out to find a more reliable approach to identify *Cinnamomum* species correctly using RAPD and SRAP techniques. Some primers gave highly polymorphic banding patterns using these techniques. This preliminary study showed that using these molecular markers, it is possible to identify the *Cinnamomum* species (genus specific and species specific) and intra-species variations (Abeysinghe *et al*., 2014). Therefore, the present study is focused on the *Cinnamomum* germplasm which were collected from different locations of Matara district to analyze the morphological variation.

MATERIALS AND METHODS

Total forty seven accessions were collected according to their distinct morphological characters from these cinnamon growing areas particularly from Deiyandara, Ehala Athuraliya, Karapotu Gala, Palolpitiya, Ehalawitiyala and Kamburupitiya during September, 2014. Semi-hard 1/1.5 inch stem cutting with 1 or 2 leaves and active buds from every accession had been planted in nursery for further studies. In the Laboratory the Leaf length (LL), Leaf width (LW), Leaf length-width ratio (LLWr), Petiole length (PL) of samples were measured while other morphological traits Leaf arrangement (LA), Leaf shape (LS), Leaf apex (LAP), Leaf base (LB), Leaf texture (LT), Upper surface leaf color (ULC), Flush color (FC), Bark color (BC), Bark surface (BS), and Bark fragrant (BF) were observed in the time of every field visit during September, 2014. Flush color had been observed following Munsell Color Chart (Munsell Color, 1977). Morphological analysis of collected samples was done considering both quantitative and qualitative characters.

Analysis of variance applying descriptive statistics such as mean, standard deviation, coefficient of variation and correlation coefficient for quantitative traits were calculated. Principal Component Analysis (PCA) was conducted in order to identify the patterns of morphological variation using IBM SPSS Statistics 20.0 software (version 20), IBM, USA. Clustering of genotypes into similar groups was carried out using Ward's hierarchical algorithm based on squared Euclidean distances.

RESULTS AND DISCUSSION

Fourteen morphological characters were recorded from 47 accessions. Among fourteen morphological characters, four quantitative characters of Leaf length (LL), Leaf width (LW), Leaf length-width ratio (LLWr), Petiole length (PL) and ten qualitative characters of Leaf arrangement (LA), Leaf shape (LS), Leaf apex (LAP), Leaf base(LB), Leaf texture (LT), Upper surface leaf color (ULC), Flush color (FC), Bark color (BC), Bark surface (BS), and Bark fragrant (BF) were recorded.

The correlation coefficient was observed between four different morphological traits (Table 1). There were positive significant linear relationships between the Leaf width and Leaf length (0.699), Petiole length and Leaf length (0.613) and Leaf width and Petiole length (0.574) at 0.01% significant level. The positive and significant relationships among the traits will provide plant breeders an understanding on manipulation of such traits.

Table 1. The correlation of quantitative traits according to Pearson's Correlation Coefficient evaluated in cinnamon germplasm collections.

Variable	LL	LW	LLWr	PL
LL	-	.699**	.367*	.613**
LW		-	-.396**	.574**
LLWr			-	.045
PL				-

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

The Principal Component Analysis showing the factor scores of each character among the cinnamon accessions, eigan values and percentage total variance accounted by four principal component (Table 2). The PCA was used to remove redundancy in the data set. The first two principal components (PC-1 and PC-2) accounted for most of the variability observed among the accessions and their eigen value is more than 1. The first two principal components accounted for 88.88% of the total variability where PC-1 explained 56.45% of the total variability was loaded on LL, LW and PL and the PC-2 accounted for 32.43% of the variation and was loaded on LLWr. PCA is commonly used to analyze large data sets. It has been used to evaluate germplasm of rice (Sohrabi *et al*., 2012), olive (Cantini *et al*., 1999), vineyard peach (Nikolic *et al*., 2010), peach (Perez *et al*.,1993), loquat (Leguizamón *et al*., 2003; Badenes *et al*., 2000; Martinez-Calvo *et al*., 2008), and apricot (Yilmaz *et al*., 2012; Ruiz and Egea, 2008). Its main purpose is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components, and to show the pattern of similarity of the observations and of the variables as points in maps (Abdi and Williams, 2010).

Table 2. Eigen values of the correlation matrix and their contribution to total variation of cinnamon germplasm collections.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.25	56.47	56.47	2.25	56.47	56.47	2.25	56.45	56.45
2	1.29	32.40	88.88	1.29	32.40	88.88	1.29	32.43	88.88
3	.43	10.92	99.80						
4	.008	.193	100.00						

The cluster analysis using Ward's method classified the 47 cinnamon accessions in to nine clusters at rescaled distance of 3.0 (Fig. 1). Accessions from Cluster no. 8 showed highest CV% of LL (15.10%), LW (13.53%) and PL (28.28%), which indicated those accessions are highly variable in contrast to the other accessions (Table 3). On the other hand, CV% of LW (11.61%) and PL (17.30%) of the accessions from cluster no. 9 also higher than the other accessions. Accessions belong to cluster no. 1 and cluster no. 5 showed variation in CV% of PL (11.73% and 22.12% respectively) comparing other accessions. All accessions in one cluster represent the respective cluster in terms of qualitative characters while the qualitative characters vary among clusters.

Table 3. Mean (M), Standard Deviation (SD) and Coefficient of Variation (CV%) of quantitative characters according to clusters.

Cluster number	LL			LW			LLWr			PL		
	M	SD	CV %	M	SD	CV%	M	SD	CV %	M	SD	CV%
1	14.01	1.22	8.73	6.51	0.36	5.55	2.15	0.12	5.71	2.06	0.24	11.73
2	18.70	0	0	9.13	0	0	2.05	0	0	2.10	0	0
3	12.90	0.63	4.91	7.68	0.03	0.45	1.68	0.09	5.15	1.90	0.17	9.12
4	19.48	0.59	3.03	7.44	0.68	9.14	2.63	0.17	6.43	2.37	0.25	10.63
5	11.37	0.91	7.97	5.73	0.50	8.67	1.99	0.09	4.61	1.33	0.29	22.12
6	7.43	0	0	3.40	0	0	2.19	0	0	1.20	0	0
7	12.64	1.04	8.22	4.73	0.33	7.09	2.67	0.08	2.87	1.36	0.13	9.38
8	15.45	2.33	15.10	5.75	0.78	13.53	2.68	0.04	1.60	2.00	0.57	28.28
9	13.37	1.28	9.60	5.71	0.66	11.61	2.35	0.09	3.66	1.67	0.29	17.30

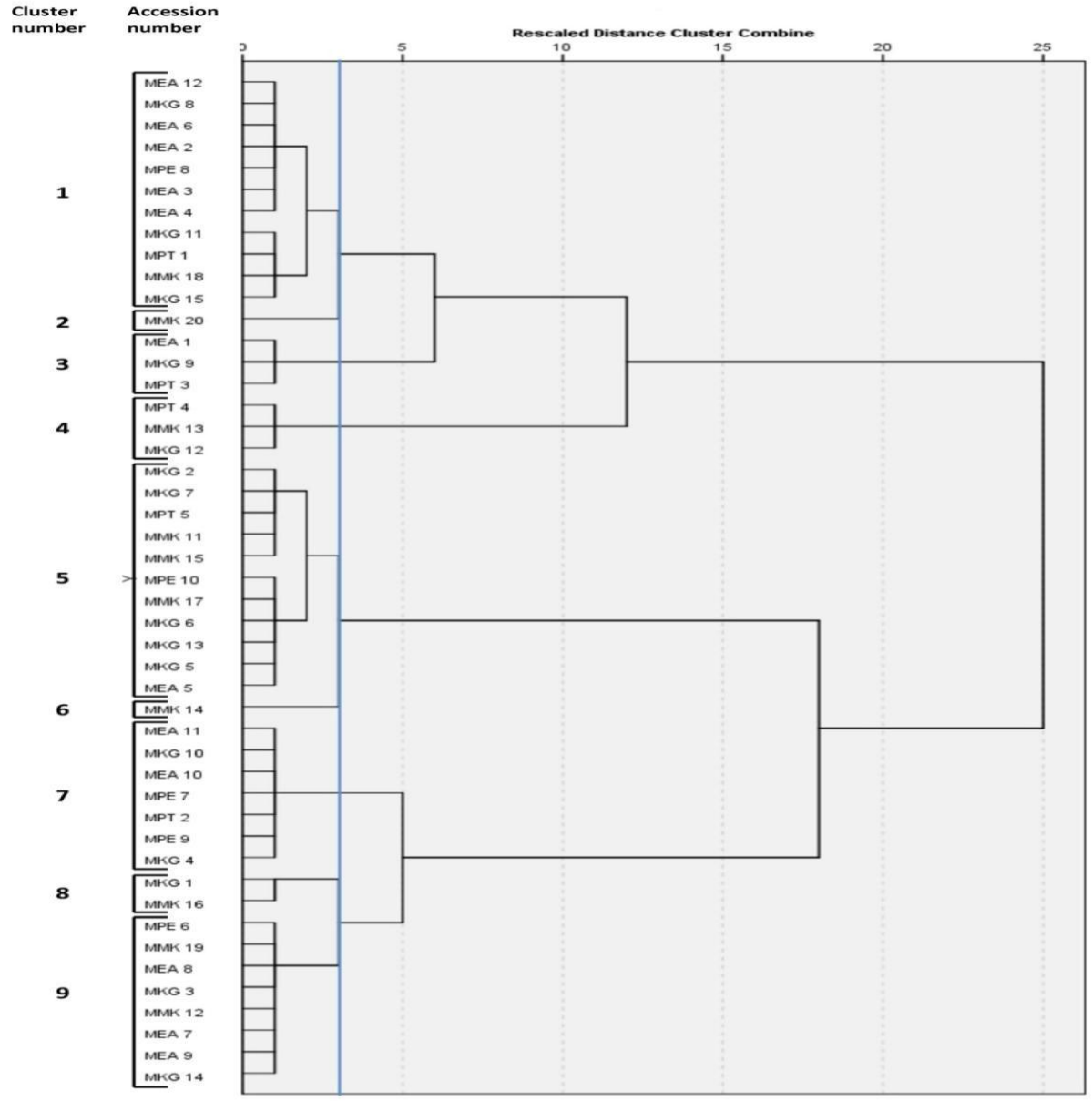

Figure 1: Dendogram of cinnamon accessions derived through Ward's linkage Cluster Analysis based on four quantitative traits.

The qualitative characters of all the accessions were arranged in Table-5 following quantitative characters originated from nine clusters. Qualitative characters of LA, LS, LB and ULC of the accessions belong to cluster 4 and cluster 8 are similar to each other whereas, cluster 1, 5, 7 and 9 with large number of accessions showed considerable variation in qualitative traits. Flush color of cinnamon accessions showed a variation in the collection. There may be a relationship between their oil contents and flush color as previously reported by (Krishnamoorthy *et al*., 1988). Accessions from all the nine clusters showed variations in Leaf shape (Fig. 2). One accession (MPT-03) belongs to cluster no.03 have ovate Leaf shape which is different from the other accessions. In addition, accessions MEA-11 and MKG-01 grouped in to cluster no.07 and cluster no.08 respectively showed narrowly elliptic Leaf shape which is not similar to the other accessions. According to the two types of trait combination it has been clearly manifested that both types of traits has a substantial contribution in accession grouping. These variations ensured genetic differentiation and allele richness among the accessions.

Table 4. Qualitative traits with Type code in cinnamon germplasm.

S. No.	Qualitative traits	Pattern/ Color type	Type code
1	Leaf arrangement (LA)	Opposite	1
		Sub-opposite Opposite or	2
		sub-opposite Opposite to	3
		sub-opposite	4
2	Leaf shape (LS)	Elliptic	1
		Lanceolate	2
		Ovate	3
		Narrowly elliptic Elliptic	4
		to broadly elliptic Ovate-	5
		lanceolate	7
		Ovate-oblong to ovate-lanceolate	11
3	Leaf apex (LAP)	Acute	1
		Obtuse	2
		Acuminate	3
		Gradually acuminate	4
		Long acuminate	5
		Broadly acuminate	6
		Narrowly acuminate	7
		Blunt or subacute	10
4	Leaf base(LB)	Acute Obtuse	1
		Cuneate	2
		Shortly acute	3
		Rounded or subacute	5
			6
5	Leaf texture (LT)	Coriacerous	
		Subcoriaceous	1
		Rigidly coriaceous	2
		Thinly to stiffly coriaceous	3
		Chartaceous to rigidly chartaceous	4
		Chartaceous	5
			6
6	Upper surface leaf color (ULC)	Dark green	
		Green	1
			3
7	Flush color (FC)	2.5R 7/6	
		2.5R 6/8	2
		5GY 7/10	4
		2.5GY 8/10	6
		2.5GY 8/6	7
		2.5R 4/8	8
		2.5R 7/8	9
			12
8	Bark color (BC)	Brown Whitish	
		brown Light	1
		brown	2
			3
9	Bark surface (BS)	Slightly rough	
		Rough	1
		Smooth	2
			4
10	Bark fragrant (BF)	Weak fragrant aroma	
		Intermediate fragrant aroma	1
		Good fragrant aroma	2
		Strong fragrant aroma	3
			4

Table 5. Variation of qualitative characters within clusters which were derived through Ward's linkage method.

Cluster number	Accession number	Qualitative characters									
		LA	**LS**	**LAP**	**LB**	**LT**	**ULC**	**FC**	**BC**	**BS**	**BF**
1	MEA 12	3	5	3	1	5	1	9	1	2	1
	MKG 8	4	11	4	5	5	1	7	3	2	2
	MEA 6	2	1	1	5	1	1	9	1	1	2
	MEA 2	3	5	6	5	6	3	9	3	4	1
	MPE 8	4	2	6	1	5	1	12	1	4	3
	MEA 3	4	7	7	5	5	1	12	1	1	2
	MEA 4	4	5	10	1	6	1	4	1	1	2
	MKG 11	1	1	1	1	3	1	12	2	1	1
	MPT 1	4	7	3	6	6	1	2	1	1	2
	MMK 18	4	2	1	1	6	1	12	3	4	1
	MKG 15	2	2	6	1	6	3	8	2	1	2
2	MMK 20	2	5	1	5	5	1	6	3	4	2
3	MEA 1	4	7	1	5	6	1	2	1	1	2
	MKG 9	4	5	10	5	6	1	9	1	4	2
	MPT 3	4	3	2	2	1	1	9	1	4	2
4	MPT 4	4	2	3	1	5	1	12	1	4	4
	MMK 13	4	2	5	1	6	1	6	1	4	4
	MKG 12	4	2	3	1	6	1	9	3	4	1
5	MKG 2	1	1	10	6	3	3	9	3	4	1
	MKG 7	1	7	10	6	2	1	6	3	4	1
	MPT 5	4	7	3	2	1	1	9	3	4	2
	MMK 11	2	5	1	1	1	3	6	3	4	3
	MMK 15	4	5	4	1	5	1	12	1	4	2
	MPE 10	2	1	3	6	6	1	12	3	4	2
	MMK 17	4	1	1	1	4	1	6	1	1	2
	MKG 6	1	1	4	6	1	3	7	1	1	1
	MKG 13	4	1	3	5	5	1	4	2	1	1
	MKG 5	1	7	10	6	3	1	4	1	4	2
	MEA 5	4	7	3	6	5	1	7	2	2	2
6	MMK 14	2	1	10	5	6	1	7	1	4	3
7	MEA 11	2	4	1	1	4	1	12	1	2	1
	MKG 10	4	4	10	5	6	1	9	1	4	2
	MEA 10	3	4	10	1	6	3	8	3	1	3
	MPE 7	4	1	7	1	5	1	7	1	4	4
	MPT 2	4	2	3	1	5	1	9	1	4	3
	MPE 9	2	4	3	3	6	1	7	1	4	2
	MKG 4	4	2	3	1	6	1	9	2	2	1
8	MKG 1	4	4	3	1	6	1	2	2	4	2
	MMK 16	4	4	5	1	6	1	4	1	1	1
9	MPE 6	4	1	3	1	6	1	12	1	1	2
	MMK 19	4	1	7	1	2	1	4	1	4	2
	MEA 8	4	2	4	1	3	1	9	1	2	1
	MKG 3	1	7	3	1	2	3	9	3	4	1
	MMK 12	2	1	4	1	6	1	9	3	4	2
	MEA 7	3	1	3	5	6	1	9	3	2	1
	MEA 9	3	5	4	5	5	1	7	3	2	2
	MKG 14	2	1	4	1	6	1	12	2	1	4

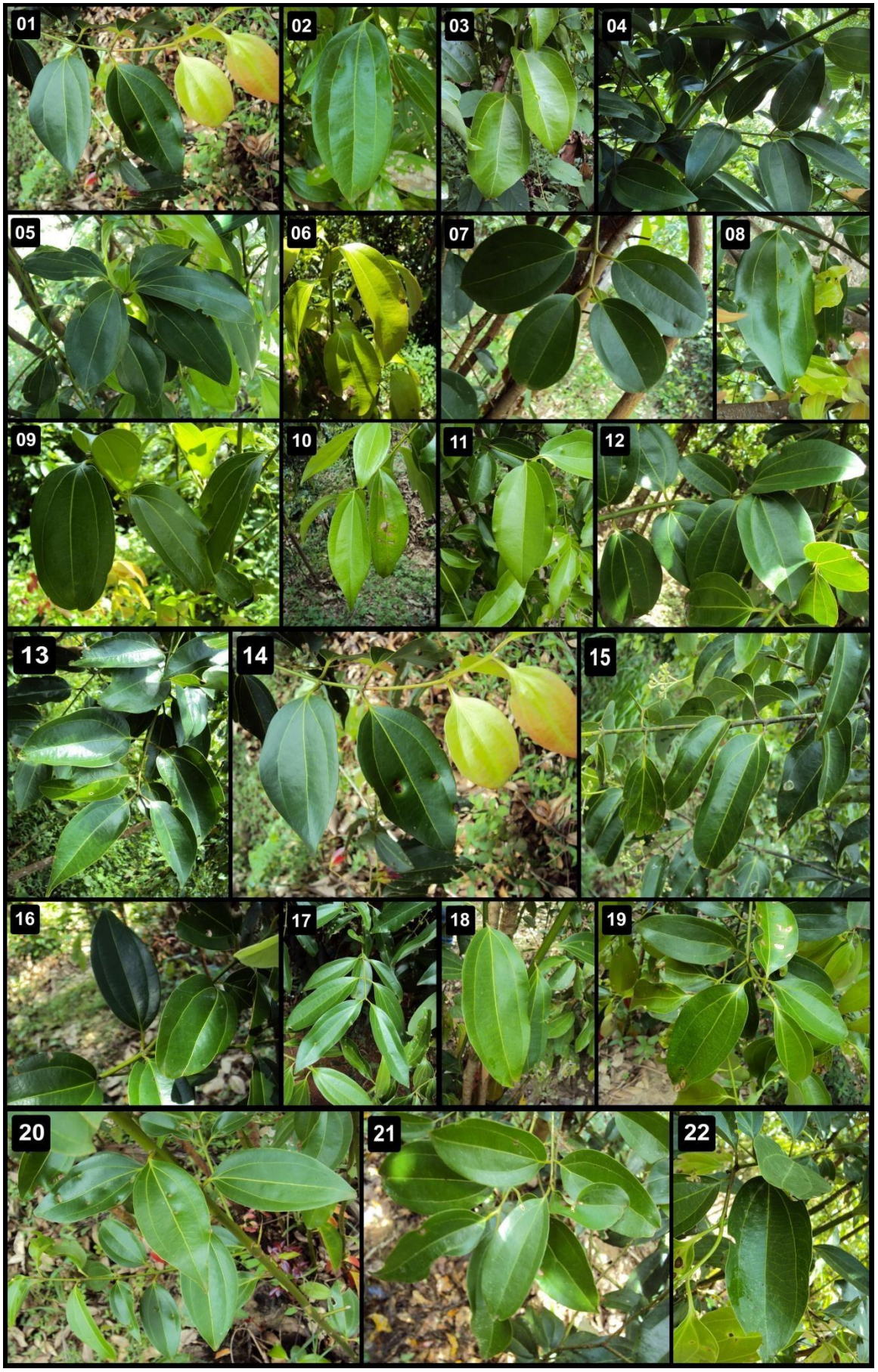
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Figure 2: Variation in leaf shape within clusters; **Cluster-01**: 01(MEA-06) Elliptic, 02 (MMK-18) Lanceolate, 03 (MEA-02) Elliptic to broadly elliptic, 04 (MPT-01) Ovate-lanceolate, 05 (MKG-08) Ovate-oblong to ovate-lanceolate; **Cluster-02**: 06 (MMK-20) Elliptic to broadly elliptic; **Cluster-03**: 07 (MPT-03) Ovate, 08 (MKG-09) Elliptic to broadly elliptic, 09 (MEA-01) Ovate-lanceolate; **Cluster-04**: 10 (MMK-13) Lanceolate ; **Cluster-05**: 11 (MKG-06) Elliptic, 12 (MMK-11) Elliptic to broadly elliptic, 13 (MEA-05) Ovate-lanceolate; **Cluster-06**: 14 (MMK-14) Elliptic; **Cluster-07**: 15 (MPE-07) Elliptic, 16 (MPT-02) Lanceolate, 17 (MEA-11) Narrowly elliptic; **Cluster-08**: 18 (MKG-01) Narrowly elliptic; **Cluster-09**: 19 (MMK-12) Elliptic, 20 (MEA-08) Lanceolate, 21 (MEA-09) Elliptic to broadly elliptic, 22 (MKG-03) Ovate-lanceolate.

There is a variation in qualitative and quantitative characters among the cinnamon accessions of Matara district which were categorized into nine distinct clusters at rescale distance of 3. Accessions MMK14 and MMK 20 could be distinct genotypes as they clustered independently. Significant positive correlations were observed between Leaf width and Leaf length (0.699), Petiole length and Leaf length (0.613) and Leaf width and Petiole length (0.574). Morphological diversity among accessions would indicate the genetic diversity which could be used for exploitation of economically important traits of cinnamon in the future. The next step of this research project through molecular and chemical characterization of representative accessions from each cluster would provide precise information on economically important genotypes and the morphological markers for better genotypes.

