Morphological characterization of unique genotypes of nutmeg (*Myristica fragrans* Houtt.)

S.C. Priyanka* and N. Miniraj

College of Horticulture, Kerala Agricultural University, Thrissur 680656, Kerala, India.

Received 6 September 2016; received in revised form 3 December 2016; accepted 16 December 2016

Abstract

Twenty one unique accessions of nutmeg possessing 13 distinct characters were identified and collected through an extensive survey carried out in the nutmeg growing tracts of Kerala. These unique genotypes along with the two improved accessions were subjected to morphological characterization. As a deviation from the normal nutmeg, some unique types such as yellow maced nutmeg, double seeded nutmeg, cluster fruited nutmeg, monoecious, wild and grape nutmegs were identified in the study. All these accessions were characterized using seven qualitative and fourteen quantitative traits. Twenty three accessions were grouped into 12 clusters at 60% similarity. A concept diagram was developed for utilizing these unique accessions. Yellow maced accessions (YL-1 and YL-2) can be directly utilized for yellow colour, as they fetch premium price in the market. Double seeded accession (DS-1) had the highest dry nut weight and kernel weight. Seedless nutmeg accession (SL-1) possessed highest fresh mace weight. Wild nutmeg (*M. malabarica*) possessed fruits which were large, having brown velvety rind with yellowish orange coloured mace. Cluster fruited accession (CF-1) was the best accession among all the unique nutmeg accessions, possessing all the desirable features of an elite nutmeg genotype. All the unique accessions are worthy of conservation.

Keywords: Cluster fruited nutmeg, Double seeded nutmeg, Monoecious nutmeg, *Myristica fragrans,* Seedless nutmeg, Unique accessions, Yellow mace nutmeg

Introduction

Nutmeg (*Myristica fragrans* Houtt.) a member of the primitive family, Myristicaceae, is an evergreen aromatic tree spice yielding two distinct spices of commerce; the nutmeg and the mace. It is a native of Banda islands in Indonesia. Area and production of this twin spice in Kerala is showing a marked log phase over the past few years; the present area being 20630 ha and production 14190 tonnes (Spices board, 2015). Kerala has tremendous diversity in nutmeg. Collection of germplasm with special attributes is a prioritized area in the conservation and utilization of plant genetic resources. These unique accessions could be evaluated and used in crop improvement programmes. It is in this background that the present study was undertaken to collect and characterize unique genotypes of nutmeg of Kerala.

Materials and Methods

The study was carried out at the Department of Plantation Crops and Spices, College of Horticulture, Kerala Agricultural University during 2014 - 2016. Twenty one unique nutmeg accessions were collected through an extensive survey carried out in the nutmeg growing tracts of Kerala. Two improved accessions identified in an earlier study were also included for a comparative evaluation. The details of accessions and their unique features are listed in Table 1. Mother trees of these unique accessions were characterized using morphological parameters. Morphological parameters included

*Author for correspondences: Phone: 9497376399, Email: priyankajayan91@gmail.com

Table 1. Unique accessions of nutmeg identified from Kerala

Accession ID	Features the tree	Age of	Location
YL-1	Yellow maced type	17 yrs	Thrissur
YL-2	Yellow maced type	10 yrs	Kottayam
SL-1	Seedless type	18 yrs	Idukki
DS-1	Double seeded type	14 yrs	Thrissur
DS-2	Double seeded type	18 yrs	Thrissur
MN-1	Monoecious type	18 yrs	Thrissur
MN-2	Monoecious type	26 yrs	Thrisssur
CF-1	Cluster fruited type	16 yrs	Kottayam
CF-2	Cluster fruited type	15 yrs	Thrissur
LA-1	Low astringent type	15 yrs	Thrissur
LA-2	Low astringent type	23 yrs	Malapuram
PT-1	Pyramidal type	15 yrs	Thrissur
PT-2	Pyramidal type	25 yrs	Ernakulam
GT-1	Grape type	20 yrs	Thrissur
GT-2	Grape type	15 yrs	Thrissur
OB-1	Oblong type	15 yrs	Thrissur
OB-2	Oblong type	18 yrs	Thrissur
TM-1	Triangular mace type	14 yrs	Thrissur
SM-1	Small leaf type	18 yrs	Kottayam
WT-1	Wild type	18 yrs	Thrissur
WT-2	Wild type	15 yrs	Idukki
IA-1	Improved accession	16 yrs	Thrissur
IA-2	Improved accession	16 yrs	Thrissur