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Health beverages from bayberry and yellow Himalayan raspberry

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ABSTRACT

In this study, total carotenoids, anthocyanins, total flavonoids, total phenolics and total antioxidant capacity (CUPRAC) of underutilized fruit crops like bayberry and yellow Himalayan raspberry based health beverages (ready-to-serve, RTS) were investigated. Feedback collected from the trained panel revealed significant (P <0.05) differences in appearance, colour, flavour and texture upon sensory evaluation of the beverages. Based on ranking, bayberry RTS was most preferred in overall appearance, colour and flavour. The higher acceptance of bayberry RTS among testers could be owed remarkably to its attractive red colour and appearance.

Keywords: Ready-to-serve, health beverages, antioxidants, sensory quality, bayberry, Himalayan raspberry

INTRODUCTION

A number of wild but potentially commercialized fruits are available in Himalayan regions of India (Mehta *et al.*, 2010). Of which, red fruited 'bayberry' (*Myrica esculenta* Buch. Ham. Ex D. Don) locally known as '*kaphal*' and 'Yellow Himalayan Raspberry' (*Rubus ellipticus* Smith) commonly referred as '*hisalu*' are amongst highly valued edible fruits (Kala, 2007). Kafal is an important medicinal tree distributed all along outer Himalaya from Ravi (Punjab) eastwards to Assam, in Khasia, Jaintia, Shimla, Bengal, Naga and Lushai hills at altitudes of 900-2100m. The tree can grow up from 3m to 15m. Pulp constitutes 75.4% of whole fruit and is edible with juice content of 40%. The juice possesses 3.68% acidity, 12.65% total sugars, which are mostly reducing sugars. The mineral content of the fruit pulp is 0.387% by its ash. The fruit pulp contains 0.97% protein, 0.007% phosphorus, 0.194 % potassium, 0.039% calcium, 0.013% magnesium and 0.004% iron (Panthari *et al.*, 2012). The tree is a popular remedy for different ailments and is documented for the same (Kala, 2007). The yellow Himalayan raspberry is one of the tastiest wild fruits, growing in abundance throughout the North-Western Himalayas (Singh *et al.*, 2011). Berry weight varies from 0.3-0.9 g, TSS from 10-20 ^{0}Brix and acidity 1.0-1.7%. Berry length varies between 7.8 to 14.37 mm, while berry breadth 10.03 to 15.85 mm. The reducing sugars range between 2.2% and 4.9%, non-reducing sugars from 5.9% to 11.5% and the ascorbic acid content ranges from 3.0 to 5.1mg/ 100g fresh pulp (Singh *et al.*, 2009).

These wild fruits have great potential in agro-processing as they are rich in malic acid, citric acid, tartaric acid and carbohydrates (Singh *et al.*, 2009). It would be advantageous to assess the antioxidant properties of these plants for possible use in the elaboration of functional foods or for consideration as potential sources of natural antioxidants (Rawat *et al.*, 2011; Trivedi *et al.* 2016). The objectives of the present investigation were to design alternative use of such underutilized crops, other than the fresh consumption, by developing new antioxidant rich health beverages.

MATERIALS AND METHODS

The present study was undertaken at ICAR-Central Institute of Temperate Horticulture, Regional Station, Mukteshwar, which is situated at 2250m above mean sea level. Fresh fruits of bayberry and yellow Himalayan raspberry were collected from forest area of Mukteshwar, District-Nainital, Uttarakhand, India.

Preparation of ready-to-serve (RTS) beverages

After proper washing, cleaning and sorting of *kafal* and *hisalu* fruits, juice was extracted through an electronic juicer (Philips, India). Fruit juices were added @ 100 ml/ L of finished product. The required acidity in ready-to-serve (RTS) was adjusted with citric acid. No preservative was added to the prepared product. Final RTS characteristics were adjusted to 0.3 % acidity and 13 % TSS. The step wise preparation of RTS has been presented in Fig. 1. Blended RTS was prepared by adding fruit juices of both *kafal* and *hisalu* @ 50 ml/ L; thereby, keeping total juice percentage constant i.e. @ 100 ml/ L of finished product.

Soluble solid content, titratable acidity, reducing and total sugars and pH

Brix was measured at 20 °C using an Abbe refractometor (Atago, Tokyo, Japan). Titratable acidity, reducing and total sugar were estimated as per

the method suggested by Ranganna (1986). The pH of the beverages was assessed using a pH meter (Inolab pH 730, Merck Specialities Pvt. Ltd., India).

Estimation of ascorbic acid, total carotenoids and total anthocyanin

The ascorbic acid and total carotenoids contents of the samples were estimated according to Ranganna (1986). Results were expressed on mg/ 100 ml. The total monomeric anthocyanin content was determined by the pH-differential method suggested by Giusti and Wrolstad (2003). The pigment content was calculated and expressed as mg cyaniding 3-glucoside (Cyd 3-glu) per L, using an extinction coefficient (Є) of 26,900 L/cm/ mol and a molecular weight of 449.2 gmol/L.

Determination of total flavonoids and total phenolics content

The estimation of total flavonoids was performed according to Chang *et al.* (2002). Results were expressed as mg of querecetin equivalents/ 100 ml. The results were expressed as mg phloroglucinol equivalents/ 100 ml. Total phenolic content was quantified spectrophotometrically employing Folin–Ciocalteu reagent and results expressed as gallic acid equivalents (mg GAE/100 ml) (Singleton and Rossi, 1965).

Antioxidant activity (Cupric reducing antioxidant capacity, CUPRAC)

CUPRAC assay was carried out by the method described by Apak *et al.* (2004) using copper (II) chloride, neocuproine and ammonium acetate buffer solutions. The antioxidant activity was expressed as mmol Trolox®/ liter, or mM TE.

Organoleptic evaluation for acceptability of the RTSs

Organoleptic evaluation was performed on beverage preparations by a ten-member trained panel. For each sensory parameter, such as colour and appearance, body or texture, flavour, taste and overall acceptability, 100 marks were allotted and the products were given to the panelist in coded form. (Attri *et al.*, 2014) The panelists washed their mouths with water intermittently to evaluate samples. Significant differences were determined at the (P<0.05) level of significance using the Duncan's multiple range tests.

Statistical analysis

Experiments were laid in complete randomized design with three replications. Duncan's Multiple Range Test was used to determine significant differences. Significance was determined at P<0.05.

RESULTS AND DISCUSSION

Besides commercial fruits, the consumption of wild and underutilized fruits is also gaining importance owing to their antioxidant contents and consequently health benefits (Krishna and Parashar, 2013). As these underexploited fruits are available for a very short period, the value added products will definitely help to provide taste throughout the year if processed during the growing season (Nandlal and Bhardwaj, 2014). Underutilized fruit crops can be utilized by designing alternative use, other than the fresh consumption, by developing new antioxidant rich beverages (Krishna *et al.*, 2014). The results of our investigation show that both bayberry and yellow Himalayan raspberry based health beverage possess high content of various antioxidants (Table 1). The total carotenoids contents were found to be highest in RTS prepared from *hisalu*, while the least was recorded in RTS from *kafal*. Yellow coloured berries are reported to be rich source of carotenoids (Egea *et al.*, 2010). On the other hand, *kafal* RTS had the highest contents of anthocyanin, while it was not detected in RTS prepared from *hisalu*. *Kafal* or *M. esculenta* broadly resembles with *Myrica rubra*, found commonly in China and Japan, which is also reported to have high anthocyanin contents (Rawat *et al.*, 2011). The high total antioxidant activities of *kafal* RTS can be attributed to presence of higher contents of phenolics and anthocyanin. Higher values of phenolics and anthocyanin has been reported to contribute towards higher total antioxidant activities in many other crops like mulberry (Krishna *et al.*, 2012); *Rhododendron* (Krishna *et al.*, 2014) and blended squashes of *Rhododendron arboreum*, *Berberis asiatica*, *Crataegus crenulata* and *Galgal* (Attri *et al.*, 2014).

Results of the trained sensory panel are presented in Fig. 3. Feedback collected from the trained panel revealed significant (P <0.05) differences in appearance, colour, flavour and texture upon sensory evaluation of the beverages. Based on ranking, bayberry RTS was most preferred (P <0.05) in overall appearance, colour and flavour (Fig. 2, Fig. 3). The least values were scored by the bayberry-yellow raspberry blended RTS on all sensory attributes. The higher acceptance of bayberry RTS among testers could be owed remarkably to its attractive red colour and appearance. Likewise, Attri *et al.* (2014) reported that among the 10 blended squash involving *Rhododendron arboreum*, *Kilmora* (*Berberis asiatica*), *Ghengharu* (*Crataegus crenulata*) and *Galgal* (*Citrus pseudolimon*), treatment combination *Rhododendron* (15%) + *Galgal* (5%) + ginger (5%) was adjudged the best in terms of overall sensory attributes due to its pleasant red colour.

It can be concluded that both bayberry and yellow Himalayan raspberry, which are highly perishable in nature and are available for short period can be utilized effectively by preparing health beverages. Earlier, Dwivedi and Ahmed (2008) successfully attempted to make squash and nectar from seabuckthorn, a crop rich in antioxidants, which is now being commercialized owing to its huge health attributes. Therefore, exploiting the phytochemical contents of underutilized fruits, like bayberry and yellow Himalayan raspberry, could offer the enormous opportunities for devising better marketing strategies for the sale of beverages made of it (Krishna *et al.*, 2014).

Figure 1. Flow chart of ready-to-serve (RTS) beverage preparation

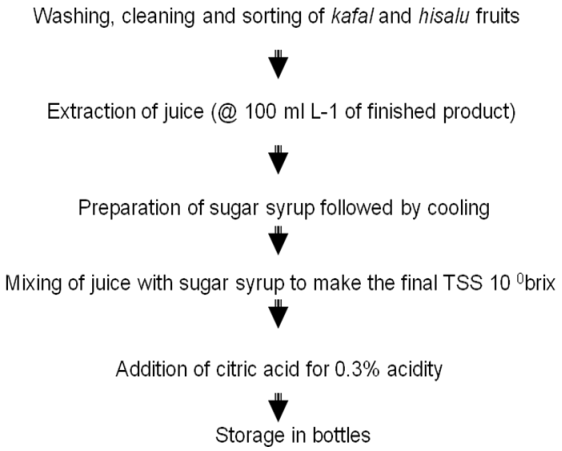


Figure 2. RTSs prepared from *kafal* and *hisalu*(From left to right: *Kafal* RTS, *Hisalu* RTS and Blended RTS)

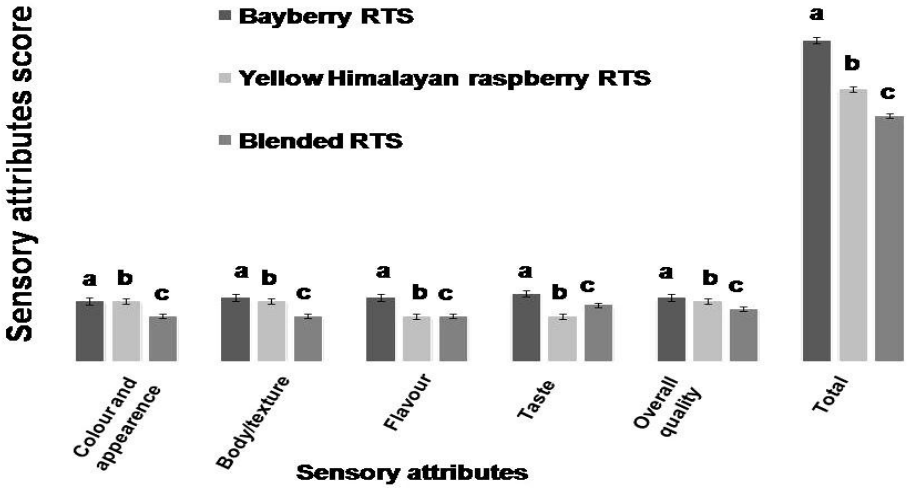
Table 1. Quality characteristics of different ready-to-serve (RTS) beverages

Quality attributes	Bayberry RTS	Yellow Himalayan raspberry RTS	Blended RTS
Soluble solid content, SSC (^{0}Brix)	10.0±0.7a	10.0±0.4a	10.0±0.6a
Reducing sugars (%)	4.2±0.4a	4.7±0.5a	4.5±0.2a
Total sugars (%) Quality attributes	9.7±0.6a	9.3±0.3a	9.6±0.2a
Acidity (%)	0.3±0.01a	0.29±0.01a	0.3±0.01a
SSC: acid ratio	33.3±0.3a	34.5±0.4a	33.3±0.4a
Ascorbic acid (mg 100ml^{-1})	0.2±0.0c	2.1±0.3a	0.98±0.1b
Total carotenoids (µg 100ml^{-1})	29.7±0.7c	516.9±8.2a	297.5±4.3b
Total flavanoids (mg 100ml^{-1})	25.4±1.3a	16.2±1.7c	20.6±0.4b
Total anthocyanins (mg L^{-1})	1.58±0.4a	-	0.77±0.1b
Total phenols (mg 100ml^{-1})	45.2±1.0a	14.5±0.6c	27.9±0.3b
Total antioxidant capacity (mM Trolox Equivalent (TE) L^{-1})	4.95±0.2a	1.47±0.1c	3.19±0.3b

Data represents means of three samples (n=3) ± s.d.

Values are mean of three replicates. Means followed by different letters in a row are significantly different ($p<0.05$).

Figure 3. Sensory analysis of different ready-to-serve beverages



Values followed by the same letter are not significantly different (P <0.05). Each value is expressed as mean ± standard deviation (n = 3).

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Fruit Growth and Proximate Composition of *Dilllenia indica* Linn.

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ABSTRACT

***Dillenia indica* Linn. is an important minor fruit of Dilleniaceae. It is commonly known as 'Chalta' in Bangladesh. Botanically, chalta is a pseudo fruit where the persistent and fleshy calyx with interior ovary forms the prominent edible part. Though eaten fresh, the fruit is usually cooked and it can be made into juice, jam, jelly, pickles and chutney. Fruit growth and nutritional composition of chalta were investigated at the Botanical Garden of Bangladesh Agricultural University, Mymensingh (24º26' and 24^{0}54' N and 90^{0}15' and 90^{0}30' E) between August and October, 2011 to ascertain the horticultural harvesting stage of fruit. Flowers were tagged at first opening (days after flowering) and fruit growth was investigated up to harvest maturity. Fruit size (length and diameter), and growth of calyx were investigated at 7-days interval up to 77 days after flowering. Calyx and fruit size, and fruit weight were gradually increased with increasing ages, up to 77 days after flowering. However, the increment between 75 and 77 days after flowering appeared non-significant. Hence, the fruit harvesting age was set at 75 days after flowering. The fruit length and diameter (9.50 and 11.51 cm, respectively) were attained at 75 days after flowering. The length, breadth, and thickness of individual sepal (9.94, 9.28, and 2.20 cm, respectively) were obtained at 75 days after flowering. The fresh and dry weights of calyx (480.53 and 163.73 g, respectively) were also recorded at 75 days after flowering. The calyx of 75 days aged contained appreciable amount of crude protein, crude fibre, crude fat, ash, and total carbohydrate (5.70, 32.02, 3.34, 4.61, and 51.22%, respectively). It might be concluded that harvest maturity of chalta attained around two and a half months from flowering when fruits turn into yellowish green colour with average fruit fresh weight of 523 g.**

Key words: *Dillenia indica,* fruit growth, harvest maturity, nutrient composition.

INTRODUCTION

Dillenia indica Linn. is an evergreen large shrub or small to medium- sized tree belongs to family Dilleniaceae. It is commonly known as 'Chalta or Hargesa' (Dipal and Priti 2013) and 'Chalita' (Talukdar *et al.,* 2012). It grows all over the Bangladesh (Parvin *et al.,* 2009) and widely distributed in South-east Asia (Ramesh *et al.,* 2008). It is a spreading tree and has beautiful white fragrant flowers, toothed leaves, and globose fruits with small brown seeds (Janick and Paull 2008). Flowering occurs in July-August and fruit ripens in November-December (Dipal and Priti 2013). Fruits of chalta are globose, 10–15 cm in diameter, indehiscent, persistent sepals, fleshy and slightly swollen (Dipal and Priti, 2013). The fruit of chalta is a special type, where the enlarged persistent fleshy calyx forms the predominant edible part (Bose *et al.,* 2002). The ripe fruits are widely used in the flavoring curries and preparation of jam and jelly (Sunil *et al.,* 2011; Kumar *et al.,* 2011) and good beverages, jam, jelly, pickles and chutney can be prepared (Saikia and Dutta 1995). Fruits are nutritionally rich and contain (per 100 g of edible portion) calories 59, fibre 2.1-2.5 g, fat 0.2-0.34 g, protein 0.8 g, ash 3.54 g, phosphorus 26 mg, calcium 16 mg (Neog and Mohan 1993; Saikia and Dutta 1995). Chalta possess many medicinal properties and it is reputed as a cooling beverage in fever, expectorant in cough mixture, tonic, laxative and astringent (Maniruzzaman and Samhita 1993).

Assessment of fruit maturity indices is important to ensure sensory traits (flavour, colour, aroma, and texture) and nutritional quality, and increase postharvest shelf life. Appropriate maturity indices also facilitate scheduling of harvest and packing operations and marketing of products (Dhatt and Mahajan, 2007). Horticultural maturity is the stage of development at which a plant or plant part possesses the prerequisites for use by consumers for a particular purpose i.e. ready for harvest (Dhatt and Mahajan 2007). A given commodity may be horticultural mature at any stage of development. Horticultural maturity of chalta fruits is considered when they attained a desirable size with good fibre content for making juice, jam, jelly, pickles and chutney, whereas physiological maturity commences at maximum seed dry weight. In general, fruit maturation is accompanied by significant changes in external appearance. Any fruit picked either early or too late is more susceptible to physiological disorders or has a shorter shelf life than fruit picked at the proper maturity (Kader, 1999). A couple of researches on growth of minor fruits such as in cowphal (*Garcinia cowa*) (Roy *et al.,* 2010), china cherry (*Muntingia calabura*) (Rahman *et al.,* 2010), deshi and bilati gab (Hasan *et al.,* 2014) has performed and

only one report on chalta in Bangladesh (Hasan *et al.*, 2015) is available. Hence, the current study was conducted (i) to investigate the fruit growth of chalta at different ages; and (ii) to determine the nutritional value (proximate composition) of the fruit. Overall objective was to ascertain the right stage of fruit harvest i.e. horticultural maturity.

MATERIALS AND METHODS

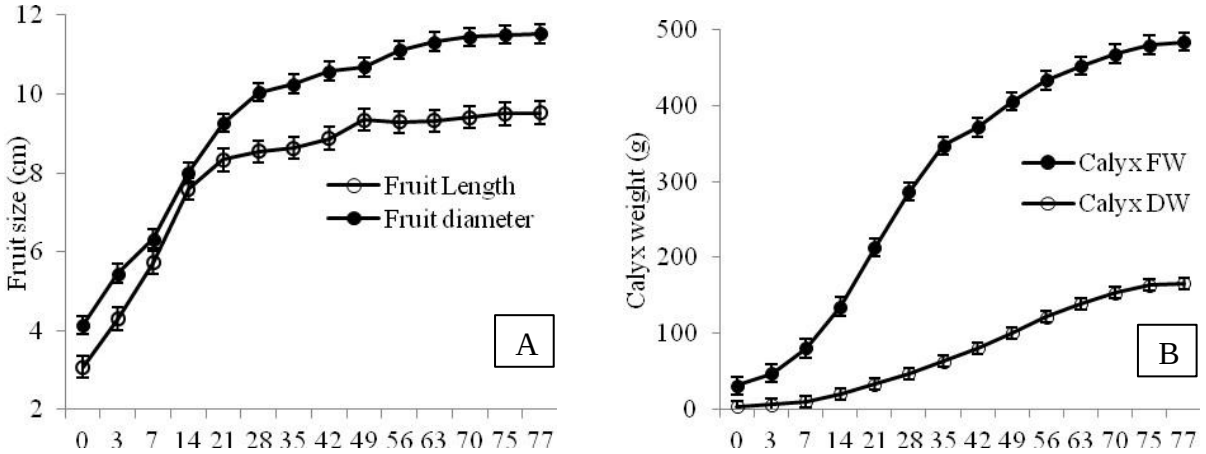
Three chalta trees were selected at Botanical Garden and Faculty of Veterinary Science in the Bangladesh Agricultural University campus, Mymensingh to study the fruit growth during August to October, 2011. Different coloured woolen threads were loosely fastened in the pedicel of flowers to record fruit age at 0, 3, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 75 and 77 days after first opening of flowers (DAF). At each DAF, at least 15 fruits (five each from three replicates) were harvested. Fruit length and diameter were measured by ruler. The length and breadth of calyx were also recorded by ruler, while calyx thickness was measured by slide calipers. The sepal was divided into two equal halves and thickness was determined from the maximum thickened middle portion. Fresh weight of freshly harvested fruits were recorded and then shelled and the seeds were separated. The dry weight of calyx and seed were recorded after oven drying (80 ± 2^0C) till constant weight. The absolute growth rate, AGR= $\{(W_2-W_1) \div (T_2-T_1)\}$ of calyx was also calculated, where W and T represent fresh weight and time of fruit harvest, respectively. The proximate constituents: crude protein (CP), crude fibre (CF), ether extract (EE) or crude fat, ash, and nitrogen free extract (NFE) or total carbohydrate of calyx were determined at four (42, 56, 75, and 77) DAFs (AOAC, 1990). The Completely Randomized Design (CRD) was followed with three replications. Different ages i.e. DAFs were used as treatment in analyzing the data. The program MSTAT-C (Russell, 1986) was used to analyze the data. The mean differences were compared by least significant difference (LSD) test (Gomez and Gomez 1984).