qualitative (tree and fruit characterstics) and quantitative parameters. Fruit characterstics were recorded during the peak harvesting period. Qualitative parameters were recorded using repeated visual observations. Qualitative parameters included canopy shape, branching pattern, fruit colour (fresh), mace colour (fresh), mace colour (dry), shape of mace and nature of fruit dehiscence. Quantitative parameters included canopy spread, leaf area, number of female flowers per 10 cm^2,number of male flowers per 10 cm^2 , number of hermaphrodite flowers per 10 cm^2, fruit weight (fresh), mace weight (fresh), mace weight (dry), nut weight (fresh), nut weight (dry), number of fruits per tree, ratio of nut to mace, mace yield per tree and nut yield per tree. Ten fruit samples per accession were taken for recording the quantitative parameters and then the average was worked out. Analysis of variance of all yield parameters (quantitative data) was done using General Linear Model procedure (Mc Culloh and Searle, 2001). The qualitative data were assessed through UPGMA (Unweighted pair group method with arithematic mean) method and summarized using dendrogram (NTSYS package 2.2).

Results and Discussion

A. Unique nutmeg accessions

Nutmeg is normally dioecious in nature with a spreading branching pattern and bearing single fruit and seed which is covered with a red coloured aril called mace. As a deviation from this, the following unique nutmeg accessions were identified and characterized in the present study**.**

a. Yellow mace nutmeg

Yellow mace colour is a unique feature when compared with normal nutmeg types which have red mace. Two yellow maced accessions were collected which retained the yellow mace colour even after drying (Plate a).

b. Seedless nutmeg

Seeding is extremely essential for any tree crop but here in the seedless nutmeg identified, eighty per cent of fruits had rudimentary sterile seed inside the mace and rest twenty per cent fruits were totally seedless with a typical netted appearance on rind. The mace was thick, compactly arranged with several inner foldings (Plate b). A longitudinal section of mace showed the peculiar mace structure which resembles the folding of cerebrum in human brain

c. Double seeded nutmeg

A noticeable feature of double seeded accessions was that they appeared to be in transition of sex expression as evidenced by the presence of few male flowers and an umbellate cyme inflorescence, typical of male trees (Vikram, 2016). Number of fruits per tree was less than average which nullified the advantage of being double seeded. In both the double seeded accessions, ninety per cent of the

fruits were double seeded and the remaining 10 per cent, slightly deformed. Four halved splitting of rind was a typical feature noticed in these accessions (Plate c). It was earlier reported by Miniraj et al. (2015) that double seededness and multiple splitting of fruits were generally associated with monoecious types.

d. Monoecious nutmeg

Monoecy is a highly desirable characteristic as nutmeg is usually classified as dioecious in nature. A monoecious tree with other desirable attributes will definitely be a boon to the nutmeg planters (Plate d). Several workers reported the existence of monoecious nutmeg trees in the states of Kerala and Karnataka (Miniraj et al., 2012; Sasikumar et al., 2015 and Rema et al., 2015). In the monoecious trees, number of female flowers per 10 cm^2 was 3-4 while number of male flowers per 10 cm^2 was three. Occurrence of flowers in bunches with varied proportion of male and female flowers per bunch have been reported in monoecious trees (Krishnamoorthy et al., 2012). In addition to male and female flowers, hermaphrodite flowers (2 per 10 cm^2 area) were also noticed in both the accessions (Table 2). Hermaphroditic nature is rarely reported in nutmeg, except for the record of a hermaphrodite variety Konkan Sugandha from Maharashtra (Parthasarathy, 2010).

e. Cluster fruited nutmeg

Clustering of fruits is not a common phenomenon in nutmeg, but it definitely is a desirable attribute. In the cluster fruited nutmegs, eighty per cent of the fruits were in clusters of three, fifteen per cent fruits in two and remaining in 4-8 fruits per cluster (Plate e). Of all the 23 accessions evaluated in the study, including the improved accessions, fruit yield per tree was significantly high in one of the cluster fruited accessions (CF-1). One-two fruits in a cluster was observed as common in nutmeg by Vikram (2016).

Table 2. Tree and flower characters of unique accessions of nutmeg

Accession	Canopy spread (m)		Leaf area	No.of female	No. of male	No.of hermaphrodite
	N-S	E-W	(cm^2)	flowers/ 10 cm^2	flowers/ 10 cm^2	flowers/ 10 cm^2
YL-1	6.20	5.30	49.09	4	NA	NA
YL-2	5.00	5.20	43.3	4	NA	NA
SL-1	9.11	8.35	43.2	3	NA	NA
DS-1	7.34	9.75	33.75	4	1	NA
DS-2	8.50	7.91	38.2	4	2	NA
MN-1	7.40	7.20	29.68	3	3	2
MN-2	9.50	8.60	27.85	4	3	2
CF-1	8.36	7.63	42.648	10	NA	NA
CF-2	9.10	8.90	32.2	4	1	NA
LA-1	6.20	6.10	27.85	5	NA	NA
LA-2	8.20	7.30	35.76	6	NA	NA
PT-1	4.30	4.80	25.55	5	NA	NA
PT-2	5.90	5.70	33.75	4	NA	NA
GT-1	7.40	6.50	30.25	2	4	NA
GT-2	6.20	5.80	27.16	3	NA	NA
WT-1	11.13	11.78	44.61	4	1	NA
WT-2	13.10	14.70	47.74	4	NA	NA
IA-1	10.6	10.20	30.84	5	NA	NA
IA-2	10.3	9.95	40.56	4	NA	NA
OB-1	4.95	4.90	37.81	3	NA	NA
OB-2	5.05	5.30	29.57	3	NA	NA
TM-1	6.60	7.60	36.51	4	NA	NA
SM-1	8.50	8.10	15.05	5	NA	NA