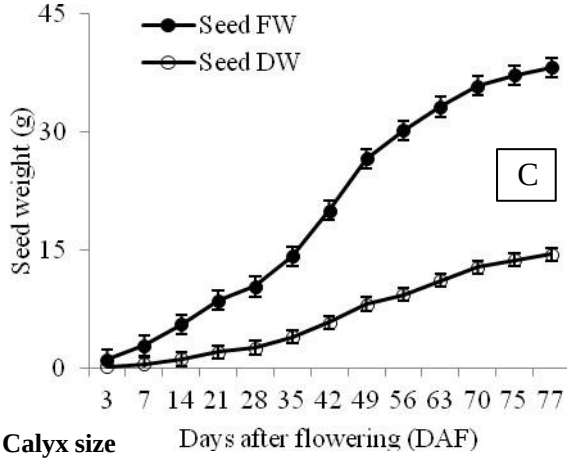
RESULT AND DISCUSSION

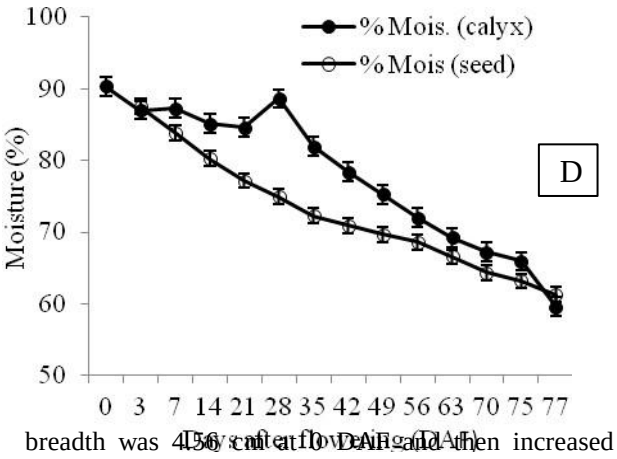
Fruit size

Fruit length and diameter followed sigmoid growth pattern and increased with increasing ages (days after flowering, DAF) (Fig. 1A). The length was 3.08 cm at first day of flower opening and grew rapidly and reached 7.59 cm at 14 DAF. After that, fruit length increased gradually and reached maximum at 77 DAF (9.53 cm). Fruit diameter also followed almost similar pattern to that of length but at higher rate. At initial stage (0 DAF), it was 4.14 cm and increased very rapidly up to 28 DAF (10.05 cm) and then gradually increased towards horticultural maturity (11.54 cm) (Fig. 1A). Sigmoid growth pattern in *Dillenia* fruits was also observed by Bose *et al.,* (2002) and Das *et al.,* (2011). The present result regarding fruit diameter is in partial conformity with the report of Bose *et al.,* (2002) who reported that fruit diameter of chalta ranged from 10 to 15 cm. Talukdar *et al.,* (2012) reported that fruit diameter of *Dillenia indica* ranged from 7.5 to 10 cm which also agrees the present finding. The increase in fruit diameter can be attributed to an increase in the size of the cells and accumulation of carbohydrates and mucilage in the intercellular spaces in fruit (Bollard 1970).

Fig. 1. Changes in fruit size (A), calyx and seed weight (B, C) and moisture (%) in chalta at different ages (DAF). Vertical bars indicate $lsd_{0.05}$.







Calyx size

Significant variation was observed in case of calyx size (length, breadth and thickness) at different ages (DAF) (Table 1). Like fruit size and weight, the length, breadth, and thickness of calyx also attained maximum value at horticultural mature stage i.e. at 77 DAF (Table 1). Calyx length was 5.17 cm at first day of flowering followed by rapid increase up to 28 DAF (8.36 cm). Thereafter, length increased gradually towards picking period and attained an average of 9.96 cm (between 75 and 77 DAF) (Table 1). Calyx breadth was 4.56 cm at 0 DAF and then increased sharply up to 42 DAF (8.63 cm) followed by gradual but slow increase towards horticultural maturity with an average of 9.29 cm (between 75 and 77 DAF) (Table 1). At initial stage (0 DAF) calyx thickness was 0.49 cm followed by gradual increase up to 7 DAF and thereafter attained maximum rate between 14 and 28 DAF (average of 1.24 cm). At later stage of growth, thickness increased slowly towards picking period with an average size of 2.22 cm (between 75 and 77 DAF) (Table 1).

Table 1. Variation in calyx size, calyx: to fruit ration, and absolute growth rate (AGR) of chalta at different ages (days after flowering, DAF)

DAF	Calyx size (cm)			Calyx: Fruit	DAF (AGR)	AGR of calyx (gd^{-1})
	Length	Breadth	Thickness			
0	5.17m	4.56m	0.49l	1.00a	-	-
3	5.36l	4.64l	0.55k	0.98ab	0-3	0.49i
7	5.54k	5.26k	0.71j	0.96ab	3-7	1.01h
14	5.90j	6.16j	0.84i	0.96ab	7-14	1.48g
21	6.95i	6.83i	1.22h	0.96ab	14-21	1.79f
28	8.36h	7.57h	1.67g	0.97ab	21-28	2.01e
35	8.51g	8.02g	1.77f	0.96ab	28-35	2.28d
42	9.08f	8.63f	1.92e	0.95ab	35-42	2.51c
49	9.25e	8.82e	2.01d	0.94b	42-49	2.86b
56	9.42d	9.01d	2.09c	0.94b	49-56	3.02a
63	9.57c	9.11c	2.14bc	0.93b	56-63	2.53c
70	9.72b	9.20b	2.18ab	0.93b	63-70	2.05e
75	9.94a	9.28a	2.20a	0.93b	70-75	1.45g
77	9.98a	9.30a	2.23a	0.93b	75-77	1.03h
$lsd_{0.05}$	**0.05**	**0.08**	**0.05**	**0.05**	**-**	**0.12**
Sig. level	**	**	**	*	-	**
CV (%)	**0.40**	**0.56**	**1.67**	**1.88**	-	**3.85**

In each column, figures bearing uncommon letter(s) are significantly different at P≤0.05. Each figure is the mean of 15 fruits (5 fruit × 3 replications). **= Significant at 1% level of probability, *= Significant at 5% level of probability.

Calyx weight

Calyx fresh weight followed a typical sigmoid pattern while dry weight followed almost a linear pattern (Fig. 1B). Fresh weight of calyx was 30.89 g at first day of flowering and increased very rapidly up to 35 DAF (347.83 g) followed by a gradual increase up to harvest maturity with maximum weight of 484.42 g. Calyx dry weight was 2.97 g at first day of opening and linearly increased to 165.79 g towards harvestable stage (Fig. 1B).

Seed weight

Like calyx weight, seed fresh weight also followed a sigmoid pattern while dry weight followed almost a linear pattern (Fig. 1C). Seed fresh weight was 1.03 g at 0 DAF and increased linearly up to 10.32 g (28 DAF) followed by a sharp increase till 49 DAF (26.60 g). After that, fresh weight again increased gradually towards maturity 38.21 g. Seed dry weight was 0.12 g at first day of flowering and then increased almost linearly to 14.41 g at harvestable condition (Fig. 1C).

Fruit (calyx and seed) weight attained maximum at 77 DAF (523 g). The present result regarding fruit weight is in partial conformity with the report of Bose *et al.,* (2002) who reported that single fruit weight of *Dillenia* ranged between 400 and 600g.

Moisture of calyx and seed

Moisture content of both calyx and seed decreased with increasing ages (DAF) (Fig. 1D). Initially, moisture content of calyx was highest at 0 DAF (90.37%) and then decreased gradually up to 21 DAF (average of 86.02%) followed by an increase at 28 DAF (88.66%). Later on, moisture content of calyx again decreased gradually and reached the minimum at 77 DAF (59.58%). Highest seed moisture was found at 3 DAF (87.51%) and lowest (61.27%) recorded at 77 DAF (Fig. 1D). The decrease in moisture content towards harvesting maturity might be due to an increase in fibre content and dry matter accumulation in calyx (Bose *et al.,* 2002).

Calyx to fruit ratio

Calyx to fruit ratio was statistically significant at different ages (DAF) (Table 1). It was maximum (1.00) at 0 DAF followed by gradual decrease up to 42 DAF (average of 0.96) and minimum value was recorded between 63 and 77 (average of 0.63). Decreased calyx to fruit ratio with increasing ages might be due to increase in seed weight along with high accumulation of mucilage pulp in seeds towards harvest period. Decreased pulp to fruit ratio with increasing ages after flowering was reported in *Garcinia cowa* (Roy *et al.,* 2010).

Fruit absolute growth rate (AGR)

Effect of ages (days after flowering, DAF) on AGR of fruit was significant ($P \leq 0.05$) in chalta (Table 1). The AGR increased gradually with the advancement of ages and showed greater between 49 and 56 DAF (average of 3.02 g/day). After that AGR again declined towards maturity. AGR of calyx was not highest at horticultural mature stage which indicates that it may not be used a reliable index of fruit harvest.

Proximate Composition of calyx

Calyx of chalta showed significant variation in terms of crude fibre, ash and nitrogen free extract content (Table 2). Maximum crude protein and ash content (5.90% and 20.25%, respectively) were found at 42 DAF while highest ether extract and total carbohydrate (3.55% and 54.76%, respectively) were recorded at 56 DAF (Table 2). Crude fibre content was maximum (33.95%) at right harvest stage of fruit i.e. 77 DAF. Proximate composition is considered as a predictor of fruit maturity in terms of nutritional quality (Roy *et al.,* 2010; Rahman *et al.,* 2010; Hasan *et al.,* 2014). Edible calyx of 77 DAF contained crude protein, crude fibre and crude fat (5.64, 33.95 and 3.33%, respectively) but according to Neog and Mohan (1993), and Saikia and Dutta (1995) *Dillenia* fruits contained protein (0.8%), fibre (2.1-2.5%) and fat (0.2-0.34%). These variations in proximate composition might be due to different maturity stages, cultivars, climate etc. However, calyx of 77 DAF aged contained 4.74% ash which is in partial conformity with Neog and Mohan (1993); Saikia and Dutta (1995) who reported about 3.54 g ash content per 100 g of edible portion. In case of *Dacryodes edulis*, the amount of crude protein and carbohydrate of fruits varied during various maturation stages and the fully matured fruits contained lowest value (5.13, and 16.07%, for protein and carbohydrate respectively) (Majesty *et al.,* 2012). Therefore, the calyx of chalta possesses appreciable nutrition in terms of proximate composition.

Table 2. Proximate composition (crude protein-CP, crude fibre-CF, ether extract-EE, ash and total carbohydrate-NFE) of calyx of chalta at different ages (days after flowering, DAF)

DAF	% Proximate Constituents				
	CP	CF	EE	Ash	NFE
42	5.90	20.93d	3.23	2.25c	47.33d
56	5.80	22.22c	3.55	4.58b	54.76a
75	5.70	32.02b	3.34	4.61b	51.22b
77	5.64	33.95a	3.33	4.74a	48.71c
$lsd_{0.05}$	**0.42**	**0.55**	**0.42**	**0.11**	**1.23**
Sig. level	**NS**	**	**NS**	**	**
CV (%)	**3.62**	**1.01**	**6.33**	**0.69**	**1.22**

In each column, figures bearing uncommon letter(s) are significantly different at P≤0.05. Each figure is the mean of 15 fruits (5 fruit × 3 replications). **= Significant at 1% level of probability, NS= Non significant.

Fruits of chalta require about 160 days reaching the stages of harvest maturity (Das *et al.*, 2011). But under Bangladesh contest, around two and a half months duration is required from flowering to fruit harvesting. This variation might have occurred due to variety and climatic factor. Changes in visual appearance of fruits have also been reported in China cherry (Rahman *et al.*, 2010), cowphal (Roy *et al.*, 2010) and deshi and bilati gab (Hasan *et al.*, 2014) to ascertain fruit maturity stage. Around two and a half months from flowering, the chalta fruits developed yellowish green colour (observation). Such future study on visual indices may be important.

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Correlation study and cluster analysis in Burmese grape (*Baccaurea sapida* Muell. Arg.) under the sub-Himalayan *terai* region of West Bengal

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ABSTRACT

Burmese Grape (*Baccaurea sapida* Muell. Arg.), a dioecious underutilized fruit crop which is commonly grown in homestead condition under the sub-Himalayan *terai* region of West Bengal. The crop not only holds good nutritional properties but also has its ritual values in this part of the globe. Since, it is a cross pollinated crop; therefore, it is believed to have a high degree of variability. So, in this study an effort was made to group the available variability based on flowering and fruiting characteristics. Correlation and cluster analysis studies indicated strong relationships between some parameters and broad two sub-groups of Burmese grape.

Key words: Burmese Grape, Correlation, Cluster Analysis

INTRODUCTION

Burmese grape (*Baccaurea sapida* Müell. Arg.) is one of the popular underutilized fruit crop native to Southeast Asian region. This tree is well distributed in sub Himalayan tracts from Nepal to Sikkim, Darjeeling hills, Arunachal Pradesh to Assam, Tripura, Bhutan, Burma, Bangladesh, South China, Malaya Peninsula and Andamans (Sundriyal and Sundriyal, 2001). It is a slow growing, dioecious, short to medium height, evergreen, shade loving plant. It flowers during the summer months and fruits are mature during the rainy season (Bhowmick, 2010). The fruit bearing habit of Burmese grape is cauliflory and appears in bunch. Tree shows mild biennial in cropping pattern (Pal *et al.,* 2008). In West Bengal, it is mainly cultivated in Cooch Behar and Jalpaiguri districts (Bhowmick, 2011). The flowers are born on 10-40 cm long clauiflorous raceme (Chakrabarty and Gangopadhyay, 1997) and flowering is reported to be in March-April (Bhowmick, 2011). Matured fruits are roundish to oval in shape, greenish when tender and turns yellow or yellowish brown in colour at ripening. Fruits are sub-acid in taste having 3-4 segments and the edible portion of the fruit is the aril covered by the leathery skin (Bhowmick, 2011). Fruits contain 5.5% protein, 178 mg vitamin C per 100 g of pulp; besides being rich in minerals like calcium, potassium, phosphorous, and iron (Kermasha *et al*., 1987). At Citrus Research Station, Bangladesh, five superior genotypes *viz.* BSJai001, BSJai 002, BSJai 003, BSJai 004 and BSJai 005 were evaluated for different horticultural parameters (Rahman *et al.*, 2014). However, there is complete lacking in literature regarding the correlation studies in Burmese grape.

The present study is aimed to categorize the available variability and study the correlation of different horticultural parameters and make a group of closely associated accessions among various Burmese grape accessions surveyed.

MATERIALS AND METHODS

The experiment was carried out during 2010-2012 in and around the premises of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. Since the Burmese grape is commonly propagated by seeds, dioecious and highly heterozygous in nature, so it has been assumed that variations among the population exists; therefore, each plant was treated as a single accession during the experiment. The general information like age of the plant, yield pattern, behaviour of the plant was documented by making a questionnaire at the time of the survey during 2010-11 and after the whole survey of various home garden in different villages, a total 20 numbers of female plants (accession) were selected as superior accessions based on their age and normal vigour of tree, bearing habit, size, shape and colour of fruits, taste, appearance for further analyses during the experiment to investigate the variability among the selected plants. During the selection of accessions among the surveyed plants, points like their age, bearing pattern, fruit characteristics, size of fruits were considered. 20 numbers of female accessions were named, sequentially, starting from ACC-1 to ACC-20. Parameters like number of flowers, fruit number, length of inflorescences (cm), fruit weight (g), peel weight (g), pulp percentage, fruit set percentage, fruit retention percentage, acidity, reducing sugar percentage, total sugar percentage and total soluble solids (^{O}brix) were

recorded for correlation studies. Total soluble solids (TSS), total sugar and reducing sugar were estimated by the method described by Mazumdarand Majumder (2003). The acidity and ascorbic acid were estimated by the method described by Rangana(1977). Correlation studies were performed using Proc Corr of Statistical Analysis System (SAS) by using SAS Enterprise Guide 4.3. Dendrogram of cluster analysis was prepared by Ward's minimum variance method (Ward, 1963). One way classified data analysis was performed with twenty accessions having four replications each.

RESULTS AND DISCUSSION

The correlation studies revealed that the number of flowers was highly significant to that of number of fruits, initial fruit set percentage and reducing sugar. Likewise, number of flower was negatively significant with, total sugar and non reducing sugar. The number of fruit was highly significant with initial fruit set percentage, while it was negatively significant with TSS. Length of inflorescence was significant with fruit weight. Fruit weight was highly significant with peel weight and significant with pulp percentage and ascorbic acid content. Fruit breadth was significant with total sugar and non-reducing sugar. The peel weight was highly and negatively significant with pulp percentage and significant with fruit retention and fruit diameter. Initial fruit set was negatively significant with ascorbic acid content; while it was significant with total sugar and non reducing sugar and TSS. Reducing sugar was negatively significant with non-reducing sugar. Total sugar was highly significant with non-reducing sugar, while negatively significant with vitamin C. Non- reducing sugar was negatively significant with ascorbic acid content. In similar study Saraswathy *et al*. (2010) reported that there was a positive correlation between tree height and canopy spread in sapota and the attributes like number of fruits per tree and canopy spread had positive correlation with fruit yield per tree. The quality traits, viz., total sugars and ascorbic acid content had negative correlation with fruit yield indicating that simultaneous improvement of yield and quality was not possible. Rekha *et al.* (2011) reported that the correlation studies among most of the fruit parameters indicated positive relationship in sapota.

The cluster analysis indicates that there is certain relationship between different female accessions. There are two main cluster comprising of 8 and 12 accessions amongst which accession 1, 4, 6, 7, 10, 16, 17, 20 and accession 2, 3, 5, 8, 9, 11, 12, 13, 14, 15, 18, 19, are closely related while these two group are distantly related. Similar findings were reported by Cluster analysis study of sapota clearly indicating relationship between different accessions having four sub-clusters (Rekha *et al.*, 2011).

The study thus revealed that there is a negative correlation among the flower numbers and the fruit set percentage; however, positive correlation among the fruit numbers, that indicates high drop of fruits during early stages. Fruit weight has strong positive correlation with peel weight, pulp percentage and ascorbic acid content, whereas, the pulp content has strong negative correlation with peel content. This indicates if the pulp weight increases then the peel weight may decrease; hence, selection should be made for optimum pulp weight. Cluster analysis also showed affinity of surveyed accessions in two broad sub-groups for further evaluation programme.

Table 1: Correlation studies among various growth and quality parameter in Burmese grapes

Characters	2	3	4	5	6	7	8	9	10	11	12	13. Ascorbic acid
1. Flower Number	0.516** (<.0001)	-0.059 (0.601)	0.096 (0.398)	0.087 (0.442)	-0.001 (0.992)	-0.324* (0.003)	-0.084 (0.458)	-0.069 (0.541)	0.245* (0.028)	-0.378** (0.0002)	0.004 (0.971)	0.164 0.147
2. Fruit number	-	0.078 (0.490)	-0.042 (0.714)	-0.050 (0.660)	0.047 (0.681)	0.640** (<.0001)	-0.204 (0.069)	0.137 (0.227)	0.052 (0.649)	-0.034 (0.764)	-0.240* (0.032)	-0.183 0.104
3.Length of inflorescence	-	-	0.279* (0.012)	0.134 (0.235)	0.169 (0.135)	0.131 (0.245)	-0.013 (0.911)	0.129 (0.254)	0.040 (0.722)	0.118 (0.296)	-0.056 (0.624)	-0.100 0.376
4.Fruit weight	-	-	-	0.552** (<.0001)	0.338* (0.002)	-0.132 (0.242)	0.190 (0.092)	-0.091 (0.423)	-0.005 (0.964)	0.084 (0.457)	0.011 (0.926)	0.228* 0.042
5.Peel weight	-	-	-	-	-0.569** (<.0001)	-0.122 (0.280)	0.291* (0.009)	0.034 (0.765)	0.014 (0.900)	-0.105 (0.354)	-0.027 (0.814)	0.155 0.169
6.Pulp %	-	-	-	-	-	0.038 (0.737)	0.138 (-0.221)	-0.113 (0.320)	-0.030 (0.792)	0.198 (0.078)	0.055 (0.626)	0.022 0.848
7.Fruit set%	-	-	-	-	-	-	-0.142 (0.211)	0.217 (0.053)	-0.157 (0.165)	0.316* (0.004)	-0.260* (0.020)	-0.351** 0.001
8.Fruit retention%	-	-	-	-	-	-	-	-0.083 (0.462)	0.007 (0.949)	-0.025 (0.826)	0.004 (0.975)	-0.068 0.552
9.Acidity %	-	-	-	-	-	-	-	-	0.076 (0.504)	0.216 (0.054)	-0.143 (0.207)	-0.218 0.053
10.Reducing sugar%	-	-	-	-	-	-	-	-	-	-0.218 (0.052)	0.102 (0.369)	0.198 0.078
11.Total sugar%	-	-	-	-	-	-	-	-	-	-	0.071 (0.534)	-0.547** <.001
12.Total Soluble solids	-	-	-	-	-	-	-	-	-	-	-	-0.017 0.879

(*significant at 1% and **significant at 5% level of significance, value in parenthesis is the table value)

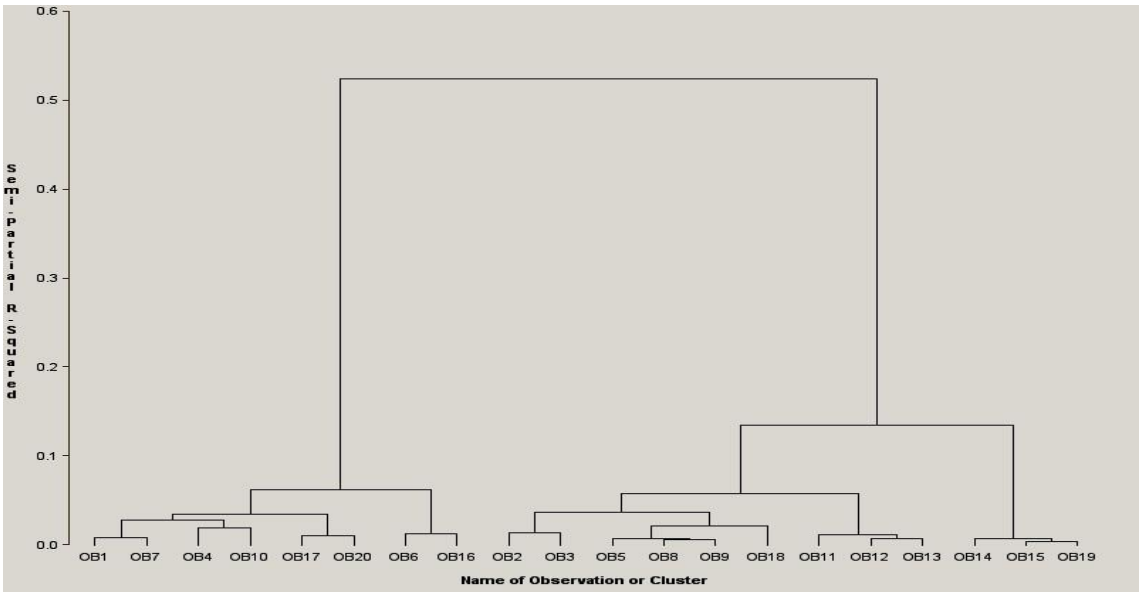

Fig.1. Dendrogram derived using Ward's method for Cluster Analysis showing genetic relationships among the 20 Burmese grape accessions

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Biodiversity of grapevine in Azerbaijan

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ABSTRACT

Results of studies of the genetic diversity of grapes in Azerbaijan are discussed. The large distribution of local varieties and their wild relatives in the republic is presented. The main bio-morphological and economic characteristics of the samples are determined. The essential differences between varieties and wild samples were is defined. As a result their areal was determined, mechanical and chemical composition of fruits, biological-agricultural traits of collected varieties and wild forms were evaluated. Results indicated that in Azerbaijan wild grape samples are spread widely in large areas and along the banks and shores of river, lake and sea, and on mountain slopes. There are two kinds of wild grape in Azerbaijan: *typica* Negr. (with hairs) and *aberrans* Negr. (hairless). At present more than 600 local and introduced grape varieties are spread in Azerbaijan, of which more than 100 varieties are threatened. White, red, black and pink coloured table, technical and universal grape varieties are cultivated. Salt and drought tolerant varieties also reported. Most of the local threatened varieties are conserved for utilizing them in future improvement programme.