Table 3. Fruit characters of unique accessions of nutmeg

Accessions	Fruit wt (g)	Mace wt fresh (g)	Mace wt dry (g)	Nut wt fresh (g)	Nut wt dry (g)	Ratio of nut to mace	Number of Fruits per tree	Mace yield per tree (kg)	Nut yield per tree (kg)
YL-1	108.9 ^{b}	4.524^{d}	1.45^{h}	17.02^{a}	8.35^{fg}	2.68^{hi}	980$^{(14)}$	1.42	8.18
YL-2	90.34^{def}	3.55^{fg}	1.266^{hi}	12.16^{c}	5.97^{i}	2.61^{hi}	1000$^{(13)}$	1.27	5.97
SL-1	86.35^{efg}	9.744^{a}	3.82^{c}	NA	NA	NA	800$^{(15.5)}$	3.06	NA
DS-1	126.05 ^{a}	5.70^{c}	3.31^{d}	16.18^{ab}	13.03^{a}	2.90^{gh}	700$^{(17)}$	2.32	9.12
DS-2	50.33^{l}	1.79^{j}	0.90^{j}	5.55^{i}	4.23^{kl}	3.63^{fg}	280$^{(19)}$	0.25	1.18
MN-1	63.52^{jk}	2.57^{hi}	1.41^{h}	13.11^{c}	8.13^{fg}	4.45^{de}	250$^{(21)}$	0.35	2.03
MN-2	71.65^{hij}	2.17^{hij}	1.28^{h}	8.42^{fg}	5.90^{i}	3.98^{ef}	275$^{(20)}$	0.35	1.62
CF-1	99.56 ^{c}	4.37^{de}	2.35^{ef}	12.82^{c}	10.75^{bc}	2.92^{gh}	2250$^{(3)}$	5.29	24.19
CF-2	61.23^{k}	1.99^{ij}	0.86^{j}	7.65^{gh}	4.98^{ijk}	3.95^{ef}	1800$^{(7)}$	1.55	8.96
LA-1	72.85^{hi}	2.16^{hij}	0.94^{j}	13.11^{c}	8.13^{fg}	6.40^{a}	800$^{(15.5)}$	0.75	6.50
LA-2	61.65^{k}	2.37^{hij}	1.28^{hi}	12.28^{c}	9.54^{de}	5.22^{cd}	1750$^{(8)}$	2.24	16.70
PT-1	92.82^{cdef}	2.87^{gh}	1.342^{hi}	12.14^{c}	5.65^{ij}	4.27^{ef}	850$^{(14)}$	1.14	4.80
PT-2	85.90^{fg}	1.89^{ij}	1.20^{h}	12.69^{c}	8.75^{ef}	6.75^{a}	1150$^{(12)}$	1.38	10.06
GT-1	47.14^{l}	1.07^{k}	0.35^{k}	6.33^{i}	3.54^{lm}	6.16^{ab}	2000$^{(5)}$	0.70	7.08
GT-2	38.87^{m}	0.99^{k}	0.39^{k}	6.57^{hi}	3.06^{m}	4.79^{de}	1900$^{(6)}$	0.74	5.81
WT-1	85.08^{fg}	8.70^{b}	6.75^{a}	6.21^{i}	4.74^{jk}	0.71^{j}	3500$^{(2)}$	23.63	16.59
WT-2	88.13^{efg}	8.33^{b}	5.28^{b}	14.96^{b}	11.44^{b}	1.81^{i}	4000$^{(1)}$	21.12	45.76
IA-1	98.33^{cd}	3.73^{ef}	2.58^{e}	17.02^{a}	10.04^{cd}	4.72^{de}	1450$^{(10)}$	3.74	14.56
IA-2	98.44^{cd}	2.90^{gh}	2.36^{ef}	14.98^{b}	8.68^{ef}	4.72^{d}	1350$^{(11)}$	3.19	11.72
OB-1	64.69^{ijk}	1.96^{ij}	1.16^{hi}	10.86^{d}	7.48^{gh}	5.65^{bc}	2200$^{(4)}$	2.55	16.46
OB-2	73.15^{hi}	4.39^{de}	2.43^{ef}	10.41^{de}	7.34^{gh}	2.45^{hi}	1500$^{(9)}$	3.65	11.01
TM-1	95.18^{cde}	5.28^{c}	2.60^{e}	12.66^{c}	8.03^{fgh}	2.41^{hi}	680$^{(18)}$	1.77	5.46
SM-1	79.74^{gh}	3.88^{def}	1.98^{g}	10.25^{de}	7.02^{h}	2.65^{hi}	1580$^{(8)}$	3.13	11.09

f. Low astringent nutmeg

The astringency of pericarp is usually a reckoned characteristic; deviation from this towards a low level is highly desirable in the value addition of nutmeg rind. While considering the biochemical components of nutmeg rind, acidity and tannin contents were lower and pectin content was higher in LA-2, which signifies its use in value addition. Vikram (2016) reported the range of titrable acidity in nutmeg rind as 1.28 -1.92 per cent. In the present study, low astringent types had an acidity content below the range mentioned by Vikram (2016). Even though LA-1 was initially designated as low astringent type, on final analysis it was other unique accessions which recorded comparatively lesser acidity and tannin contents than these low astringent types.

g. Narrowly pyramidal nutmeg

Narrowly pyramidal (conical) tree shape is the unique feature of PT-1 and PT-2, which can be utilized in high density planting system as it will occupy only less horizontal ground space coverage (Plate f). High density planting in nutmeg is an upcoming area of research due to reduced land availability. Erect branching pattern was observed in these types which resulted in the narrowly pyramidal canopy shape.

h. Grape nutmeg

Grape nutmeg can definitely be exploited as ornamental types suitable for landscape horticulture. The fruits were quite small when compared to the normal nutmeg, but number of fruits per tree was on the higher side. As the fruit itself is small, fresh mace and nut weight were also significantly low. GT -2 had lowest measures of fruit characteristics among all the unique accessions studied. Sasikumar et al. (2014) also reported a distinct nutmeg type with small fruits and thin shell with high yield in terms of number of fruits along with profuse bearing habit. Small fruitedness may not be a desirable character from the economic point of view. But it can definitely be utilized in landscaping. Dwarfness

Plate a. Yellow maced nutmeg

Plate b. Seedless nutmeg

Plate c. Double seeded nutmeg

Plate d. Monoecious nutmeg

Plate e. Clusterfruited nutmeg

Plate f. Narrowly pyramidal

Plate g. Wild nutmeg

Plate h. Oblong nutmeg

Plate i. Small leaved nutmeg

with short and spreading growth habit has been reported in clove (Krishnamoorthy and Rema, 1994).

i. Wild nutmeg

Even though nutmeg is an introduced crop to India, there exist natural populations of other Myristicaceae members in the forests of Kerala. Towards this end, WT-1 and WT-2 (*Myristica malabarica*) can be exploited for their valuable features. Krishnamoorthy (2008) reported the significance of *Myristica malabarica* as a drought hardy rootstock in water scarce areas. The roots of wild nutmeg are quite stronger and can penetrate deep inside soil till it attains the water table. The wild nutmegs were monoecious in sex form. Another noticeable feature in wild nutmeg was the comparatively small flower size compared to *M.*

Table 4. Clustering of nutmeg and their measured characteristics

Cluster ID	Accessions	Canopy shape	Branching pattern	Fruit colour (fresh)	Mace colour (fresh)	Mace colour (dry)	Shape of mace	Nature of fruit dehiscence
Cluster 1	YL-1	Pyramidal	Spreading	Light yellow				
	YL-2		Erect	Yellow	Yellow	Yellow	Round	Two halves
Cluster 2	LA-1	Pyramidal,	Erect	Light yellow				
	PT-1	Conical		Yellow	Red	Scarlet red	Oval	Two halves
	PT-2			Light yellow				
Cluster 3	GT-2				Red			
	IA-1	Globular	Spreading	Yellow	Red	Scarlet red	Round	Two halves
	IA-2				Deep red			
Cluster 4	LA-2			Light yellow			Oval	
	TM-1	Pyramidal	Spreading	Yellow	Red	Scarlet red	Triangular	Two halves
	SM-1						Oblong	
Cluster 5	WT-1	Pyramidal	Spreading	Brown	Yellowish	Orange red	Oblong	Two halves
	WT-2				orange			
Cluster 6	OB-1	Pyramidal	Spreading	Light yellow	Deep red	Red	Oblong	Two halves
	OB-2			Red	scarlet red			
Cluster 7	MN-1	Globular,	Spreading	Yellow	Red	Scarlet red	Oval	Three halves
	MN-2	pyramidal,						Three halves
	CF-2	pyramidal						Two halves
Cluster 8	CF-1	Pyramidal	Drooping	Yellow	Deep red	Scarlet red	Oval	Two halves
Cluster 9	SL-1	Pyramidal	Spreading	Yellow - light green	Deep red	Scarlet red	Oblong	Two halves
Cluster 10	DS-1	Globular	Erect	Light yellow	Red	Scarlet red	Oval	Four halves
Cluster 11	DS-2	Oblong	Erect	Light yellow	Red	Scarlet red	Round	Four halves
Cluster 12	GT-1	Pyramidal	Spreading	Yellow	Red	Red	Round	Two halves