Keywords: Biodiversity, genetic resources of grapes, local varieties and wild grapes.

INTRODUCTION

Azerbaijan is considered one of evolution centers of cultivated plants. Practically all present-day major cultivated plants for the first time appeared in Azerbaijan several millennia B.C. As example there can be mentioned signs of farming, ancient horticulture discovered in a settlement westward of Goy-Gol town in the early second millennium B.C. Fruit crops (apple, pear, apricot, pomegranate, quince, fig, almond, walnut, hazelnut etc) and grape have been cultivated to meet the demand of the population for foodstuff and other products. Most of these crops are still considered major agricultural crops in the country.

Vine-growing was one of the most ancient and widely spread fields in economic life of people of Azerbaijan. From the results of different investigation and study like archaeological excavations, paleobotanical, ampelographic information, tongue and folklore samples, written sources, toponomic etc., Azerbaijan was determined as one of the cultural centers of vine-growing. The territory of Azerbaijan has very favourable conditions for improvement and development of vine-growing. Primitive men had collected wild fruits and berries, as well as wild grape, besides hunter and fishery and used them as tasty food stuffs.

In 1963 in the western part of Bozdagh (Goy Gol region) while geological investigations by Azerbaijan scientists, by chance found lots of plant remains in Absheron sediments which formed 1-2 million years ago. Most of these residues were tracks of wild grape leaves on stone. Formation of wild grape in this area (approximately 500, 000 years ago) was proved by stoned grape leave found in Nakhchivan (Allahverdiyev *et al.*, 1973; Babayev, 1988). This finding proves that, the region is one the ancient vine-growing centers. These discoveries are very valuable not only for historians but also specialists of other sciences like paleobotanics, ampelographics, fruit-growers, geologists and soil scientist. Researchers concluded that, the origin of cultured grape was from wild grape areas. According to a notable scientist N.I. Vavilov, as animals, plant domestication is also possible in areas which enriched with available species. By his long term investigations, he had determined that, Azerbaijan and Southern Caucasus are the main origin centers of crops, as well as grape (Vavilov 1931).

While archaeological excavations near Aghstafa region in 1962 year, various plant remains, also grape seeds had been found in “Shomutepe” monument belonged to V-IV millennium BC. Investigations had showed the culture and year parameters of grape seeds. Mainly on the base of this finding it was proved that, the history of cultured vine-growing in Azerbaijan has at least 7 millenniums.

MATERIALS AND METHODS

Materials of research work consisted of grapevines and yields of local grape varieties and wild grape forms. Ampelographic description of grape varieties and wild grapevines had been implemented on the base of common methods (Lazarevsky, 1963; Morozova, 1987; Negrul 1959; Smirnov *et al*., 1987). Phytopathological and

immunological descriptions and assessments of grapevines on natural background were carried out by appropriate methods (Nedov, 1985) and stress factors resistance of varieties and forms had been evaluated by appropriate methods (Kushnirenki *et al.*, 1976, Udovenko, 1988).

RESULTS AND DISCUSSION

In the Republic of Azerbaijan, the wild grape samples spread widely in large areas and in the banks and shores of river, lake and sea and mountain slopes of Absheron, Nakhchivan AR, Ganja-Gazakh, Garabagh, Mil-Mughan, Shirvan, Talysh and etc. A number of researches were implemented in Khachmaz, Guba, Khudat, Nabran, Gusar, Shamakhi, Ismayilli, Aghsu, Oghuz, Gabala, Shaky, Zagatala, Lankaran, Fuzuli and etc. regions for studying the genetic resources of grape.

At the same time as it may be concluded that wild grape spread on the whole territory of Azerbaijan is very ancient formation. Wild grape - *V.vinifera* L. subsp. *sylvestris* (C. C. Gmel.) Hegi. of Azerbaijan is distinguished with specific characters. It is spread on the territory of Azerbaijan from 18 m below sea-level (Kyur riverside, Salyan region) to 2000 m above sea- level (Gusar region). There are two kinds of wild grape in Azerbaijan: *typica* Negr. (with hairs) and *aberrans* Negr. (hairless).

While expedition in Guba-Khachmaz region it was known that, Guba region is enriched with wild grape. In forests of this region (Uzunmeshe, Alpan, Khujbala, Digah, Aghbil, Susay Gishlag, Dallakand villages) along Guruchay, Gusarchay, Gudyalchay rivers lots of wild grape forms were found. In Nabran forests of Guba-Khachmaz region dark and dark purple coloured grape forms were found. In forests of Khachmaz (Pir forest), Shaky (Oraban), Lankaran (Seligavul) and Gabala (Shongar) regions small seedy dark wild grape varieties were also determined. On the banks of Kondalanchay river in Fuzuli region dark, dark red, dark purple coloured grape seed forms were observed. In general, more than 3000 forms of wild grapes were found in expedited villages and regions and phitocenetic features of their spreading areas were described.

At the result of investigations it was determined that, different populations of wild grape in Azerbaijan republic spread mainly in three formations - tugay (streamside forest), typical broad-leaved forests and coastal area of the Caspian Sea. On the banks of Kungut river (Oraban village) of Sheki, Guruchay, Gusarchay, Gudyalchay rivers (Uzunmeshe, Alpan, Khujbala, Digah, Akbil, Susay Gishlag, Dallakand villages) of Guba region wild grapevines spread mainly in tugay forests densely and widely. But typical forest formation of wild grape was found in Agharehimoba, Godekli, Gimilgishlag, Gadashoba, Nerecan and etc. villages and forests (forest number 1, Pir forest) of Khachmaz region, Seligavul forest of Lankaran region and Shongar spring of Gabala region.

Wild grape samples distinguish each other for their biomorphological traits. As rule male grapevines are strong while functional female grapevines are weak. All samples of wild grape can be divided into 4 groups for leaves bigness: very small (length up to 4,0-8,0 cm), small (length up to 8,0-12,0), medium (length 12,0-15,0 cm) and large leaved (length more than 15 cm). Most of studied varieties were involved to small and medium leaved group. Wild grape samples can be divided into 3 groups for leaves sub-sections: whole, medium and cross-section leaves. Some samples are covered with white net-shaped blooms, but in some cases under surface are bare. Samples are distinguished for leave sides. Sides are mainly sharp, triangular and round shaped. Stalk hollows are namely lira-shaped, but rarely sides are parallel and bottom is flat. Wild grape samples are two housed, that is they have male or female flower groups (Akparov *et al*, 2010).

Self-pollinated bisexual flower groups of wild grape samples were not found. According to some researchers' opinions that types of flower groups of wild grape are very important morphological trait for defining grape origin, because wild grape is two housed subspecies. Bunch flowers of wild grape can be distinguished each other for their forms, they are small or medium sized. As a rule, the bunch flowers of male grapevines are big and cone-shaped. But bunch flowers of female grapevines are small, cone-shaped-cylindrical or cylinder-shaped. Bunches of wild grape are small, the length is 7.0-13 cm and the width is 6-8 cm. There are 1-2 bunches on productive shoots. Bunches are mainly set on 3-5th churn-stuffs of new shoots. Skin of separate seeds of grape is dark or reddish dark. Seeds are oval-shaped. The surface is covered with thick wax layer. Most of wild grape varieties are resistant to mildew and oidium disease.

More famous local varieties of grapevine are cultivated in Absheron, Garabagh, Ganja-Gazakh, Shirvan, Guba-Khachmaz regions and Nakhchevan AR of Azerbaijan. Hundreds (according to some information about more than 600) of landraces of grapevine are grown in the Republic. White, red, black, pink colored table, technical and seedless grapevine varieties – 'Agh shani', 'Agh Sahibi', 'Agh Aldara', 'At uzum', 'Aghri', 'Arnaqrna', 'Bandi', 'Rishbaba', 'Chilal', 'Kishmishi', 'Tulkuguyrugu', 'Huseyni', 'Madrasa', 'Marmari', 'Qara Aldara', 'Qoc uzumu', 'Tabrizi', 'Molla Ahmadi', 'Novrast', 'Karimgandi', 'Durna gozu', 'Devegozu', 'Kechiamcayi', 'Khazri', 'Khalili', 'Gara shani', 'Gizil uzum', 'Chil uzum', 'Beylagani', 'Kharci', 'Khan uzum', 'Pishras', 'Malayi', 'Mahmudabi', 'Misgali', 'Khindogny', 'Hafizeli', 'Hachabash',

'Haji Abbas', 'Hamashara', 'Sarigila', 'Shiray', 'Shirvanshahi', 'Shireyi', 'Shirshira', 'Shafeyi', 'Shakarbura', 'Shahangir', 'Shakari', 'Sisag' and etc. are cultivated here. Most of them are only grown in definite areas and private courtyards by amateur gardeners (Akparov and Musayev, 2012, Musayev, 2003).

Physiological complete maturing period is characteristic inherited trait for each variety. Varieties, clones, new forms studied in genefund are distinguished each other for their maturing periods. It was determined by investigations that, maturing periods of fruits of local grape varieties in Azerbaijan Republic can be divided into the following groups. Existing local grape varieties are distinguished each other for their use directions in the Republic. Here table, technical and universal varieties are met. Between them the table grape more dominates.

Expeditions and investigations were implemented for the purpose of finding, collection and inventory of local grape varieties in Azerbaijan. Spreading areas of local grape varieties and wild grapevines found through expeditions and investigations, etiquette of grapevines were noted, their some morphological-biological and immunological characteristics were determined and mechanical and chemical investigation (in lab condition) of yields were carried out.

During expeditions and researches arranged in Absheron region 'Gavangir', 'Fatmayi', 'Haji Abbas', 'Sarigile', 'Absheron gelinbarmaghi', 'Ala shani' table grape varieties were found freshly. Gavangir and Sarigile varieties possess more juice extraction than others. Therefore doshab and grape juice are produced of them. It was known that, bunches and seeds of these varieties are medium and big-sized and this is characteristic for table varieties. The biggest separate seeds of variety belong to 'Absheron gelinbarmaghi' (berries size – 18-23x16-22 mm), 'Haji Abbas' (berries size - 20-26x19-24 mm), 'Ala shani' (berries size – 16-24x15-23 mm) varieties. This preference was reflected on the weight of 100 separate seeds of grapes. Sweetness of separate seeds of grape was 17.2 ('Gavangir') - 27.9 gr/100 cm^3 ('Sarigile'). Average weight of bunches was lower in 'Sarigile' (170 gram) and 'Fatmayi' (180 gram) varieties, in 'Absheron gelinbarmaghi' (250 gram), 'Ala shani' (240-278 gram), 'Haji Abbas' (286 gram) was medium, but in 'Gavangir' variety was higher (386,4 gram) (Akparov *et al*, 2010). It was known at the result of phenological observations that, studied varieties ripen averagely ('Sarigile', 'Fatmayi', 'Absheron gelinbarmaghi') and lately ('Gavangir', 'Haji Abbas', 'Ala shani').

It was determined while immunological assessments of local grape varieties of Absheron on the natural background that, they were resistant to oidium disease (2-2.5 points) and tolerant (3-3.5 points). The climate of Absheron is dry-subtropical and therefore in most cases development of mildew disease is not found there. At the result of observations it was known that, 'Gavangir' and 'Fatmayi' (3-3,5 points), 'Haji Abbas', 'Sarigile', 'Absheron gelinbarmaghi', 'Ala shani' varieties (2.5 point) were tolerant to grey rot disease.

25 local and 2 introduced grape varieties were observed while expedition in Garabagh-Mil region that, 12 of them were low spread local varieties. 'Agh Beylagani', 'Gelinbarmaghi', 'Nubari', 'Ari uzumu', 'Arayatli gara uzumu', 'Agh Gavra', 'Surmeyi', Fuzuli kechimemesi', 'Gizil uzum', 'Alikhanli kechimemesi', 'Bey uzumu' are such grape varieties. It was known during morphometric measurements that, their bunches were medium ('Nubari', 'Arayatli gara uzum', 'Alikhanli kechimemesi') and big sized ('Agh Beylagani', 'Gelinbarmaghi', 'Agh Gavra', 'Surmeyi', 'Fuzuli kechimemesi', 'Gizil uzum', 'Gozel uzum', 'Bey uzumu'). Separate seeds of studied varieties were different-coloured, formed, mainly small ('Nubari), medium ('Ari uzumu', 'Arayatli gara uzumu', 'Gizil uzum'), bid ('Agh beylagani') and bigger ('Gelinbarmaghi', 'Agh gavra', 'Surmeyi', 'Fuzuli kechimemesi', 'Gozel uzum', 'Alikhanli kechimemesi', 'Bey uzumu') sized.

It was concluded through phytopathological evaluation of above-mentioned varieties against mildew, oidium and grey rot diseases in natural situation that, 'Agh Beylagani' and 'Gelinbarmaghi' varieties were not resistant to mildew disease (4 points), but showed average resistance (3 points) to oidium and grey rot diseases. 'Surmeyi' variety was tolerant (3.5 points) to mildew and oidium diseases, but bunches were low tolerant (5 points) to grey rot disease. And other varieties showed resistance (3-3.5 points) to mildew and oidium diseases. It was also defined that, 'Nubari', 'Ari uzumu', 'Arayatli gara uzumu', 'Agh Gavra', 'Gozel uzum', 'Alikhanli kechimemesi', 'Bey uzumu' varieties were resistant (2.5 points) to grey rot disease. Above-mentioned varieties are local and they are mainly used freshly. 'Agh Beylagani', 'Gelinbarmaghi', 'Agh Gavra', 'Fuzuli kechimemesi', 'Gozel uzum', 'Alikhanli kechimemesi', 'Bey uzumu' can be conserved for a long time and even yield is kept on grapevines till winter. 'Arayatli gara uzumu' and 'Ari uzumu' varieties possess high juice extraction and sweetness, therefore red table wines are made of these varieties by local people (Akparov *et al*, 2010).

Research works on evaluation of biological-agricultural traits of grape varieties and forms (local, introduced) cultivated in ampelographic collection gardens and experimental fields were implemented. While evaluating disease and pest resistance of studied 74 varieties and forms it was noted that, a number of varieties were infected by oidium disease.

Among them 17 varieties – 'Agh uzum', 'Fuzuli kechimemesi', 'Gara Asma', 'Parkent', 'Sari Karan', 'Oktyabrski', 'Vishnyoviy', 'Tozlayici', and etc. showed tolerance (3-3.5 points). Only 'Bayanshire' variety was tolerant to mildew disease. 4 varieties and forms –'Nakhchivan gulabisi', 'Gara Nakhchivan Khatini', 'Kishmish Khishrau' and form number 2 were resistant to pests and were less infected (1 point).

Salt and drought resistance of 15 grape varieties and 21 wild samples were studied for their main physiological traits (stress depression of pigment complex in osmotic solution (sucrose 2% NaCL) in complete formation stage of leaves). It was known that, studied varieties and wild samples demonstrated different reaction to stress factors and plants showed unlike attitude to salt and drought. And it was possible to select resistant varieties on these bases. At the result of experiments high salt and drought resistance were observed in 5 varieties ('Agh kishmish', 'Tozlayıcı', 'Gara qush ureyi', 'Agh shanı', 'Bayanshire') and resistance in 3 varieties and 3 varieties ('Hafizeli', 'Sarıgile', 'Shamakhı merendisi') were observed as resistant to these stress factors. Among the wild samples, 7 samples (No. 71, 78, 43, 74, 34, 32, 72) were identified as resistant to both of these stress factors (Musayev and Huseynova, 2007, Musayev and Huseynova, 2012).

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Varietal performance of fenugreek under Akola conditions

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ABSTRACT

The varietal performance of fenugreek under Akola conditions was studied at the Department of Horticulture during 2014. Seven cultivars *viz.*, Hisar Sonali, Hisar Madhavi, Hisar Suvarna, Hisar Mukta, Pant Ragini, Rajendra Kranti and Pusa Early. Bunching were evaluated for growth yield and quality parameters. The varieties showed significant variation in all aspect. The cultivar Hisar Suvarna took minimum days for seed germination, Hisar Sonali gave better growth performance in respect of plant height, number of branches and also found superior in respect of green leaf yield and fresh weight. Similarly in leaf quality attributes, Hisar Sonali had maximum leaf chlorophyll content while iron content was found maximum in Rajendra Kranti but maximum moisture content was recorded in Pant Ragini. The green leaf yield exhibited positive correlation with the plant height at 30 DAS, number of branches plant^{-1} and fresh weight.

Key words: correlation, Fenugreek, green leaf yield, quality,

INTRODUCTION

Fenugreek or methi (*Trigonella foenum-graecum* L.) is an important leafy vegetable which is quite popular in India. It is cultivated as leafy vegetable, condiment and as medicinal plant. It belongs to the family leguminaceae. There are two species *viz. Trigonella foenum-graecum* (common methi) and *Trigonella corniculata* (kasuri methi). India is the largest producer of fenugreek vegetable throughout Karnataka. Rajasthan is considered as "fenugreek bowl" of the country (Anon., 2013). Recently Methi No. 14 and Methi No. 47 are high yielding cultivars released for leaf yield in Maharashtra and there is ample scope for its cultivation (Mini and Krishnakumary, 2004). Being a cool season crop, it is cultivated for leaf purpose throughout the country. As multifarious importance of this crop, every part of its plant is utilized in one or the other forms. The dried leaves and tender shoots are all consumed and are valued as food, flavouring agent and medicine. It is extensively used as fresh leaves (green leafy vegetable), chopped leaves (flavouring agent), sprouts (salad) and micro greens (salad) (Aggarwal *et al*., 2013). Fenugreek leaves being rich in iron, calcium, protein and vitamins and suggested as iron chelator (Kumar *et al.*, 2010). Vidarbha region has potentiality for the cultivation of fenugreek as vegetable, farmers are growing local types and performance of local types is poor. It may be due to the lack of information about variety best suited under the prevailing agro-climatic conditions. Before recommendation of any variety suitable for the region, it is pertinent to evaluate varieties giving emphasis on the aspect of genotypic suitability and yield. Considering all above mentioned facts, a pertinent need was felt to undertake an experiment on varietal performance of fenugreek under Akola conditions so as to ascertain and recommend the cultivar best suited for the agro-climatic conditions of Akola.