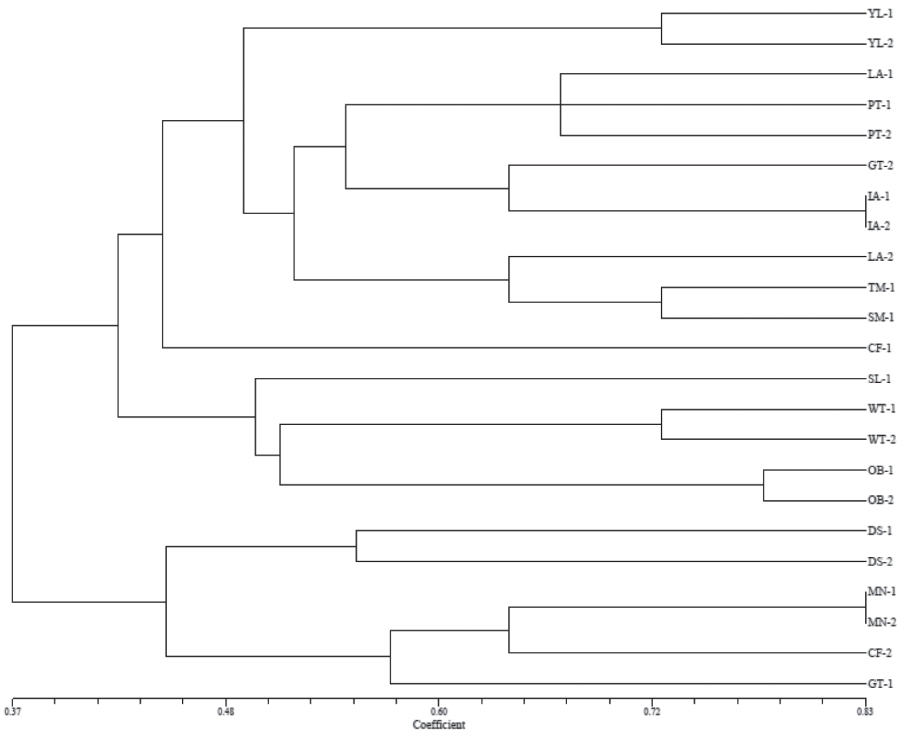

Figure 1. Dendrogram based on qualitative parameters of unique nutmeg accessions

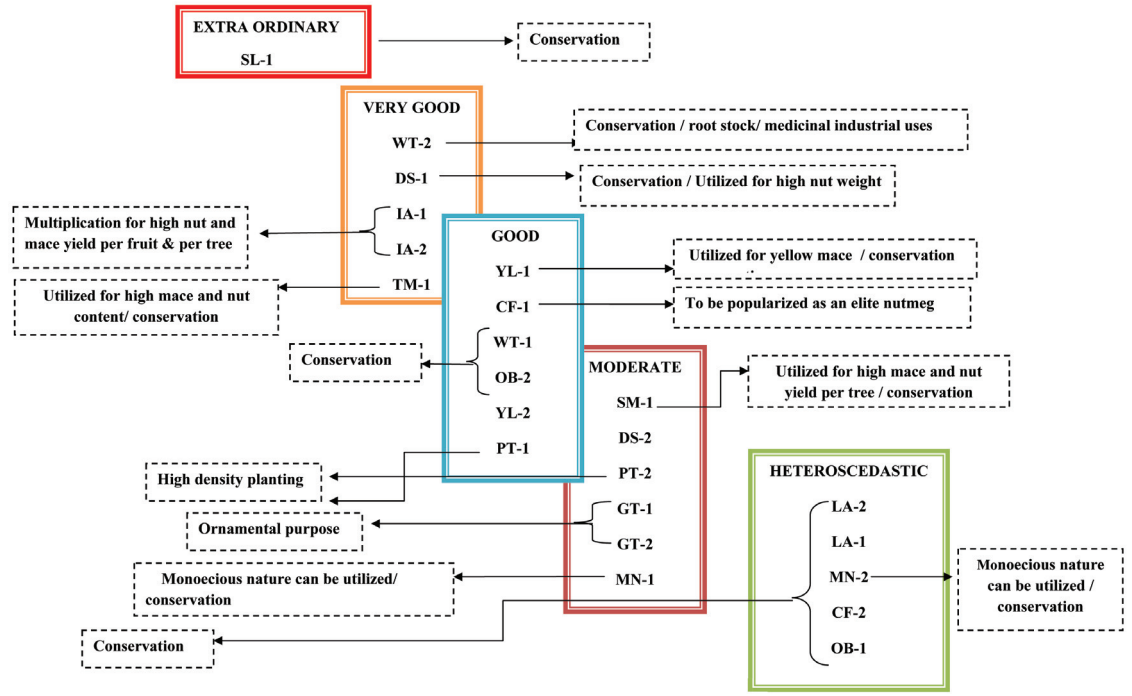

Figure 2. Concept diagram for utilization of unique nutmeg accessions

fragrans. Fruits of wild nutmeg varied significantly from normal nutmeg in terms of fruit colour, fruit shape, fruit size, mace shape and nut shape. Velvety brown rind with oblong yellowish orange coloured mace were the typical features in wild accessions (Plate g). Kernel development was improper in WT-1 and on drying it could not be separated from the thin shell. The seeds did not germinate indicating the poorly filled endosperm. Kumar et al. (2002) reported that the viability of seeds of *Myristica malabarica* was only upto one week under natural condition.

j. Oblong nutmeg

Another interesting unique feature observed was oblong nutmeg, with fruit shape deviating from the normal nutmeg. The nut and mace in both accessions OB-1 and OB-2 were oblong shaped and had thin mace; it was very difficult to get flower grade quality mace from these fruits (Plate h). But the number of fruits per tree was significantly higher and was comparable with other unique nutmeg accessions evaluated in the study. Nitta (1993) reported from Moluccas Island about the occurrence of nutmeg trees with different fruit shapes, viz., *pala tidore* which has pear shaped fruits and *pala bali* which has large globoid fruit.

k. Triangular maced nutmeg

Triangular shape of mace was very distinct when mace was attached to the nut. Normally the mace shape in nutmeg varied among round, oval and oblong shapes. Occurrence of beaked nutmeg accessions has been reported from Kerala by Vikram (2016).

l. Small leaved nutmeg

These trees possessed small elliptic leaves, dark green in colour (Plate i). Leaf dimensions in this accession makes it distinct from the normal nutmeg types with lowest leaf length and breadth along with a minimum leaf area of 15.05 cm^2. Leaf area is one of the parameters which influence photosynthesis and also the final biomass output of a tree including

the yield (Vikram, 2016). Even though the leaves are small, the foliage density was abundant. However, the number of orthotropic shoots in SM-1 was found to be 45, which is a highly preferred characteristic in nutmeg with regard to the vegetative propagation and is a feature that is very useful to a nutmeg grower in propagating this unique nutmeg type through budding /grafting. This solidifies the significance of orthotropic shoot production in nutmeg. Kakkappara-2, a narrow leaved thick mace type nutmeg tree with open canopy structure has been spotted by Sasikumar et al. (2014) in Kerala.

B. Evaluation of unique nutmeg accessions

The fruit characteristics being the ultimate economic end point for a farmer, a comprehensive assessment of quantitative characters was done after collecting the representative samples of fruits from all the trees. All the fruit characteristics were analyzed for identification of sub groups among the 23 accessions using Univariate General Linear Model. The results of the analysis for all fruit characteristics are discussed and depicted in Table 3. Double seeded nutmeg accession DS-1 had high fruit weight and dry nut weight among all the unique accessions. Seedless nutmeg accession (SL-1) possessed highest fresh mace weight among all the unique accessions. Wild type nutmeg possessed highest number of fruits. Cluster fruited nutmeg accession (CF-1) was the best accession among all the unique nutmeg accessions belonging to *Myristica fragrans* Houtt with highest nut and mace yield per tree.

After characterization of all the unique accessions, the similarity based on qualitative characters was achieved through UPGMA (unweighted pair group method with arithematic mean) method and a dendrogram (Fig. 1) drawn accordingly using NTSYS (Numerical Taxonomy System) package 2.2. Based on the dendrogram generated, 12 clusters were formed at 60% similarity. The characteristics that were profusely spotted were pyramidal canopy shape and spreading branching pattern as depicted in Table 4. Fruit colour was predominantly light yellow with red coloured mace and yellow coloured mace at times. Brown coloured fruits with yellowish orange fresh mace were noticed in wild nutmeg. On drying, the colour retention of mace was scarlet red in most cases with an exceptional one in yellow mace type. Nut colour was brown on drying.

As a contrast to the widely noticeable characteristics above, divergence in measure with respect to each and every characteristic was prominently noticed, asserting that a unique genotype can never merge into any other genotypes. There was no definite pattern of concentration of most of the characteristics in one or the other of the unique accessions. Hence, a ranking method was adopted to evaluate the accessions on a rational scale. Rank scores quantified the relative worthiness of the accession. The results based on the pooled rank scores were further explored using the summary statistics, mainly quartiles. The quartiles of the data of the rank score were computed and the accessions under quartiles was designated as very good, good, moderate and heteroscedastic group. In addition to this Seedless nutmeg (SL-1) is regarded as extraordinary due to its specific seedless nature.