MATERIAL AND METHODS

A field experiment was laid out during 2014 at experimental field of College of Horticulture (20.7°N latitude, 77.02°E longitude and altitude 307.4MSL). During the experimental period from the January to February the mean maximum temperature ranges from 30.0°C to 31.0°C and 12.0°C to 12.6°C as minimum temperature. While maximum relative humidity 68 per cent and minimum 25 per cent during winter. The soil of the experimental field was well drained with uniform texture and structure. The experiment was laid out in Randomized Block Design with four replications. The plot size measured 1.5 m × 1.1 m and spacing was 15 cm apart in line. Seven cultivars *viz.*, Hisar Sonali, Hisar Madhavi, Hisar Mukta, Hisar Suvarna, Pant Ragini, Rajendra Kranti and Pusa Early bunching were included in the experiment. Well rotten FYM @25 t/ha and NPK @ 20:60:30 kg/ha were applied in the experimental plot. Seeds were sown on 18th January, 2014. Recommended practices were followed to raise healthy crop. Five plants were selected randomly from each replication for recording observations on four growth characters *viz.*, days required for germination, plant height (cm), number of branches per plant, leaf area (cm^2), two yield parameters *viz.*, fresh weight (g) and green leaf yield (q/ha) and quality parameters *viz*., chlorophyll content from

leaves was calculated by using spectrophotometer as suggested by Arnon (1949). Moisture content of fenugreek leaf was measured on electric moisture meter (Shimadzu-Make, electronic moisture balance, MOC-120H) and leaf iron content was estimated by using atomic absorption spectrophotometer, procedure suggested by Wolf (1982). The data were subjected to statistical analysis through Randomized Block Design by using Indian NARS Statistical Computing Portal, IASRI, New Delhi

RESULTS AND DISCUSSION

Performance of any crop in respect of growth, yield and quality is highly influenced by various factors like genetic constitution of variety, micro-climate of the area and crop management. The results obtained from the present investigation on growth parameters exhibited significant difference by all the cultivars. The variety Hisar Suvarna took minimum period for seed germination (3.93 days) followed by Pusa Early Bunching (4.17 days) and Hisar Mukta (4.40 days) whereas; the variety Rajendra Kranti recorded maximum days (5.38 days) for seed germination. All the cultivars showed significant variation in respect of plant height at 15 and 30 days after sowing. Hisar Sonali recorded maximum plant height (8.72 cm and 17.95 cm at 15 and 30 days after sowing), followed by Hisar Madhavi (7.38 cm and 16.98 cm) and Hisar Suvarna (6.18 cm and 16.38 cm) respectively. The maximum numbers of branches were produced by variety Hisar Sonali (5.08) which was found to be *at par* with Pusa Early Bunching (5.05), Hisar Suvarna (4.68) and Rajendra Kranti (4.30) whereas, the minimum number of branches (3.75) were recorded in Hisar Mukta (3.75). The maximum leaf area (12.92 cm^2) found in Pant Ragini it was found to be *at par* with Hisar Madhavi (12.28 cm^2) and Hisar Suvarna (12.27 cm^2) whereas, the minimum leaf area was recorded in Pusa Early Bunching (10.08 cm^2). The wide variation in growth parameters of all the cultivars might be due to their genetic makeup, which indirectly govern the morphology of plant. These results are in conformity with the findings of Aggarwal *et al.* (2013) and Datta and Chaudhari (2005). All the genotypes showed the significant variations in yield attributing characters. In respect to fresh weight, significantly the cultivar Hisar Sonali recorded maximum fresh weight per plant (7.97 g) which was found to be *at par* with Pusa Early Bunching (7.68 g) whereas, the cultivar Pant Ragini recorded minimum fresh weight (5.98 g). The cultivar Hisar Sonali showed significant effect on green leaf yield. The maximum yield (302.63 q/ha) was recorded in the cultivar Hisar Sonali was found to be *at par* with variety Pusa Early Bunching (293.18 q/ha), Hisar Madhavi (279.72 q/ha), Rajendra Kranti (266.36 q/ha) and Hisar Suvarna (255.35 q/ha) whereas, the minimum leaf yield was recorded by Pant Ragini (194.81 q/ha). The variation in yield characters might be due to differences in response of different fenugreek varieties to agro-climatic conditions and different vegetative characters of cultivars might cause the significant difference. Similar results under different set of climatic conditions as influenced by the cultivars of fenugreek were reported by Mandal *et al.* (2013).

The data presented in Table 1 indicates that, there were significant differences in respect of leaf chlorophyll content of different fenugreek varieties. The maximum leaf chlorophyll content (43.73 mg/g) was recorded by the variety Hisar Sonali and found superior over all other cultivars followed by Pusa Early Bunching (42.18 mg/g) and Hisar Suvarna (41.63 mg/g) whereas, the minimum leaf chlorophyll content was observed in Hisar Madhavi (38.48 mg/g). Significantly maximum moisture content was observed in Pant Ragini (84.69 %) which was found *at par* with Pusa Early Bunching (84.43 %) whereas, the minimum moisture content was observed in Rajendra Kranti (81.98 %). Maximum leaf iron content (112.90 ppm) was recorded in cultivar Rajendra Kranti and found *at par* with Hisar Suvarna (110.70 ppm) whereas, the minimum leaf iron content was recorded in Hisar Sonali (102.28 ppm). The variation in quality parameter might be due to varietal characters and genetic inheritance of the fenugreek varieties (Aggarwal, 2013).

Table 1. Performance of different fenugreek varieties in respect to growth, yield and quality parameters.

Treatments	Days required for germination	Plant height (cm)		Number of branches $plant^{-1}$	Leaf area (cm^2)	Fresh weight (g)	Green leaf yield (q/ha)	Leaf chlorophyll content (mg/g)	Leaf moisture (%)	Leaf iron content (ppm)
		At 15 DAS	At 30 DAS							
Pant Ragini	5.02	5.38	15.18	3.93	12.92	5.98	194.87	39.48	84.69	106.10
Hisar Suvarna	3.93	6.18	16.38	4.68	12.27	7.28	255.35	41.63	83.97	110.70
Hisar Mukta	4.40	6.10	16.05	3.75	10.43	6.15	234.94	39.60	83.29	109.08
Hisar Sonali	4.52	8.72	17.95	5.08	12.02	7.97	302.63	43.73	82.08	102.28
Hisar Madhavi	4.50	7.38	16.98	4.05	12.28	6.45	279.72	38.48	82.00	108.03
Rajendra Kranti	5.38	6.08	15.97	4.30	11.63	7.08	266.36	38.50	81.98	112.90
Pusa Early Bunching	4.17	5.84	15.99	5.05	10.08	7.68	293.18	42.18	84.43	103.63
SE(M)±	0.05	0.29	0.51	0.28	0.22	0.17	16.40	0.51	0.18	0.58
CD at 5%	0.14	0.85	1.08	0.82	0.66	0.49	48.75	1.53	0.54	1.72

Table 2. Correlation between yield and its contributing characters of fenugreek

	Green leaf yield (q/ha)	Plant height (cm) 30 DAS	Number of branches plant^{-1}	Leaf area (cm^2)	Fresh weight (g)
Green leaf yield (q/ha)	1				
Plant height (cm) 30 DAS	0.763	1			
Number of branches plant^{-1}	0.743	0.499	1		
Leaf area (cm^2)	-0.343	0.084	-0.185	1	
Fresh weight (g)	0.824	0.588	0.968**	-0.237	1

*, significant at 5% level; **, significant at 1% level, DAS- Days After Sowing

Correlation

Correlation among the yield and yield components in fenugreek are presented in Table 2. in the present investigation. Green leaf yield per hectare observed to be positive association with the plant height at 30 DAS, number of branches plant^{-1} and fresh weight (g). The green leaf yield per hectare showed positive and non-significant association with plant height at 30 DAS (0.763), number of branches per plant (0.741) and fresh weight of plant (0.824) and negatively correlated with leaf area (cm^2) (-0.343).

Plant height at 30 DAS expressed positive and non-significant association with number of branches per plant (0.499), leaf area (0.084) and fresh weight (0.588). The number of branches per plant had highly significant positive correlation with fresh weight of plant (0.968), but it was negatively correlated with leaf area (-0.185). Negative correlation among yield components reveals that selection for an increase of any component might not bring improvement for yield. These findings were in agreement to Sharma *et al.* (1990), Singh *et al.* (2013) and Lodhi *et al.* (2015) in fenugreek.

It can be concluded that, the cultivar Hisar Sonali performed best in respect of plant height, number of branches, fresh weight, dry weight, leaf chlorophyll content and found promising for green leaf production under Akola conditions.

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Study on the ethnobotany and nutritional status of three edible *Ficus species* in hill district of Bangladesh

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ABSTRACT

The natural habitats of the Khagrachari of Bangladesh are incredibly full of natural biological resources, on which the tribal ethnic people, primarily, depend for their all sorts of livelihood. Along with different food items, they traditionally use different ethnic fruits. Wild edible Fig plants (*Ficus* sp.) make a significant contribution to diets and medicines of ethnic people. Among those *Ficus carica* L, *Ficus semicordata* Buch.-Ham. Ex smith and *Ficus auriculata* Lour. belonging to the family Moraceae have been traditionally used by ethnic people in Khagrachari hill district as the popular food and medicine plants. Present investigation has been aimed to study the ethnobotany and nutritional status of these three important edible figs. The results showed the highest protein and fat contents in *Ficus auriculata,* while the lowest in *Ficus semicordata* and *Ficus carica,* respectively. Starch contents were the highest in *Ficus carica* and the lowest in *Ficus auriculata*. β-Carotene and mineral contents were the highest in *Ficus auriculata* but vitamin C contents were the highest in *Ficus semicordata* and the lowest in *Ficus carica*. Fig fruit extracts have been recommended for developing herbal formulation that could reduce the diarrhea and dysentery and prevent cancer development.

Key words: Bangladesh, edible *Ficus* sp., ethnobotany, hill district, nutritional status

INTRODUCTION

Bodo-Dumur (Ficus auriculata Lour.), *Angir-Dumur (Ficus carica* L) and *Sadimadi-Dumur* (*Ficus semicordata* Buch.-Ham. Ex smith) are three popular wild edible fruits of Khagrachari district in Bangladesh. *Ficus*- the fig genus consists of over 800 species within 40 genera of the Moraceae family (Gaire *et al*., 2009). In this sub-continent fig grows naturally. A good number of *Ficus* species have been reported as food and for medicinal properties in Ayurvedic and Traditional Chinese Medicine (TCM). There are many *Ficus* species, which grow everywhere in Bangladesh and Khagrachari is the most suitable place for fig plants. Thirty six species of *Ficus* are reported so far from Nepal but a detail investigation of their indigenous uses has never undertaken till now (Kunwar and Bussmann, 2006). Besides their usage as food item; these wild fruits plants are also explored for their medicinal properties. Most of these species are utilized against various diseases by the local communities through their indigenous knowledge. *Ficus sp*. has got various traditional medicinal uses such as in treating wounds, diarrhea and dysentery, mumps, cholera, vomiting etc. (Ripu *et al*., 2009). Nutrient analysis of wild edible fruits plays a crucial role in assessing their nutritional significance (Pandey *et al*., 2006). The considerable use of wild edible fruit species by the local people in hill districts of Bangladesh in their diet motivated us to carry out the present work on nutrients analysis of *Ficus* species. In spite of their importance as a food source, there are no published reports on the nutritional composition of wild edible figs. The present study was therefore initiated to evaluate the ethnobotany and nutritive value of *Ficus carica*, *Ficus semicordata* and *Ficus auriculata*.

MATERIALS AND METHODS

Wild fruits of edible figs, *Ficus carica*, *Ficus semicordata* and *Ficus auriculata* used as experimental material, were collected from

Shotokheda, Ramgorh of Khagrachari district and Pablakhali of Rangamati district through an initial ethnobotanical survey (January, 2011-september, 2014). The collected fruit materials were placed in polythene bag to prevent loss of moisture during transportation to the laboratory. Efforts were made to collect these plants in flowering and fruiting conditions for the correct botanical identification. Detailed ethnobotanical information was recorded while collecting voucher specimens. Botanical identification and authentication were made through consulting the Encyclopedia Flora of Bangladesh and expert taxonomist in Bangladesh National Herbarium (DACB), Dhaka and cross checking was also done through matching with the specimens preserved in DACB. Chemical and nutritional analyses were done at Postharvest Technologies Division and Soil Science Division, Bangladesh Agriculture Research Institute (BARI), Gazipur, Dhaka.

Preparation of samples

Freshly collected sample was washed with deionized water to eliminate visible dirt and excess water was quickly removed with blotting paper. Then the samples were cut into small pieces, homogenized and accurate amount was weighed as required for different analysis. Three test samples from each fruit were selected for measurement of various parameters.

Reagents

All chemical and reagents used in the analysis of the nutrient profile were of analytical grade and were purchased from Merck (Darmstadt, Germany, BDH, UK). β-carotene, ascorbic acid and minerals standards, 2,4 di-nitrophenyl hydrazine were purchased from Sigma Chemical Co. (St. Louis, MO, USA).

Methods of nutrient analysis

a. Estimation of weight, p^H, Titratable Acidity, Moisture, TSS and Total sugar

Weight of figs was estimated by digital weight balance. The pH was determined with digital pH meter (Ibrahim, 2002) and Titratable acidity was estimated with the visual acid-base method (Ranganna, 1986). Moisture content was determined by digital moisture analyzer. Total Soluble Solid (TSS) was determined with hand refractometer (Gofur *et al.*, 1998). Total sugar was determined by Lane and Eynon method (Ranganna, 1986).

b. Estimation of Protein

Protein content in the food item was determined by indirect method estimating total nitrogen. It was calculated by multiplying the total nitrogen using the respective factor as estimated by Micro-Kjeldahlmethod (AOAC, 1998b).

c. Estimation of Fat

Powdered sample was subjected to extraction with mixture of chloroform and methanol (Raghuramulu *et al*., 2003). Total fatty acid content was estimated by calculation and by multiplication of total fat content by a factor.

Table 1. Pictures of three edible ethnic figs

Fig 1: *Ficus carica* L

Fig 2: *Ficus semicordata* Buch.-Ham. Ex smith

d. Estimation of Starch

Starch was hydrolysed into simple sugars by dilute acids and the quantity of simple sugars was measured colorimetrically (Ranganna, 1986).

e. Analysis of Vitamin C

Ascorbic acid was estimated by spectrophotometer method (AOAC, 1998e). The fresh fruit sample was homogenized in a mortar with pestle using metaphosphoric acid, filtered, treated with 85% sulfuric acid solution and 2,4-dintrophenylhydrazine and incubated at 60°C for 60 minutes in water bath. It was read at 520nm in spectrophotometer (UV-1601, UV-Visible, Shimadzu, Tokyo, Japan).

f. Analysis of β- Carotene

Reverse phase HPLC (Shimadzu PC based Binary Gradient HPLC Prominence System with PDA Detector, SPD- M20A; Solvent delivery System, LC-20AT; LC Solution Multi workstation Software was used to determine the β-Carotene (Roriguez-Amaya, 2004).

g. Analysis of mineral profile

Mineral content was analyzed by Atomic Absorption Spectrophotometer method (Petersen, 2002).

RESULTS AND DISCUSSION

Taxo-Ethnobolanical Information of three *Ficus spp.*

Scientific name : *Ficus carica* L
Synonym : *Ficus carica* var. caprificus Risso
Common/Local name : Common fig; *Deshi dumur*
Vernacular name : *Angir-dumur*, *Anjir* (Bangla), *Sudreshi* (Marma), *Soficgula* (Chakma), Common fig, European fig (English).
Family : Moraceae (Mulberry family)

Distribution

The fig is believed to be indigenous to Western Asia and to have been distributed by man throughout the Mediterranean area. It is found everywhere in Bangladesh.

Botanical description

Ficus carica, commonly called common fig, is a deciduous shrub or small tree. It is noted for its spreading habit, attractive foliage and edible fruit. Old trees with smooth silver-gray bark (sometime gnarled with age) are ornamentally attractive. Large, palmate, hairy, 3-5 lobed leaves are rough dark green above and smooth light green beneath. Non-showy greenish flowers form in spring inside hollow receptacles near the branch growing tips. The most fig cultivars are parthenocarpic (fruits develop without cross pollination). The fruit (edible fig) develops within each receptacle.

Consumption practice

Fruits are eaten raw or as vegetable. The latex is widely applied on warts, skin ulcers and sores, and taken as a purgative and vermifuge, the fruits are much used as poultices on tumors and other abnormal growths. The leaf decoction is taken as a remedy for diabetes and calcifications in the kidneys and liver. Fresh and dried figs have long been appreciated for their laxative action.

Scientific name : *Ficus semicordata* Buch.-Ham. Ex smith
Synonym : *Ficus cunea* Buch.-Ham. ex Roxb.
Common/Local name : Dumur, Lata dumur,
Vernacular name : *Sadimadi* (Marma), *Kurali* (Chakma), *Thaijang* (Tripura), Aninsep, Garo), *Thydu* (Khumi), *Jonua, Sodoi* (Mogh), *Ududui Ui-Duth* (Murang), *Chorki Gula* (Tanchangya), Fig (English).
Family : Moraceae (Mulberry family)

Distribution

Forests of Chittagong, Chittagong Hill Tracts and Cox's Bazar.

Botanical Description

A small to medium-sized evergreen tree with long spreading branches down to the ground, bark grey, smooth. Leaves are very variable in size, usually elliptic or oblong-lanceolate, acuminate, entire or serrate, scab rid on both surfaces, waxy glands in the axils of the basal lateral veins. Receptacles in pairs or small clusters on long leafless scaly shoots from the

larger branches or main stem near the base, shortly pedunculate, globose or pyriform. Fruit an achene, broadly ovoid, whitish, apically slightly concave on one side, with small tubercles, reddish-brown when ripen.

Consumption practice

Fruits are eaten raw or as vegetable. The leaves are used for carbuncle, dysentery, hematuria, piles; dried leaves and stems for boils, rheumatism, sore throat. Women and children eat this fruit to improve appetite. Latex is used for skin disease; stem or fruit peel for backache, cancer, hernia, piles, swellings, and tuberculosis of the testicles. Root is used for bladder inflammation.

Scientific name : *Ficus auriculata* Lour.
Synonym : *F. oxburghii* Wall. ex Miq. *F. macrophylla* Roxb. *F. regia* Miq.
Common/Local name : Jaggu Dumur, Demur, Doomoor
Vernacular name : *Kani-bot, Baradumur*, *Sapai* (Bangla), *Bora Jagna gach* (Chakma), *Jaggu Dumur* (Marma), *Thebol* (Tripura), *soh-la-kechiath* (Khasia), Elephant ear fig tree, Gaint Indian fig, Eve's apron (English).
Family : Moraceae (Mulberry family)

Distribution

It is native to Asia especially in China, Nepal, India, Bhutan, Pakistan, Myanmar, Thailand, Vietnam, Malaysia, etc. This *Ficus* species have a wide range of distribution in Bangladesh.

Forests of Chittagong, Chittagong Hill Tracts, Cox's Bazar and Sylhet.

Botanical description

Low spreading with elongated and wide crown, dioecious tree, bark grayish brown with rough texture. Leaves broadly ovate, alternate, base cordate, marin shallowly or coarsely toothed; stipules triangular. Peduncles on short, thick, leafless branches from the trunk and major branches. Male flowers sessile, female flowers pedicellate or sessiles. Fruits specialized on leafless branchlets at base of trunk and main branches, reddish brown, pear shaped, depressed globose shaped, with 8 – 12 conspicuous longitudinal ridges, white, shortly pubescent when young, glabrescent when mature. Peduncle is thick.

Consumption practice

This fruits are eaten raw or to make vegetable. Leaves of *Ficus auriculata* are crushed and the paste is applied on the wounds. They are also used in diarrhoea and dysentery. Stem bark juice is effective for diarrhoea, cuts and wounds. Roasted figs are taken for diarrhea and dysentery. Root latex is used in mumps, cholera, diarrhea and vomiting. Mixture of root powder of *F. auriculata* and bark of *Oroxylum indicum* is taken in jaundice (Kunwar and Bussmann, 2006).

Nutrient composition of three *Ficus spp*

The composition of fruits may vary from one continent to another, one country to another in the same continent and in the same country, and also may vary from region to region. This variation may be due to change of climatic condition, nature of soil and sometimes rainfall. The results of the investigation on chemical and nutritional parameters of three wild edible fig species are given in the Table 2 and Table 3 respectively.

Table 2: Proximate chemical composition of three edible fig.

Parameter	*Ficus carica*	*Ficus semicordata*	*Ficus auriculata*	LSD at 5%
Moisture (%)	92.83	89.01	87.91	2.11
pH	4.56	3.70	5.39	0.31
TSS (%)	2.68	2.33	4.42	0.13
Titratable Acidity (%)	0.16	1.02	0.47	0.011
Total Sugar (%)	16.43	10.11	4.15	2.45
Protein (%)	1.75	1.24	3.50	0.45
Fat (%)	0.22	0.79	1.71	0.021
Starch (%)	17.18	15.11	13.13	1.13

Table 3: Micronutrient composition (Vitamin and Minerals)

Parameter	*Ficus carica*	*Ficus semicordata*	*Ficus auriculata*	LSD at 5%
Vitamin C (mg)	5.37	7.77	5.48	1.01
β-Carotine (µg)	257.1	600.9	898.0	22.13
Ca (mg)	80.0	12.1	15.6	3.45
Mg (mg)	35.0	11.71	68.0	6.78
K (mg)	240	112	329	34.97
Na (mg)	11	31	29	2.56
P (mg)	77	33	31	7.81
S (mg)	0.03	0.03	0.02	.001
B (mg)	0.01	0.06	0.03	.002
Fe (µg)	3322	2340	5432	231

Proximate composition of Macronutrient

The proximate composition of three wild edible figs is presented in Table 2. The moisture content of figs ranged from 87.91 to 92.83% of fresh weight. The pH values varied from 3.70 to 5.39 . The lowest pH (3.70) and the highest amount of titratable acidity (1.02) were found in *Ficus semicordata*. On the other hand, the highest pH (5.39) was observed in *Ficus auriculata* Lour. and the lowest amount of titratable acidity was found in *Ficus carica* (0.16%). Ceggara (1964) found that the pH range of ripe fruits was 4.5 to 5.35. The Total Soluble Solids (TSS) varied from 2.33% to 4.42%. The highest amount (4.42%) of TSS was found in *Ficus auriculata* and the lowest (2.33%) in *Ficus semicordata*. Generally higher TSS indicates more sugar in the pulp. The riper the fruits contained more amount of sugar in fruits. Highest fat and protein content of fruits were 1.71 % and protein 3.5% respectively and the findings of this result are similar to the results found by Potter (1976). The range of protein content of figs was 1.24 to 3.50% dry weight. The highest Protein content was 3.5% in *Ficus auriculat* and lowest in *Ficus semicordata. Ficus carica* L as an excellent source of starch and total sugar (17.18%, 16.43%, respectively in dry weight basis) while the lowest quantity of starch and total sugar were found in *Ficus auriculata* (13.13%, 4.15%, respectively, on dry weight). The fat contents ranged from 0.22 to 1.71% on dry weight basis. Due to generally low level of fat in the fruits, their consumption in large amounts is a good dietary habit and may be recommended to individuals suffering from overweight or obesity. The highest contents of fat (1.71%) were found in *Ficus auriculata* and the lowest fat contents were found in *Ficus carica* (0.22%). *Ficus auriculata* was found to be rich in protein and fat content (3.50%, 1.71%, respectively) which is comparatively higher than the fruit which we use in our daily life like, Mango (0.61%, 0.63%), Jackfruit (1.53%, 0.14%), Papaya (0.61%, 0.14%) (Islam *et.*,2012).

Vitamins and Minerals analysis

The results of the vitamins and minerals estimation of the three edible figs are presented in Table 3. In this study, it was observed that *Ficus semicordata* contained the highest amount (7.77mg/100g) of vitamin C and the lowest amount (5.37 mg/100g) was present in *Ficus carica*. According to the Nutrition Expert Committee (ICMR, India, 1981), the daily requirement of vitamin C for an adult is 40 mg; however, the fig contains 7.77 mg/100g of vitamin C. The U.S. recommended dietary allowance (RDA) for β-**c**arotene or other provitamin A carotenoids. The IOM (2001) states that consuming 3-6 mg of β-Carotene daily (equivalent to 833 IU to 1,667 IU vitamin A) will maintain blood levels and lower risk of chronic diseases. In the present study, the highest amount (898 µg/100g) of β-**c**arotene was found in *Ficus auriculata* Lour. and the lowest amount (257.1/100g µg) was found in *Ficus carica*. It indicates that these wild fruits could prevent the night blindness in the children due to rich source of pro-vitamin A.

The species analyzed in this study contained remarkably the highest amount of calcium (Ca) (80 mg/100g) in *Ficus carica* and lowest (12.1 mg/100g) in *Ficus semicordata. Ficus auriculata* Lour. contain highest amount of magnesium (Mg), potassium (K) and iron (Fe) (68.0 mg/100g , 329 mg/100g and 5432 µg respectively). Sodium (Na), sulpher (S) and boron (B) were highest (31 mg/100g, 0.03 mg/100g, 0.06 mg/100g) in *Ficus semicordata* and lowest amount of Na and B (11mg/100g and 0.01mg/100g respectively) in *Ficus carica.* But *Ficus carica* contain highest amount (77mg mg/100g) of phosphorus (P) and lowest amount of P (31 mg/100g) in *Ficus auriculata* Lour. It is indicated that these minor fruits contain a relatively higher amount of minerals than the exotic fruits (USDA-NNDSR, 2011). When compared to the ripe Mango (calcium 16.9mg/100g, magnesium 6.7mg/100 g, potassium 98.5 1.0 mg/100 g, phosphorous 7.7mg/100 g edible) and the national fruit of Bangladesh – ripe Jack fruit (calcium-12.6 mg/100g, magnesium 26.8mg/100 g, potassium 305.0 mg/100 g and phosphorous 10.9 mg/100 g edible) (FAO-NFPCSP, 2010), it was seen that most of the wild fig species contain higher amount of minerals and vitamins.

Fig 3: *Ficus auriculata* Lour.

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Integrated nutrient management in bael (*Aegle marmelos* Corr.) in New Alluvial soil

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ABSTRACT

Considering the demand of bael fruits in *Ayurvedic* and preservative industry, an attempt was made to know the effect of organic and inorganic fertilizers on bael grown in gangetic alluvial soil. The experiment was conducted on 4-year old budded plants of local elite type, planted at 6 x 6 m spacing at the Horticultural Research Station of Bidhan Chandra Krishi Viswavidyalaya, Mandouri, Nadia, West Bengal. There were 11 treatments applied per plant/ year in two equal split doses following randomized block design having five replication of each treatment. The treatments were: T_1-Control, T_2-FYM at 30 Kg, T_3-Vermi compost at 8 kg, T_4-mustard cake at 4 kg, T_5-FYM 16 kg + mixed fertilizer (10:26:26) 800g, T_6-FYM 16 kg + mixed fertilizer (10:26:26) 1600g, T_7-FYM 16 kg + DAP 800 g + MOP 400 g, T_8- FYM 16 kg + DAP 1600 g + MOP 400 g, T_9- FYM 16 kg + urea 800 g + SSP 1600g +MOP 400 g, T_{10}-FYM 16 kg+ Mustard cake 2.4 kg and T_{11}-FYM 16 kg + vermi-compost 4 kg.

Results of two successive years of investigation revealed that growth of the plant in terms of height, basal girth and plant spread towards East-West and North-South direction was maximum in the plant received yearly application of mustard cake at 4 kg followed by the plant with FYM 16 kg+ Mustard cake 2.4 kg. Highest fruit yield of 14.7 kg /plant was recorded from the plant received yearly application of FYM 16 kg+ Mustard cake 2.4 kg this was associated with foliar N and P values of 1.60 and 0.46 percent respectively. The lowest yield was obtained from the control plants. Highest organic carbon content of soil (0.84%) was recorded from the plots of the treatment with FYM 16 kg+ Mustard cake 2.4 kg/ plant. TSS and ascorbic acid content of the fruit were more in the plant received the treatment of FYM 16 kg+ Mustard cake 2.4 kg. The acidity content in the pulp of different treated plants did not vary significantly.

Key words: Bael, fruit quality, integrated nutrient management, new alluvial soil, yield,

INTRODUCTION

Bael (*Aegle marmelos* Corr.) is one of the most important underutilized fruits of the family Rutaceae of international importance. It is well known for its medicinal and nutritional values. It is utilized in day-to-day life in various forms and is highly nutritive crop due to presence of riboflavin (1.19 mg), carbohydrates (31.8g), protein (1.8 g), vitamin C (8-18 mg) and niacin (1.1 mg) per 100 g of edible pulp. Besides, it contains good amount of Fe, Zn, Cl and Na (Barthakur and Arnold, 1989). Beside fruit, every part of the tree viz., leaves, wood, roots and bark are used for preparation of various types of Ayurvedic medicine and other uses. The plant is best suited for low rainfall areas (> 1500 mm per annum) of tropical and subtropical regions. It can be grown in such land situation like poor and marginal lands, saline, alkaline, acidic and rocky soils having P^H 5 to 10 where many crops are failed to grow successfully. It is grown in various parts of South East Asia including India, Sri Lanka, Pakistan, Burma, Bangladesh, Thailand, etc. In spite of its nutritive and therapeutic values, cultivation of this important fruit crop in the form of organized orchard is absent. It is found in scattered way here and there which is seedling origin with no management practices resulting erratic and low yield. For obtaining quality fruits with good yield, use of suitable variety with proper management practices is the foremost criteria in any fruit crop.

Considering the demand in ayurvedic and processing industries and due to having long physiological maturity period, nutrition through organic sources may be the most practical approach of bael nutrition. Research information or literature on any aspect of nutrition of bael is very scanty and most of the recommendation is based on experience basis which has no scientific data base. Considering the importance in bael nutrition, an investigation was made in alluvial soil to find out the effect of organic and inorganic fertilizers on bael in respect of growth, bearing, fruit quality, NPK status of leaves and soil.

MATERIALS AND METHODS

The experiment was conducted on 4-year old budded plants of local elite type, planted at 6 x 6 m spacing at the Horticultural Research Station of Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia, West Bengal. The site is subtropical humid climate with average annual rainfall varies between 1500-2000 mm. The experimental field was situated at 23.5^0 N latitude and 89^0 E longitudes with an elevation of 9.75 m above mean sea level. The soil texture of the experimental field was sandy loan

having pH 6.8; available nitrogen was 230 kg/ha, available P_2O_5 was 35.20 kg/ha and available K_2O was 88.0 kg/ha. There were 11 treatment combination applied per plant/year following RBD having five replications. The treatments were: T_1 : Control (No organic manure and fertilizer) ; T_2 : Farm yard manure (FYM) at 30 kg ; T_3 : Vermicompost at 8 kg ; T_4 : Mustard cake at 4 kg ; T_5 : FYM at 16 kg + mixed fertilizer (10 : 26 : 26 : : N : P : K) at 800 g ; T6 : FYM at 16 kg + Mixed fertilizer at 1600 g ; T_7 : FYM at 16 kg + Di-ammonium phosphate (DAP) at 800 g + Muriate of potash (MOP) at 400 g; T_8 : FYM at 16 kg + DAP 1600 g + MOP 400 g ; T_9 : FYM at 16 kg + Urea 800 g + SSP (Single super phosphate) 1600 g + MOP 400 g ; T_{10} : FYM at 16 kg + Mustard cake 2.4 kg : T_{11} : FYM at 16 kg + Vermicompost 4 kg. The treatments were applied in two equal split doses i.e., during 2nd week of June and 2nd week of October every year. The manures and fertilizers were applied in a circular ring of one feet wide, prepared at 3 feet apart from the plant with a depth of 10-12 cm. The plants were grown under rainfed condition i.e. without any irrigation during off season. The plant protection measures were taken as and when it was necessary.

For estimation of foliar N, P and K content, the leaves of 5-6 month old from 5th-7th positioned were taken for the study in the month of September (Ghosh *et al*., 2014). Nitrogen content of the leaf was determined by micro-kjeldahl's method (Jackson, 1973) and it was expressed as percentage. Available phosphorus was determined by spectrophotometer. It was determined by vandomolybdo phosphoric acid yellow colour method (Jackson, 1973). The left out aliquot for phosphorus estimation was used for potassium estimation. 1 ml of aliquot from each filtered sample which was prepared as in phosphorus estimation taken in injection vial and add 9 ml of distilled water. The readings were taken in a flame photometer.

For analysis of soil, soil from 0-15 cm depth was collected after experiment and was subjected to analysis for pH, organic carbon and NPK status. The soil pH was determined with glass electrode pH meter using soil and water in the ratio of 1:2.5. Organic carbon was determined by Walkley and Black's method as described by Jackson (1973). Available nitrogen of soils was determined by micro-kjeldhl's method (Jackson, 1973). Available phosphorous of soil sample was determined colorimaetrically. Chlorostanous reduced molybdophosphric blue colour method in a hydrochloric acid system as described by Jackson in 1973. The soil sample was leached with neutral ammonium acetate and the available potassium was estimated by flame photometry method (Jackson, 1973).

Observations on plant growth, fruit yield, physico-chemical characteristics of fruits were estimated following standard procedures. The total soluble solids of the fruits were measured with the help of hand refractometer calibrated in 0^0Brix. Total titrable acidity was determined by titration of the extracted juice against /10 NaOH using phenolphthalein as indicator (Ruck, 1969). The ascorbic acid content of fruit was estimated following the method described by A.O.A.C (1984) and was expressed as mg/100g of pulp.

RESULTS AND DISCUSSION

Plant growth

The results presented in Table 1 revealed that maximum rate of growth of the plant in respect of height (96.2%) basal girth (171.0%), plant spread towards East-West (199.2%) and North-South (122.3%) direction was recorded with mustard cake applied @ 4 kg / plant followed by the plant with FYM at 16 kg + mustard cake at 2.4 kg per plant. Minimum rate in plant height (27.9%), basal girth (115.2%), and plant spared (39.0% in East-West and 46.9% in North-South direction) was recorded in the control plant. Results of two years of investigation clearly indicated that the 'bael', a neglected fruit crop, is very responsive to fertilizer application as evident by better plant growth in all the treatments as compared to the control plant (No manures and fertilizer).

Fruit yield

Judicious application of nutrients is necessary not only for sustainable production of quality fruits but also to save our costly soil. In the present investigation, treatment with organic manures or chemical fertilizers and their different combinations of organic manures and chemical fertilizers showed marked increase in yield and physicochemical characters of fruits. Similar types of results were also obtained by Tayeh (2003) in navel orange, Shi *et al.* (2007) in mandarin orange cv. Bendizao and Dheware *et al.* (2010) in sweet orange cv. Nuceller. Experiment conducted with inorganic fertilizers and organic manures revealed that organic manures were better than inorganic fertilizers in terms of fruit production. Highest fruit yield of 14.7 kg (Average of two years) was recorded from the plant with FYM 16 kg + mustard cake at 2.4 kg per plant annually; followed by mustard cake at 4 kg (11.6 kg/plant) and FYM at 30 kg (10.5 kg/plant). It was observed that vermicompost singly (8 kg / plant) or in combination with FYM was less effective as compared to FYM or mustard cake. It was also noted that fruit yield in all the treatments (Table 1) increased with the aging of the plants. It was further noted that yield variation among the treatments was very high which may be due to younger age of the plants which showed different degree of response in various kinds of manures and fertilizers and their doses. Ghosh *et al.* (2012) also noted wide differences

in yield and fruit quality among the different manurial treatments (manures and fertilizers applied singly and in combination) in pomegranate.

Foliar NPK

Leaf nutrient status, which is considered to be an indicator tool for nutrient management programme in fruit crops (Bhargara, 1999), was significantly varied due to different treatments. Highest foliar nitrogen content (1.60%) was measured from the plant received FYM at 16 kg + mustard cake at 2.4 kg per plant annually. Highest fruit yield was also observed from this plant i.e., the plant that showed highest foliar N value. The phosphorus content in leaves was measured maximum (0.46%) from the same plant; showed highest foliar N value. Potassium content in the leaves in different treatment did not tally with the corresponding plant having higher fruit yield. The control plant showed the lowest N, P, K values in the leaves (0.60%, 0.25% and 0.50% respectively).

Soil pH, organic carbon and NPK

Effect of organic manures and inorganic fertilizers on chemical composition of soil in bael orchard has been presented in the Table 2. As the soil of the experimental field was sandy loam (gangetic alluvial), the pH of the soil was near about neutral. The pH in all the treated plots had lower values as compared to control plot. However soil of the inorganic fertilizers treated plots had acidic tendency as compared to organic manure treated plots.

Beneficial effect of organic manures was noticed as improvement in organic carbon content in the soil. Higher organic carbon content was noticed in the plots treated with mustard cake singly or in combination with FYM (0.84%) and minimum organic matter content was recorded from soils of the control plots (0.65%). The available soil N was estimated highest (472.5 kg/ha) in the plot treated with FYM (16 kg) + DAP (0.8 kg) + MOP (0.4 kg). The highest content of soil P (122.7 kg/ha) and K (165.2 kg/ha) were estimated from the plot treated with FYM (16 kg) + Urea (0.8 kg) + SSP (1.6 kg) + MOP (0.4 kg). The lowest content of soil NPK was estimated from the control plot (347.2 kg/ha; 59.3 kg/ha; 114.2 kg/ha respectively). Although nutrient status in the plots under different treatments was better than control plot but differences among the treatments may not be considered as final due to short term experimentation.

Fruit weight

The data in Table 3 revealed that fruit weight was highest (1220 g) in the plant, received FYM (16 kg/plant + mixed fertilizers (1.6 kg/plant) followed by the plant (1160 g) with FYM (16 kg/plant) + DAP (1.6 kg/plant) + MOP (0.4 kg/plant). The lowest fruit weight was recorded from the control plant (360 g). There was vast difference in fruit weight between control and treated plants which may be due to younger age of the plants (4-5 years) and shorter period of experimentation (two years only).

Fruit pulp

Pulp content was maximum (74.9%) in the fruit of the plant treated with FYM (16 kg) + mustard cake (2.4 kg) followed by the plant (70.5%) with mustard cake (4 kg/plant) (Table 3). The minimum pulp content was measured from the control plant (45.0%). In bael, pulp content is one of the important parameters in respect of its utilization as fresh or processed from. It is clear from the result that nutrition has positive effect on improvement in pulp content in the bael fruit.

Fruit quality

TSS content in the fruit pulp was significantly improved due to application of organic manures and inorganic fertilizers. Highest TSS content (48.0^0 Brix) was measured from the fruits treated with FYM at 16 kg + mustard cake at 2.4 kg/plant and lowest (38.0^0 Brix) from the control plant. Acidity content in the fruit pulp did not vary significantly among the different treatments. Ascorbic acid content in the fruit pulp was significantly improved due to application of organic manures and inorganic fertilizers. Highest ascorbic acid content (10.78 mg/100 g) in the fruit pulp was noted from the fruits treated with FYM (16 kg) + mustard cake (2.4 kg) and lowest from the control plant (7.56 mg/100 g). Beneficial effect of combined application of FYM and mustard cake on fruit yield and quality (TSS) may be explained from the fact that bael has long physiological growth period where manures (slow release of nutrients in nature) were seem to be helpful in meeting the demand of required nutrients during such long growth period.

It was concluded from the results of two years of investigation that annual application of FYM @16 kg along with 2.4 kg of mustard cake per plant in two splits doses (Middle of June and October) was helpful in increasing fruit yield and improving fruit quality in younger plants grown in new alluvial soil of West Bengal.

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Table 1 : Effect of organic manures and inorganic fertilizers on plant growth and fruit yield in bael

Treatment (Per plant/year)	Plant growth (Percentage of increase over 1st reading)				Fruit yield/plant (kg)		Average Fruit yield/Plant(kg)	Foliar content (%) on dry weight basis		
	Height	Basal girth	Plant spread towards		4 year old plant	5 year old plant		N	P	K
			East-West	North-South						
T_1 : Control	27.9	115.2	39.0	46.9	0.4	5.4	2.9	0.60	0.25	0.50
T_2 : FYM – 30 kg	66.5	140.8	114.2	65.9	1.4	19.5	10.5	0.70	0.42	0.64
T_3 : VC – 8 kg	72.8	158.8	75.2	87.7	0.9	17.0	9.0	0.90	0.44	0.63
T_4 : MC – 4 kg	96.2	171.0	119.2	122.3	2.7	20.5	11.6	1.10	0.38	0.61
T_5 : FYM – 16 kg + MF – 0.8 kg	63.9	168.9	112.6	69.7	1.9	15.0	8.4	1.12	0.36	0.79
T_6 : FYM – 16 kg + MF – 1.6 kg	72.9	167.4	67.9	55.7	2.5	18.0	10.3	1.40	0.43	0.64
T_7 : FYM – 16 kg + DAP – 0.8 kg + MOP – 0.4 kg	55.2	148.0	55.0	74.2	2.7	9.0	5.8	1.50	0.44	0.82
T_8 : FYM – 16 kg + DAP – 1.6 kg + MOP – 0.4 kg	53.2	162.2	91.6	97.5	2.3	14.0	8.2	1.06	0.44	0.76
T_9 : FYM – 16 kg + Urea- 0.8 kg + SSP – 1.6 kg + MOP – 0.4 kg	61.4	148.2	89.2	70.0	3.0	16.0	9.5	1.30	0.42	0.75
T_{10} : FYM – 16 kg + MC – 2.4 kg	77.4	169.5	112.6	106.5	2.8	26.5	14.7	1.60	0.46	0.76
T_{11} : FYM – 16 kg + VC – 4 kg	68.6	165.0	91.8	77.2	2.9	12.0	7.5	1.20	0.38	0.62
C.D. at 5%	4.4	6.2	3.8	2.8	0.3	1.6	1.2	0.001	0.01	0.01

FYM - Farm Yard Manure; VC - Vermi compost ; MF - Mixed fertilizer (10:26:26::N:P:K); MC - Mustard cake
DAP - Di-ammonium phosphate; SSP – Single super phosphate; MOP - Muriate of potash

Table 2 : Effect of organic manures and inorganic fertilizers on pH and nutrient status in soil (0- 15 cm depth) of bael orchard

Treatment (Plant/year)	pH	Organic carbon (%)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T_1 : Control	6.70	0.65	347.2	59.3	114.2
T_2 : FYM – 30 kg	6.65	0.76	444.7	99.2	136.7
T_3 : VC – 8 kg	6.60	0.78	429.4	76.9	142.6
T_4 : MC – 4 kg	6.60	0.84	430.9	70.1	138.2
T_5 : FYM – 16 kg + MF – 0.8 kg	6.40	0.74	468.8	110.5	140.7
T_6 : FYM – 16 kg + MF – 1.6 kg	6.30	0.74	469.2	112.1	142.5
T_7 : FYM – 16 kg + DAP – 0.8 kg + MOP – 0.4 kg	6.40	0.73	472.5	115.6	156.7
T_8 : FYM – 16 kg + DAP – 1.6 kg + MOP – 0.4 kg	6.25	0.72	468.6	120.8	163.3
T_9 : FYM – 16 kg + Urea 0.8 kg + SSP – 1.6 kg + MOP – 0.4 kg	6.25	0.74	471.7	122.7	165.2
T_{10} : FYM – 16 kg + MC – 2.4 kg	6.60	0.84	436.2	119.3	160.5
T_{11} : FYM – 16 kg + VC – 4 kg	6.50	0.82	433.7	118.4	157.3
C.D. at 5%	0.15	0.01	1.1	0.8	0.2

FYM - Farm Yard Manure; VC - Vermi compost ; MF - Mixed fertilizer (10:26:26::N:P:K); MC - Mustard cake
DAP - Di-ammonium phosphate; SSP – Single super phosphate; MOP - Muriate of potash

Table 3 : Effect of organic manures and inorganic fertilizers on physico-chemicl composition of bael fruit

Treatment (Plant/year)	Fruit weight (g)	Pulp content (%)	TSS (^{0}B)	Acidity (%)	Ascorbic acid content (mg/100 g pulp)
T_1 : Control	360	45.0	38.0	0.35	7.56
T_2 : FYM – 30 kg	705	52.0	43.0	0.42	8.15
T_3 : VC – 8 kg	915	48.0	44.0	0.44	8.69
T_4 : MC – 4 kg	680	70.5	42.0	0.30	9.24
T_5 : FYM – 16 kg + MF – 0.8 kg	685	58.4	47.0	0.32	10.30
T_6 : FYM – 16 kg + MF – 1.6 kg	1220	56.6	47.0	0.26	9.50
T_7 : FYM – 16 kg + DAP – 0.8 kg + MOP – 0.4 kg	540	57.4	42.0	0.42	9.90
T_8 : FYM – 16 kg + DAP – 1.6 kg + MOP – 0.4 kg	1160	59.1	46.0	0.36	8.90
T_9 : FYM – 16 kg + Urea 0.8 kg + SSP – 1.6 kg + MOP – 0.4 kg	985	67.0	44.0	0.35	9.44
T_{10} : FYM – 16 kg + MC – 2.4 kg	855	74.9	48.0	0.38	10.78
T_{11} : FYM – 16 kg + VC – 4 kg	735	58.5	44.0	0.42	10.40
C.D. at 5%	0.5	1.8	0.9	N.S.	0.7

FYM - Farm Yard manure; VC - Vermi compost ; MF - Mixed fertilizer (10:26:26::N:P:K); MC - Mustard cake
DAP - Di-ammonium phosphate; SSP – Single super phosphate; MOP - Muriate of potash

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An ethno-botanical study of wild plants in Garo Hills region of Meghalaya and their usage

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ABSTRACT

The state of Meghalaya, also known as the 'Abode of clouds' has a rich reservoir of genetic variability of horticultural crops including fruits, vegetables, flowers, plantation crops, spices, medicinal and aromatic plants. The state of Meghalaya covers an approximate area of 22,429 km^2 and lies between the latitudes of 25°47'N to 26°10'N and the longitudes of 89°45'E to 92°45'E, with an altitude ranging from 100-1,965 m above sea level[1]. Meghalaya is largely dominated by three main tribes *viz.* Khasi, Jaintia and Garo and they depend largely depend on the forest wealth for their livelihood and have also acquired a vast knowledge about plant wealth and utilization of forests products. A vast diversity in geographical and climatic conditions provides a repository of valuable wild edible and medicinal plants of the region. These plants have a great importance in the indigenous system of medicine as well as tribal dietary requirements. Ethno-botanical studies reveal that how people of a particular culture and religion make use of indigenous plants and how they classify and identify them. Some edible plants have great economic value and are highly linked with socio economic development of the tribal communities of the state. Indigenous fruits like *Baccaurea ramiflora, Calamus erectus, Elaeagnus conferta, Flacourtia indica, Ziziphus mauritiana, Haematocarpus validus, Spondias pinnata, Grewia nervosa*,etc. are consumed fresh. For vegetable purpose, species like *viz. Amorphophallus paeoniifolius, Bauhinia purpurea, Clerodendrum glandulosum, Dendrocalamus hamiltonii, Houttuynia cordata, Phlogacanthus thyrsiformis, Zanthoxylum oxyphyllum*,etc. are being largely used by the Garo tribes of the state. The present study aims to create inventory of the usage of some wild plants of the Garo Hills region of the state which assists in understanding the dependency of local community and the role of wild edible plants in the local economy.