A concept diagram was drawn ultimately with all these characters (Fig. 2). From the concept diagram the unique accessions could be selected for utilization in different aspects according to their characteristics as indicated in the diagram. According to the concept diagram, all unique accessions are worthy of conservation. Grape nutmeg accessions are best suitable for ornamental purpose. Wild nutmeg accession can be utilized as rootstock for water scarce areas. Double seeded nutmeg accession DS-1 needs improvement for obtaining high mace and nut yield per tree by increasing the number of fruits. Both the improved accessions IA-1 and IA-2 can be directly multiplied for cultivation due to their high mace and nut weight. Triangular mace nutmeg TM-1 characterized by high mace and nut weight per fruit could be improved. Yellow mace nutmeg accession YL-1 can be directly utilized for its yellow mace, but for

commercial cultivation the mace and nut yield per tree has to be improved. Small leaf type accession SM-1 possessing high nut and mace yield per tree with high orthotropic shoot induction ability could be popularized commercially. Accession CF-1 which possessed all the desirable features of an elite nutmeg genotype can be commercially popularized as a variety.

Thus the present study highlighted, importance of unique nutmeg accessions which can be utilized in many aspects apart from making a significant contribution to the species richness in nutmeg. Yellow maced nutmeg is highly valued for its yellow mace colour. Wild nutmeg (*M. malabarica*) was unique with respect to almost all tree, flower and fruit characteristics. Narrowly pyramidal nutmeg trees are best suited in high density planting. Double seeded nutmeg was superior in terms of fruit characteristics. The cluster fruited accession CF-1 proved to be an elite nutmeg genotype which can be commercially popularized as a variety. All these unique accessions are worthy of conservation.

References

Krishnamoorthy, B. and Rema. J. 1994. Characterization of seedling progenies of elite lines of clove. Ind. Cocoa Arecanut Spices J**.,** 18(3):82-84.

Krishnamurthy, B., Rema, J., Mathew, P.A. and Krishnamoorthy, B. 2008. Identification of suitable Myristica species/ related taxa as rootstock to combat drought in nutmeg. Ind. J. Hort., 65(2): 204-208.

Krishnamoorthy, B., Rema, J., Nair, R.R. and Krishnamurthy, K.S. 2012. Circumventing sexual dimorphism in nutmeg-An innovation by Shri. Purnand, V. Bhat. Spice India, 25(9): 8-10.

Kumar, C.A., Babu, K.P., and Krishnan, P.N. 2002. Seed storage and viability of *Myristica malabarica* Lam. An endemic species of southern Western Ghats (India). Seed Sci. Tech., 30(3): 651-657.

Mc Culloh, C.E. and Searle, S.R.(eds). 2001. Generalized linear mixed models. In: Generalized, Linear and Mixed models, Toronto, John Wiley and Sons, pp. 220-246.

Miniraj, N., Mathew, S.K. and Nybe, E.V. 2012. Jathi Krishiyum Samskaranavum. Kerala Agricultural University Press, 62p.

Miniraj, N., Vikram, H.C. and Philip, M. 2015. Variability of nutmeg in Kerala. Ind. J. Arecanut Spices Med. Plants, 17(2): 6-14.

Nitta, A. 1993. Nutmeg found in Molucca Islands. J. Jpn. Bot., 68 (1):47-52.

Parthasarathy, V.A. 2010. An overview of genetic resources of tree spices. In: Proceedings of National Seminar on Tree Spices, HRS, Kanyakumari, March 5-7, 2010. pp. 5-21.

Rema, J., Saji, K.V., Sasikumar, B. and Anandaraj, M.A. 2015. Monoecious nutmeg in Uttarkannada and Shimoga districts of Karnataka. Ind. J. Arecanut Spices Med. Plants, 16(3): 3-5.

Sasikumar, B., Rema, J. and Saji, K. V. 2014. In the trail of elite nutmeg. Spice India, 27(9): 8-12.

Sasikumar, R., Rema, J., Saji, K.V. and Thomas, L. 2015. Scouting for elite nutmeg trees. Spice India, 28(1): 24-25.

Spices Board. 2015. Spice wise area and Production. Available athttp://www.indianspices.com. [15 July 2015].

Vikram, H.C. 2016. Characterization and evaluation of nutmeg (*Myristica fragrans* Houtt.). Ph D (Hort.) thesis, Kerala Agricultural University, Thrissur, 123p.