Key words: ethnobotany, Garo tribe, Meghalaya, wild edible plants

INTRODUCTION

The state of Meghalaya is located in the North East India and is dominated by three distinct tribes *viz*. Khasi, Garo and Jaintia. Garo tribe comprises the second largest population of tribes after Khasi and belongs to Tibeto-Myanmar sub family of Tibet Chinese linguistic group (Sharma *et al*.,2013). Garos are very closely associated with nature, and with their ethno-biological knowledge about the plants available around them, they use them as food and also can easily avert and cure themselves from several disease complications. The favourable tropical monsoonal climate of Meghalaya is believed to be responsible for adaptation and the growth of various plants ranging from herbs, shrubs to trees (Sawain *et al*.,2007).

A total of 105 plants used for food and medicine by Khasis and Garos have been identified by various researchers. Indigenous knowledge of wild edible plant is important for sustaining utilization of those plant species (Sawain *et al*., 2007). Wild foods are of particular value for tiding over lean periods when resources from agriculture are scarce, especially for the poorer sections of the society. The importance of recording the use of plants in this region is important because of rapid loss of flora and fauna. Currently, there is a renewed interest among the researchers in documenting the ethno-botanical information regarding the indigenous wild edible plants (Bharucha and Pretty, 2010). Since the traditional knowledge on wild edible plants is being eroded through acculturation and loss of plant biodiversity through extensive deforestation and *jhum* cultivation, hence promoting research on wild edible plants is crucial in order to safeguard this information for future societies for their wise use and conservation. The importance of wild edible plants is being realized as they provide all the essential minerals, fibre, vitamins and can also be used to prevent chronic diseases among the general population. It is important for people to know the prevailing traditional food plants in their areas and how they can be improved for sustainable food security/nutrition (Jeeva, 2009).

METERIALS AND METHODS

The research was carried out through field surveys and careful documentation of ethno-botanically significant plants, which are traditionally used by the Garo tribes. The whole of Garo Hills region forms a sort of undulating plateau with plenty of flat lands and valleys with altitudes varying from 100-1400 m above sea level, Nokrek being the highest point (1418m). Garo hills comprises of five districts *viz.* West Garo Hills, East Garo Hills, South Garo Hills, North Garo Hills and South West Garo Hills. Garo tribes form the predominant one in these districts, along with other indigenous habitants like Rabhas, Koch, Hajong, Rajbongshi and Kacharis. These five districts have a rich and unique flora and are supposed to be the original home of the *Citrus*. The rich biodiversity pockets of Garo hills are located at Nokrek Biosphere Reserve in West Garo Hills, Balpakram National Park in South Garo Hills and Baghmara Sanctuary which is considered the home of *Nepenthes khasiana* (Kar *et al*., 2012). The vegetation of Garo Hills can be broadly classified into those belonging to tropical and sub-tropical zones based on altitude. The tropical vegetation covers areas upto an elevation of about 1000. It embraces evergreen, semi-evergreen and deciduous forests, bamboo thickets and grasslands including riparian forests and swamps. The sub-tropical vegetation occurs at elevations above 1200 m from sea level and this type of forest is restricted in Tura Peak, Nokrek Peak etc. These are mainly evergreen forests but a few elements of deciduous forests are also seen. Information on the traditional uses of plants was collected through direct field interviews with a number of elderly people who have a rich traditional knowledge on usage of the local plants. Besides these sources, secondary data were gathered from published literature in books, magazines, booklets, newspapers, journals, etc. Various wild plants found in the study area are listed in Table 1 along with their vernacular names, family, habitat, plant parts used and their mode of usage.

RESULTS AND DISCUSSION

The indigenous plant species are the most commonly sold items at the weekly markets in Garo Hills. The local tribals are the main consumers of these wild edible plants and they either consume fresh or preserve them or process them into pickles. The ethno-botanical description of the plants have been listed in Table 1 including the botanical name, local name, family, habit, parts used and its usage.

In this paper, 36 wild edible plant species which are commonly consumed by the 'Garo' tribes as food and medicine have been identified. Most of the plants (30 species) are found in the wild followed by 6 species which grows in the wild as well as cultivated areas. Out of these, the plant parts mostly used and consumed by the tribal include fruits of 20 species, leaves of 13 species, tender shoots of 3 species, flowers and inflorescence of 4 species, seeds and barks of 2 species, corms, root, stem and stem-pith of 1 species. Rutaceae was found to be the most common family with 4 species of edible importance. For vegetable purposes, species like *Paederia foetida*, *Bauhinia purpurea*, *Dendrocalamus hamiltonii*, *Zanthoxylum oxyphyllum*, *Z. rhetsum*, *Hibiscus sabdariffa*, *Solanum violaceum*, *Phlogacanthus thyrsiformis*, *Houttuynia cordata*, *Clerodendrum glandulosum*, *Lasia spinosa*, *Dillenia scabrella*, *Rumex acetosa*, *Amorphophallus paeoniifolius*, *Musa flaviflora*, *Rhynchotechum ellipticum*, *Polygonum chinense*, *Diplazium esculentum*, *Amaranthus dubius*, *Oroxylum indicum* and *Momordica subangulata* subsp. *renigera* are commonly used. Most of these plants are cooked as a vegetable and along with dry fish or meat items. A popular fermented product 'me.a meseng' is prepared from the young shoots of *Dendrocalamus hamiltonii*. Besides these, leaves of *Zanthoxylum oxyphyllum, Hibiscus safdariffa* and flowers of *Phlogacanthus thyrsiformis* are preserved in the dried form known as 'gran'. Pickles made from young shoots of *Dendrocalamus hamiltonii* and leaves of *Hibiscus sabdariffa* are also common in the local markets. Garos use a kind of potash in curries, which they obtain by burning dry pieces of stems of *Musa flaviflora* or young bamboos locally known as *Kalchi*. Fruits like *Baccaurea ramiflora*, *Calamus erectus*, *Grewia nervosa*, *Elaeagnus conferta*, *Eugenia claviflora*, *Ficus auriculata*, *Ziziphus mauritiana*, *Flacourtia indica*, *Terminalia bellerica*, *Haematocarpus validus*, *Musa flaviflora*, *Protium serratum*, *Elaeocarpus floribundus*, *Spondias pinnata* and *Citrus macroptera* are either consumed fresh or cooked as vegetable, mixed with curry, dry fish and meat items. A fruit of *Citrus indica* commonly known as 'Me.mang Narang' is solely used for medicinal purpose to treat jaundice and stomach problems. Fruits of *Ziziphus mauritiana*, *Elaeocarpus*

floribundus, *Spondia spinnata*, *Citrus macroptera* and *Protium serratum* are processed into pickles by the local people. *Citrus macroptera* fruits are also preserved in the dried form by adding salt and its fruit peel and juice is used for cooking purposes.

The local people usually collect these fruits and vegetables from forest and wild sources and directly sell in the market or to the middlemen and are mostly sold during the weekly markets. The price of the vegetables ranges from Rs 20 to 30 and fruits ranges from Rs 50 to 100 depending on the variety. However, the prices of rare species of fruits like *Calamus erectus*, *Haematocarpus validus*, and *Citrus macroptera* are comparatively high in the market. The availability of the fruits and vegetables is not consistent and depends mostly on the season. However, plants like *Houttuynia cordata*, *Clerodendrum glandulosum*, *Musa flaviflora* and *Polygonum chinense* are available round the year.

The people of Garo Hills are very fond of wild edible plants and their use is widespread usually among the elderly people who have been using these plants since time immemorial. Younger generation mainly relies on the modern day vegetables like pumpkin, carrot, cabbage, cauliflower, tomato, gourds, etc. However, the use and conservation of these plants is not seriously thought for by the people. The use of wild edible plants plays an important role in the diet of the local people besides being an important source of income generation. Due to the rapid urbanization, fast developmental activities, practice of *jhum* cultivation and deforestation, a lot of useful plants have been lost and their population is decreasing day by day. There is an urgent need to document the traditional knowledge on the useful wild edible plants or otherwise they may become extinct with time. Further investigation is also required regarding their nutritional values, method of cultivation including their habitats and uses, possibility of processing and finally their conservation studies.

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Table 1. Wild plants used by Garo tribes of Meghalaya

Scientific Name	Local Name	Family	Habit	Parts Used	Usage
Amaranthus dubius Mart. ex. Thell	Dangasak	Amaranthaceae	Shrub	Leaf	Leaves cooked as vegetable
Amorphophallus paeoniifolius Dennst.	Songru	Araceae	Tubers	Leaf, stem and corm	Cooked as a vegetable
Baccaurea ramiflora Lour.	Gasampe	Euphorbiaceae	Tree	Fruit	Ripe fruits eaten raw and also used medicinally to treat skin diseases
Bauhinia purpurea Linn.	Bol Me.gong	Fabaceae	Tree	Leaf and flower	Cooked as vegetable and as medicine for blood pressure
Calamus erectus Roxb.	Sokmil	Arecaceae	Tree	Fruit	Fruits eaten raw and used for decoration purpose
Citrus indica Tanaka	Me.mang narang	Rutaceae	Tree	Fruit	Used for medicinal and spiritual purposes by the Garo people. The fruit is used to treat jaundice and stomach conditions in humans and animals, and it is used to treat smallpox.
Citrus macroptera Montrouz.	Chambil	Rutaceae	Tree	Fruit	Fruit juice is extracted and used for cooking and raw fruits are preserved
Clerodendrum glandulosum L.	Dongam	Verbenaceae	Shrub	Leaf	Cooked as a vegetable and used as a medicine for blood pressure
Dendrocalamus hamiltonii Nees&Arn. ex. Munro	Wa.nok	Poaceae	Tree	Tender shoot	Cooked as a vegetable and local fermented bamboo (Me.a) prepared
Dillenia scabrella Roxb. ex. Wall	Agatchi	Dilleniaceae	Shrub	Bark and fruits	Fruits cooked as vegetables and bark is used for snake bites
*Diplazium esculentum (*Retz) Swartz.	Me.konchek/ Gonginjak	Athyriaceae	Fern	Leaf	Cooked as a vegetable
Elaeagnus conferta Roxb.	Sokkua	Elaeagnaceae	Shrub	Fruit	Ripe fruits eaten raw and has antioxidant properties effective against cancer
Elaeocarpus floribundus Blume	Jolpai	Elaeocarpaceae	Tree	Fruit	Fruits are edible and used for making pickle
Eugenia claviflora Roxb.	Chambu	Myrtaceae	Tree	Fruit	Ripe fruits are eaten raw and used as medicine for diabetic patients
Ficus auriculata Lour	Te.bil	Moraceae	Tree	Fruit	Ripe fruits eaten raw and leaves are used for packing rice during occasions

Table 1. Wild plants used by Garo tribes of Meghalaya

Scientific Name	Local Name	Family	Habit	Parts Used	Usage
Flacourtia indica (Burm. f.) Merr.	Ponial	Salicaceae	Tree	Fruit	Ripe fruits eaten raw and as a medicine for diuretic, digestive, in jaundice and enlarged spleen.
Grewia nervosa (Lour) Panigr.	Bolchupret	Malvaceae	Tree	Fruit	Ripe fruits eaten raw
Haematocarpus validus Bakh.f.ex Forman	Te.pattang	Menispermaceae	Climber	Fruits	Ripe fruits eaten raw and also used as medicine for blood purification
Hibiscus sabdariffa L.	Gal.da	Malvaceae	Shrub	Leaf, fruit flower	Cooked as vegetable, made into pickle and fruits used for making jam
Houttuynia cordata Thunb.	Matchaduri	Saururaceae	Herb	Shoot	Shoots used as vegetable and as herbal medicine for antiviral, antibacterial and anti-leukemic activities
*Lasia spinosa*L. Thwaites	Chongibiret	Araceae	Herb	Shoot	Young leaves are cooked as vegetable
*Momordica subangulata*L. subsp. *renigera*	Apolka	Cucurbitaceae	Climber	Fruit	Fruits are cooked as vegetable
Musa flaviflora Simmonds	Fruits-Te.rik Inflorescence -Sobok	Musaceae	Tree	Fruit, inflorescence and stempith	Fruits consumed fresh, inflorescence used as a vegetable and stem-pith used for making local 'kalchi' (alkaline additive)
Oroxylum indicum L. Benth ex. Kurz	Khering	Bignoniaceae	Tree	Leaf	Leaves are used as boiled vegetable and as medicine for jaundice
Paederia foetida Linn.	Pasim	Rubiaceae	Climber	Leaves	Leaves are used as vegetable
Phlogacanthus thyrsiformis Nees	Allot	Acanthaceae	Shrub	Flower	Cooked as vegetable, fruits used as a medicine for diabetes
Polygonum chinense L.	Me.kri do.nok	Polygonaceae	Shrub	Shoot	Shoot are used as vegetable
Proteum serratum Wall ex. Colebr.	Te.kring	Burseraceae	Tree	Fruit	Ripe fruits eaten raw and processed into pickles
Rhynchotechum ellipticum A.DC	Me.bitchi	Gesneriaceae	Shrub	Leaf	Leaves are cooked along with dry fish and eaten
Rumex acetosa L.	Chuka	Polygonaceae	Herb	Leaf	Leaves cooked as vegetable
Solanum kurzii L.	Kimka	Solanaceae	Shrub	Fruit	Cooked as vegetable, fruits used as a medicine for diabetes
Spondia spinnata L.f. Kurz.	Ambaletong	Anacardiacaeae	Tree	Fruit	Fruits eaten raw and made into pickles
Terminalia bellerica Roxb.	Chirore	Combretaceae	Tree	Bark, fruit, root, seed	Kernels are eaten by locals and used as a medicine for headache, jaundice and gastric problem
Zanthoxylum rhetsum DC.	Smitcheng	Rutaceae	Tree	Leaf	Leaves as vegetable, fruits aromatic, gives a tingling sensation and usually used for chutney /spice
Zanthoxylum oxyphyllum Edgew.	Me.cheng	Rutaceae	Shrub	Leaf, seed	Cooked as vegetable and seed used as a spice
Ziziphus mauritiana Lam.	Kangkil	Rhamnaceae	Tree	Fruit	Ripe fruits eaten raw and made into pickles

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Phlogacanthus thyrsiformis

Haematocarpus validus

Diplazium esculentum

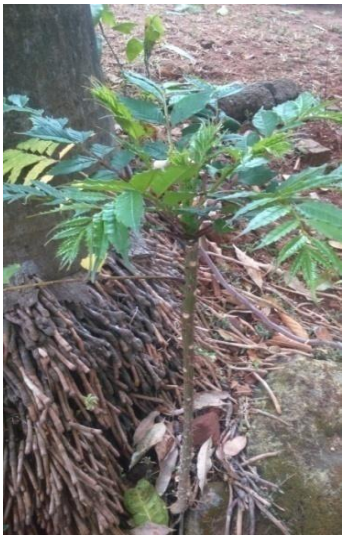
Hibiscus sabdariffa

Dendrocalamus hamiltonii

Solanum kurzii

Polygonum chinense

Rumex acetosa



Zanthoxylum oxyphyllum

Houttuynia cordata

Clerodendron glandulosum

Amorphophallus paeoniifolius

Bauhinia alba

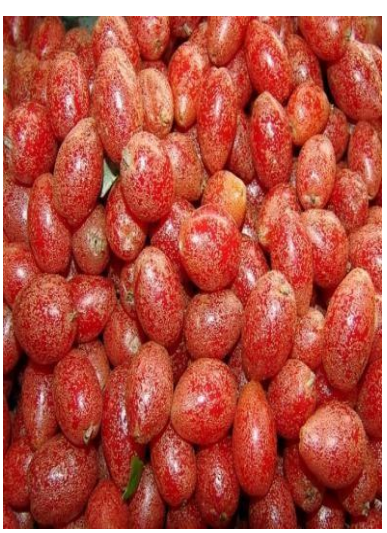
Amaranthus dubius

Baccaurea ramiflora

Grewia nervosa

Flacourtia indica

Citrus indica



Elaeagnus conferta

Calamus erectus

Paederia foetida

Citrus macroptera

Spondias pinnata

Dillenia scabrella

Oroxylum indicum

Lasia spinosa

Rhynchotechum ellipticum

Figure 1. Fruits and different parts of wild plants being used by Garo tribes of Meghalaya

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Physical and biochemical content of indigenous underutilized *Sohiong* (*Prunus nepaulensis* Ser.) fruit in Meghalaya, India

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ABSTRACT

Prunus nepalensis **belongs to the family Rosaceae, is an important underutilized fruit of the tribal population in Meghalaya. The study was conducted to investigate the physical and biochemical contents of two different genotypes of *Sohiong* fruits. Result indicated that the big fruit size type had higher values for various physic-chemical characters except for pulp recovery (74.71 %), pulp to stone ratio (2.95) and dry recovery (34.72 %), TSS (20.15%), β-carotene (2.76 mg/100g), anthocyanin (358.86 mg/100g) and fibre (2.5%). Similarly, the mineral contents of big - sized fruits were comparatively higher than the small fruit type except for potassium and ash content (1.51%). The study indicated that the availability of *sohiong* fruit ranging from August to November. In addition, fruits are rich in vitamin, minerals and bio-chemical properties. Therefore, this crop has potential to meet the nutritional needs among the tribal population of Khasi and Jaintia Hills.**

Keywords: *Prunus nepaulensis*, variability, physical, biochemical

INTRODUCTION

Prunus nepaulensis (Ser. ex DC.) Steud {syn. *Prunus nepalensis* Hook., *Padus napaulensis* (Ser. ex DC.) Schneider} is locally known as *Sohiong* and it belongs to family Rosaceae (Rymbai *et al*., 2015). This crop is an important indigenous underutilized fruit of Khasi and Jaintia Hills in Meghalaya. It is widely distributed in different parts of Khasi and Jaintia Hills. The fruit trees grow wildly in the forest areas and home backyards, and there is no established orchard of this crop in the region. *Sohiong* has an immense potential for commercial cultivation in the state as well in other parts of the world where relative cool climate is exit.

Since time immemorial, *sohiong* fruits are being utilized by the tribal population of Khasi and Jaintia Hills in various forms. The fruits are eaten fresh when ripened. The *sohiong* fruit quality possesses excellence and unique colour, taste and flavor (Patel *et al*., 2008). It is also rich in essential nutrients. It has a good potential for extraction of natural edible colour required in food industry. Authors have also been observed that its colour, when added to squash and jam, remains stable for one year. Ready to serve (RTS) product and cherry wine are also being prepared from pulp and juice of the fruit due to the fact that it imparts desirable purple colour to the wine. The expansion of area for commercial cultivation of this crop in the state may offer income and employment generation for the tribal peoples.

The plant is of low chilling types resembling very much to the common cherry (Singh *et al*., 1976). Trees are evergreen, medium to large size 15-20 m height with grey bark, open, upright branches. Leaves are oblong, lanceolate, caudate, acuminate, and glabrous with average length of 11.2 cm and breadth of 4.7 cm. Fruit-bearing starts after 7–8 years of planting the seedling. Flowering occurs between October and March. Flowers are white in colour arranged in terminal recemes or auxillary. Fruits mature between August and November, depending on the altitude. Fruit is drupe, fleshy green to pinkish in colour at early stage and later on becomes dark purple at ripening with smooth surface (Rai *et al*., 2005). The stone is hard, round in shape with smooth surface but rough in few genotypes. At present, there are no distinct varieties of *sohiong* identified in the region. However, based on variability existing in fruit size, two types of *sohiong* fruits are recognized; 1) Big fruit size and 2) Small fruit size. Although, the fruit has been consumed over centuries, however, no information exists on the nutritional values of the two types of fruit.

MATERIALS AND METHODS

The fruits of the two types (big and small fruits) of different genotypes of *sohiong* were collected from different parts of Khasi and Jaintia Hills distributed between $25^0$1' and $26^0$5' North latitudes and $85^0$49' and $92^0$52' East Longitudes with altitude ranging from 600 to 2000 m and temperature 2-28^{0}C. The fruits were analyzed for the variability existing in physical characteristics, bio-chemicals and mineral contents. Twenty fruit samples for each genotype and ten genotypes for each fruit type were analyzed at ICAR Research Complex for NEH Region, Umiam, Meghalaya. Fruits samples were washed and kept at room temperature for 10 minutes to remove the adhering water before analysis. The fruit and stone weights were determined using electronic balance (Adiar Dutt-1620C). Fruit length

and diameter, stone length and diameter were measured using digital vernier calliper (callipers (Mitutoya Digimatic Caalliper, Code No. 500-147). Pulp recovery percentage was taken as pulp weight divided by total fruit weight and multiplied by 100. Pulp: stone ratio was calculated by dividing pulp weight by stone weight. The specific gravity was determined by water displacement method. The dry matter percentage was obtained by (C-A)/(B-A) X 100, where, A, weight of Petri dish; B, total weight of fresh sample + Petri dish; C, total weight of dry sample + Petri dish. The dry weight of a sample was obtained after drying at 120 °C in an oven, until constant weight was reached. Bio-chemical analysis was determined for TSS using hand refractometer (HI 96801); acidity, ascorbic acid, reducing sugar, total sugar, β-carotene, anthocyanin and pectin were analyzed according to Rangana (1997). Moisture percentage for fruit and seeds was estimated according to Akther *et al*. (2012) and fibre content by Anon. (1990). Mineral contents for both fruit types of *sohiong* was analyzed after sample digestion with 24 cm^3 mixture of the conc. HNO_3, Conc. H_2SO_4 and 60% $HClO_3$ (9:2:1 v/v). Elemental analysis was carried out as per the standard methods of Anon. (1990). Nitrogen was analyzed using Kjeldahl method. Potassium was analyzed using flame photometer. Copper, Zinc, iron, magnesium, sulphur and manganese were analyzed using atomic absorption spectrophotometer, while phosphorus content was determined colorimetrically with spectrophotometer (Umar *et al*., 2007). Ash content was estimated according to Akther *et al*. (2012).

Table 1. Physical characteristics of two types of *Sohiong* fruits.

Parameters	Fruit size	
	Bigger	**Smaller**
Fruit weight (g)	7.91	3.98
Specific gravity	0.95	0.94
Fruit length (mm)	21.76	18.16
Fruit diameter (mm)	21.80	17.12
Stone weight (g)	2.44	1.00
Stone length (mm)	15.94	13.48
Stone diameter (mm)	15.08	11.48
Pulp recovery (%)	69.11	74.71
Pulp: stone ratio	2.24	2.95

Bio-chemical characteristics

The two types of *sohiong* genotypes showed a wide variation for biochemical characteristics (Table 2). Comparatively, higher content of acidity (3.32%), ascorbic acid (58.38 mg/100g), reducing sugar (4.44%), total sugar (8.75%), pectin (2.00%), moisture (fruit, 61.84% and seed, 33.33%) was observed in bigger fruit *sohiong* genotypes. However, smaller fruit *sohiong* genotypes recorded higher content for TSS (20.15%), β-carotene (2.76 mg/100g), anthocyanin (358.86 mg/100g) and fibre (2.5%) over bigger fruit *sohiong* genotypes. The present finding has also been observed by Rymbai *et al*. (2014) in two eco-types of *sohiong*.

RESULT AND DISCUSSION

Physical characteristics

A great variability between the two types of *sohiong* fruits was observed (Table 1). Bigger fruit size recorded higher value over smaller fruit type for fruit weight (7.91 g), fruit length (21.76 mm), fruit diameter (21.80 mm), stone weight (2.44 g) and stone length (15.94 mm). While smaller fruit size recorded higher value for pulp recovery percentage (74.71) and pulp to stone ratio (2.95). However, specific gravity (0.94 – 0.95) recorded was almost the same for the two types. The dry recovery was higher in smaller fruit types (34.72%) than in bigger fruit types (32.64%) as depicted (Fig. 1b). The variability in fruits physical characteristics within the species has also been reported by Rymbai *et al*. (2015).

Mineral contents

The two fruit types of *sohiong* genotypes were also analyzed for their minerals content which showed great variability between the two (Table 2). The bigger size fruit recorded comparatively higher amount of phosphorus (115 mg/100g), sulphur (1362.5 mg/100g), iron (9.6 mg/100 g), copper (1.56 mg/100 g), zinc (2.42 mg/100 g) and manganese (7.70 mg/100 g). Whereas, higher amount of minerals in smaller size fruit over bigger fruit types was recorded for potassium (530 mg/100 g). It was interesting to note that nitrogen content (bigger fruit, 69.95 mg/100 g; smaller fruit, 70.01 mg/100 g) of both the genotypes is the same. The ash content of smaller fruit types (1.51%) was comparatively more than that of bigger fruit size (1.03%) genotypes (Fig. 1a). Rymbai *et al*. (2014, 2015) also reported a great variation in mineral contents among different types of *sohiong*, which might be due to genetic variability.

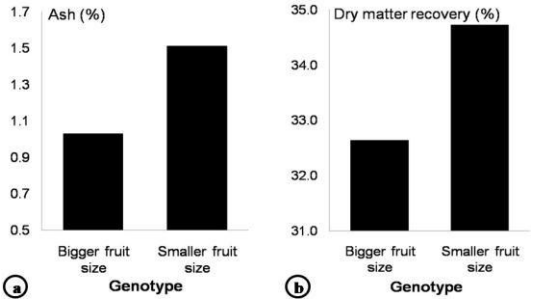

Fig 1. a) ash content (%) and b) dry recovery (%) of two types of *Sohiong* fruits.

Table 2. **Bio-chemical and mineral contents of two types of *Sohiong* fruits**

Parameter	Fruit types	
	Bigger	**Smaller**
TSS (%)	19.60	20.15
Acidity (%)	3.32	2.56
Ascorbic acid (mg/100 g)	58.38	50.04
Reducing sugar (%)	4.44	4.26
Total sugar (%)	8.75	7.50
'β' Carotene (mg/100 g)	2.16	2.76
Anthocyanin (mg/100 g)	313.34	358.86
Pectin (%)	2.00	1.80
Moisture in fruit (%)	61.84	59.71
Moisture in seed (%)	33.33	25.22
Fibre (%)	1.71	2.50
Nitrogen (mg/100g)	69.95	70.01
Phosphorus (mg/100g)	115.00	87.53
Potassium (mg/100g)	485.01	530.00
Sulphur (mg/100g)	1362.52	787.50
Iron (mg/100g)	9.60	2.32
Copper (mg/100g)	1.56	1.00
Zinc (mg/100g)	2.42	2.10
Manganese (mg/100g)	7.70	5.62

CONCLUSION

Based on the above facts, it can be concluded that the two types of *sohiong* fruits showed wide variability for physical characteristics and nutritional contents of the fruit. Bigger fruit size types recorded maximum value for most of the physical parameters, except pulp recovery, pulp: ratio and dry matter recovery. Similarly, maximum value for bio-chemical characters was noted in bigger fruit size, except for TSS, β-carotene, anthocyanin and fibre. Smaller fruit size types showed higher value for potassium content, while the other mineral contents was recorded higher in bigger fruit. But it was interesting to note that both the fruit types had the same content of nitrogen. These genotypes can also be studied in depth for further evaluation and utilization in improvement programme, with regard to wide duration availability of fruits, long post-harvest life, consumer preferences and emerging market expectations. Therefore, in view of the high nutrient contents and scope of improvement in *sohiong*, there is a need for commercial cultivation of this potential crop in order to achieve nutritional security.

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Short communication

Minor fruits of Arunachal Pradesh and their role in ethno-medicines

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ABSTRACT

Arunachal Pradesh is one of the richest reservoirs of genetic variability and diversity of underutilised fruits which exist in plant types, morphological and physiological variations or reactions to diseases and pests. It is bestowed with the most congenial climatic conditions for the production of minor fruit crops. There are vast untapped lands of different kinds which are fit for supporting cultivation of minor fruit crops. Such lands can easily be put to use for growing such crops in order to diversify the present day agriculture. The increase in area and production of these fruit crops will not only provide nutritional security, it can provide many fold employment.

Key words: Arunachal Pradesh, Underutilised fruits, Diversity

Arunachal Pradesh is the land of raising sun and one of the most fascinating state of the Eastern Himalayas which is situated between latitude of 26° 30' to 29º 28' North and longitude of 91° 25' to 97º 24' East. Its unique location in the Indian subcontinent has been blessed with wide range of agro-climatic conditions, phyto-geographical, topography and high precipitation. Thus, it possesses enormous biological diversity and formed an important part of the 'Biodiversity hot spot' in the world, one of the 25 global biodiversity hotspots (Myers *et al.*, 2000).Therefore, the region is considered to be a store house and reservoir of wild genetic resources, particularly of underutilized fruit crops occurring wildly in the forest and in almost every backyard.. Arunachal Pradesh is rich in diversity of minor fruits in wild and semi wild condition which are yet to be exploited. These minor fruit crops play a major role in meeting the nutritional and ethno medicinal need of the tribal population of Arunachal Pradesh since time immemorial. In addition, they are also used for colour, flavour and other health benefits. However, the lack of awareness averted the proper utilization of these potential fruit crops. These fruits have medicinal properties to cure various gastrointestinal disorders, respiratory problems; cardiovascular compliance, muscular illness, bone diseases, gynaecological problem, cancers, snake bite, allergy and malaria etc. (Hazarika *et al*., 2012). This indigenous system of treatment based on such fruits is still an integral part of social and cultural ethnic of the tribal. The traditional knowledge of the local people has been transferred from generation to generation without proper technological interventions. Therefore, there are chances of eroding of knowledge unless documentation is carried out. Thus, the main objective of this work is to highlight the diversity of underutilised fruits and their ethno medicinal uses.

Minor fruits of Arunachal Pradesh

The definition of minor fruit crops or underutilised fruit crops is difficult as it is somewhat location specific. In general, those fruits which have lesser demand in the market, which are grown to a limited extent and are not in commercial plantations are considered as minor fruit crops. Differentiation between the major or minor fruits find limitation if attempt to be done on a global basis. For example, jackfruit is regarded as the most important fruit in Bangladesh while it is regarded as a minor fruit crop in some western countries. If area and production are considered to be the criteria, difference may be observed even in the same country as well. Apart from natural suitability, other conditions may also be responsible to occupy large area by a fruit crop in a given locality.

The state of Arunachal Pradesh is having the largest geographical area among the states of North East and characterized by hilly terrain, variability in slope and altitude, land tenure system with rich. The agriculture production system in the region is mostly rainfed, monocropped and at subsistence level. The climatic condition in the state is diverse which varies from temperate to sub-tropical and tropical. The diverse agro-climatic conditions, varied soil types and abundance of rainfall offer immense scope for cultivation of different types of horticultural crops including minor fruits. Arunachal Pradesh has four horticultural zone based on its altitude which has been presented in Table 1.

Table 1: **Horticultural zone of Arunachal Pradesh**

Sl. No	Horticultural zone	Common horticultural crops
1	Foot hills and valley (170-915 metres altitude)	Mandarin, acid lime, Assam Lemon, Aonla, Pineapple, Jackfruit, Papaya, Beans, Cucurbits, Potato.
2	Mid hills (915-1803 metres altitude)	Peach, Plum, Apricot, Pear, Pomegranate, Grapes, Low chilling Apple, Persimon, Kiwi, Off season vegetables, Potato
3	High hills (above 1803 metres altitude)	Apple, Cherry, Walnut, Chestnut, Kiwi, Off season vegetables
4	Rain shadow areas below 40 inches annual rainfall with wide range of chilling requirement and temperature	Apple, Pear, Plum, Peach, Almond, Walnut etc.

The state has rich diversity of different minor fruit crops. Some important underutilized fruits are Garcinia, Rambutan, Longan, Bael, Aonla, Ber, Jamun, Pomegranate, Fig, Tamarind, Passion fruit, Persimmon, Carambola, *Delinia* (Chalta), Jackfruit etc and their potentialities are discussed below.

Rambutan *(Nephelium lappaceum)*: The rambutan or hairy litchi belongs to Sapindaceae family is a delicious fruit common in Arunachal Pradesh. The white semi-translucent, sub-acid sweet flavored aril is the edible flesh of the fruit. Root decoction for fevers. Leaves are used for politicking. Bark used as astringent for tongue maladies. Fruit used for dysentery and as warm carminative in dyspepsis. Fruit decoction used for diarrhea.

Aonla (*Emblica officinalis* Gaertn. Syn. *Phyllanthus emblica* L.)**:** It is belongs to family Euphorbiaceae and considered as one of the oldest minor fruits of India. Various types are grown wild in Arunachal Pradesh. The tree is hardy, prolific bearer and a suitable choice for arid regions of India. Aonla fruit is a rich source of vitamin C (500-600 mg/100 g). It also contains proteins and different minerals like calcium, phosphorus and iron. The high vitamin C concentration of fruit makes its wide use in Ayurvedic medicine. The fruit contains kaempferol, quercetin and rutin. The fruits are diuretic and laxative. They are useful in the disorders associated with the digestive system and are also prescribed in the treatment of jaundice and coughs. Aonla is one of the three ingredients of the famous *ayurvedic* preparation, *triphala*, which is given to treat chronic dysentery, biliousness and other disorders. The plant is considered to be an effective antiseptic for cleaning wounds and it is also one of the many plant palliatives for snakebite and scorpion-stinging.

Ber *(Ziziphus mauritiana* Lam.): The Indian jujube or ber, known as king of arid zone fruits is belongs to familiy Rhamnaceae. The ber is an ideal fruit tree for arid and semi-arid regions in tropical and subtropical climate where most of the fruit crops cannot be grown either due to lack of irrigation facilities or adverse climate and soil condition. Fruits are used as an ingredient in the preparation of 'Joshanda' (An Ayurvedic medicine used in chest trouble). The fruits are laxative and invigorating. The leaves are used to treat conjunctivitis. The bark is used for the treatment of diarrhea. Root decoction is used in fever and its powder is applied to ulcers and old wounds.

Longan (Dimocarpus longan Lour.): Longan is a subtropical fruit of Sapindaceae family. Longan can be eaten fresh, dried or quick frozen. The fruit can be peeled, pitted and canned. The juice of most cultivars is sufficiently sweet for processing without addition of sugar. The flesh of the fruit is administered as a stomachic, febrifuge and vermifuge, and is regarded as an antidote for poison. A decoction of the dried flesh is taken as a tonic and treatment for insomnia and neurasthenic neurosis. Dried flowers are used for medicinal purposes. The seeds are administered to counter act heavy sweating and the pulverized kernel, which contains saponin, tannin and fat, serves as astyptic.

Jamun (*Syzygium cuminii)* **:** Jamun is found in abundance in Arunachal Pradesh. The jamun belongs to Myrtaceae family. The ripe fruit is delicious as dessert. The ripe fruit is very useful in curing diarrhoea and diabetes. It is stomachie, carminative and diuretic, apart from having cooling and digestive properties which help to cure diabetes, diarrhoea, and dysentery. Recent studies have shown that it markedly lowers blood pressure. The seed powder of jamun reduces the quantity of sugar in urine very quickly and permanently. The berry is known for its hypoglycemic (lowering blood sugar) properties. The seed is used in various alternative healing methods in Unani, Ayurveda and Chinese medicine for digestive ailments. The leaves and bark are used for gingivitis and controlling blood pressure.

Bael (*Aegle marmelos* Correa)**:** Bael belonging to family Rutaceae. It is known for its high medicinal and nutritional properties. Almost every part of the bael tree is used. The fruit is very rich in sugar, riboflavin (vitamin B_2) and minerals. The ripe fruit is a tonic, restorative, laxative and good for heart and brain. The mature fruit is astringent, digestive and stomachic, and is usually prescribed for diarrhoea and dysentery. Ripe bael fruit could be used as an excellent laxative. A decoction made out of the root and bark of bael tree is used in treating fever. The bael root could also prove a useful home remedy for getting rid of ear problems.

Phalsa (*Grewia subinaequalis* D.C.)**:** The Phalsa plant belongs to the family Tiliaceae. The edible part

of fruit varies from 69 to 93% of its fresh weight. Ripe phalsa fruits are sub-acidic and good source of vitamin A and C and are fair sources of phosphorus and iron. The popularity of phalsa fruit is due to its attractive colour ranging from crimson-red to dark purple and its pleasing taste. The ripe fruits are used for making refreshing drink in summer having cooling effect. Several beverage like nectar, concentrate, squash and crushed phalsa are packed in glass bottles remain acceptable for up to 8 months in cool storage. The shoots of the plants after pruning can be utilized either for making baskets or supporting vegetable crops.

Fig (*Ficus carica* L.) **:** Fruits are laxative and are rich in protein digestive enzymes. It is also effective in the treatment of piles, constipation, asthma, corns, and chronic cough. It is an excellent tonic for weak people who suffer cracks in lips, toungh and mouth.

Tamarind: Tamarind, *Tamarindus indica* L. (syns. *T. occidentalis* Gaertn.; *T. officinalis* Hook.), belongs to the family Leguminosae. Its pulp is useful in treating fevers. Pulp of the ripe fruit is useful in the treatment of bilious vomiting, flatulence and indigestion. It is also beneficial in constipation. An infusion of the pulp prepared by softening it in water is particularly useful for loss of appetite and lack of inclination for food intake. The tender leaves of tamarind tree are an effective remedy for treating burns. Its leaves prevent oedema and help in the growth of healthy, normal skin. The oils keep the affected part well protected against moisture and entry of harmful germs.

Passion fruit (*Passiflora spp.)*: The passion fruit, belonging to the family *Passifloraceae* is an important fruit crop grown in the world having economic value. The juice but mainly the leaves of passion fruit contain the alkaloids, which has blood pressure lowering, sedative and antispasmodic action. The flower of passion fruit has a mild sedative and can help to induce sleep. Passion flower has been used in the treatment of nervous and easily excited children, bronchial asthma, insomnia, nervous gastrointestinal disorders and menopausal problems. Passion flower is sometimes used as a mild hallucinogen.

Persimmon (*Diospyros kaki* Thunb.): Persimmons belong to the family *"Ebenaceae.* Perhaps most important is the use of the fruit as an astringent for treating sores in the throat and mouth. They also used that quality of the fruit to treat hemorrhoids, and they chewed the bark to treat heartburn. Truly, persimmon fruit has lot of medicinal properties. The calyx of the persimmon fruit where it is connected to the branch of the tree can be used to make a calyx tea. Drinking calyx tea is good for stopping hiccup, and is also good for bed-wetting. For bee sting, paste a grinded astringent persimmon is very effective.

Carambola (*Averrhoa carambola* Linn)**:** Carombola belonging to the family Oxalidaceae. Carambola contains a relatively high oxalic acid and sour in taste which makes it little commercial value for consumption as a fresh fruit. However, new sweet-flavored cultivars with a low oxalic acid concentration are rapidly becoming popular. Fruits are important sources of minerals like potassium, iron, calcium, sodium and phosphorus. The ripe fruit is digestible, tonic and strengthening. The juice of fruit, when used as eye drop, is also considered to be useful for vision. The leaves are antipruritic, antipyretic and anthelmintic. They are useful in scabies, various types of poisoning, pruritus, intermittent fevers and intestinal worms. These fruit also allay thirst. The ripe fruit said to be a good remedy for bleedings piles, particularly the internal one. The dried fruit is given in some parts of India in fevers.

Delinia *(Dillenia indica)***:** Elephant apple belongs to the family Dilleniaceae; is a large, knobby fruit with acidic flavoured. Fruits are consumed as tonic and laxative. The fruit juice is mixed with sugar and used as a cooling beverage in fevers and as a cough mixture. Green fruits are very effective against rheumatism.

Durian (*Durio zibethinus* Murr.): Durian belongs to the family Bombacaceae, is one of the popular seasonal fruit in South East Asia. It is popular because of its taste and strong odour. The fruit is usually consumed fresh, but it can be processed into paste, or the flesh can be frozen or powdered or added into other products such as ice cream, cakes and confectionery, seeds roasted and eaten.

Karonda (*Carissa carandas* L.)**:** It belongs to family Apocynaceae. Karonda is an evergreen, spiny small tree belongs to Apocynaceae family. The karonda is a non-traditional fruit crop. Ripe fruits are sub-acidic to sweet in taste with peculiar aroma. The fruits may be eaten as a dessert when ripe or used in the preparation of fruit products such as jelly, squash and chutney. The dried fruits may become a substitute for raisins. The unripe fruits yield milky white latex which can also be used in preparing chewing gum and rubber. Fruits can also be used in dyeing and tanning industries. Karonda fruit is considered to be antiscorbutic. Root extracts are used in lumbago, chest complains and venereal diseases.

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International Society for Minor Fruits, Medicinal and Aromatic Plants
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The society was officially formed on 20th December, 2013 after threadbare discussion in a meeting held at the Faculty of Agriculture, University of Ruhuna, Sri Lanka. The society has been registered under University of Ruhuna, Sri Lanka and its Head Quarter is in Sri Lanka (Faculty of Agriculture, University of Ruhuna , Sri Lanka).

Main function of the society:

i. Promotion and development of Minor / Underutilized Fruits, Medicinal and Aromatic Plants through conservation, cultivation and developmental research.

ii. Organizing International symposium once in 2-years interval with main aim is to discuss the latest development in above areas, exchange ideas and policy making for future works.

1st ISMFM&AP (International Symposium on Minor Fruits, Medicinal and Aromatic Plants) was held in India during December 19-22, 2011.
2nd ISMFM&AP was held in Sri Lanka on 20.12. 2013
3rd ISMFM&AP was held in Bangladesh during May 20-21, 2015
4th ISMFM&AP will be held in Pakistan in 2017.

iii. Publication of Journal "International Journal of Minor Fruits, Medicinal and Aromatic Plants (IJMFM*&AP)"*

1st issue has already been published and it has been sent to CABI, London for publishing in their web site for abstracting. 2nd issue (Vol.2 No.1) will also be sent to CABI, London for abstracting.

iv. Collaborative research and exchange programme among the SAARC and other countries under the umbrella of the society (ISMFM&AP).

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