Research Article

doi:10.19071/jpc.2016.v44.i3.3166
Journal of Plantation Crops, 2016, 44(3):166-173

Investigations on developing a key for identification of elite nutmeg tree

H.C. Vikram*, N. Mini Raj[1] and S. Krishnan[1]

ICAR-Indian Institute of Horticultural Research, Bengaluru-560 089, Karnataka, India
[1]College of Horticulture, Kerala Agricultural University, Thrissur -680 656, Kerala, India

(Manuscript Received: 21-10-16, Revised: 10-11-16, Accepted: 25-11-16)

Abstract

Nutmeg (*Myristica fragrans* Houtt.) is unique among tree spices, as the donor of two distinct spices; nutmeg and mace. Yield is a complex phenomenon in nutmeg. Fruit yield per tree is the targeted quantitative parameter which is dependent on several other yield related components. Hence, an attempt was made towards identification of an elite nutmeg tree using desirable characteristics which are easily measurable and recognizable. Forty six morphotypes of nutmeg selected from core collections in the Chalakudy river basin in Kerala in the age group of 15 years formed the material for study. These samples of nutmeg represented almost all nutmeg growing tracts of Kerala. The accessions were evaluated based on 51 qualitative and 38 quantitative characteristics and grouped based on similarities. Thirteen key quantitative characters were selected based on their impact on yield as well as commercial importance.The qualitative clusters were ranked based on relative best performance of the perceived key characters. Database was generated for the key characters and from this database, plausible value of each character was predicted. Accordingly, an elite nutmeg tree may be characterized as having the ideal characteristics with approximate values *viz*., tree height (8 m), canopy spread (E-W: 7 m, N-S: 8 m), number of flowers (6 per 10 cm^2), fruit set percentage (37), number of fruits m^{-2} (19), fruit weight (81 g), thickness of pericarp (14 mm), dry mace weight (2 g), dry nut weight (10 g), kernel weight (7 g), ratio of nut to mace (6.6) and number of fruits per tree (3342). It is a simple key involving characters which are measurable and recognizable at the farmer level.

Keywords: Morphotypes, *Myristica fragrans*, qualitative character, quantitative characters

Introduction

Nutmeg (*Myristica fragrans* Houtt.) belonging to the family Myristicaceae, is unique among the spice crops, as the donor of two distinct spices; nutmeg and mace. It is valued for its flavouring and medicinal properties. Family Myristicaceae is a primitive one and the genus *Myristica* is predominantly dioecious. Nutmeg is native to Moluccas Islands in Indonesia; it was introduced to India about two centuries ago. Although an introduced crop, there exists tremendous variability for this crop in Kerala (Sasikumar, 2009; Miniraj *et al*., 2015a; Sasikumar *et al*., 2014), a major nutmeg growing state in the country. An understanding of the variability existing in the crop is very essential for formulating crop improvement programmes.

In nutmeg, fruit yield may vary with individual genotype or variety, from a few hundreds to about 10,000 fruits. Anandaraj *et al*. (2005) opined that a good tree yields on an average about 2000 fruits annually. The variation in yield could be due to inherent genetic make-up, seasonal weather parameters and management practices. In nutmeg, yield recorded over a longer period is more reliable than single records at early stages. A full bearing tree producing 3000 fruit per year along with other economic characters is considered as a high yielder as reported by Miniraj *et al.* (2015b). Yield is a complex phenomenon in nutmeg. Fruit yield per tree is the targeted quantitative parameter which is dependent on several other yield related components; it is not easy to define an elite crop type for nutmeg.

*Corresponding Author: vikram.hc@gmail.com

More specifically in nutmeg, an elite tree is a plant model that should have expected yield with other desirable/ideal plants characteristics. In the simplest sense, the term ideotype means ideal-type, or an idealized envisioned appearance that is desired. The term has been co-opted by plant breeders to describe the idealized appearance of a plant variety (Rasmusson, 1987). Ideal plant characters should be made simple, easily measurable and recognizable at the farmers' level. Hence, for the first time, an attempt was made towards identification of an elite nutmeg tree using desirable characteristics.

Materials and methods

Chalakudy region of Central Kerala, a major nutmeg cultivating area, shows very high variability. Hence, 46 morphotypes of nutmeg selected from core collections in the Chalakudy river basin representing almost all nutmeg growing tracts of Kerala, formed the material for the study. All the selected trees were of same age (15 years); comprising 42 females (Acc.1 to Acc. 42) and four monoecious (Acc. (H)1 to Acc. (H)4). Two trees per accession were marked and observations were recorded through various phenophases of the tree. The accessions were meticulously evaluated based on 51 qualitative and 38 quantitative characteristics.

Fifty one qualitative parameters were subjected to cluster analysis. Based on the similarity matrix, cluster analysis was performed and dendrogram was constructed by UPGMA method for 46 morphotypes (Sneath and Sokal, 1973). All the 38 quantitative characters were initially subjected to analysis of variance as completely randomised design (CRD). Out of the 38 observations recorded, 26 characters were selected based on statistical significance and economic importance for further analysis. Grouping of the accessions was done and the genetic divergence was computed for 46 accessions following the D^2 statistics developed by Mahalanobis (1936).

Inter cluster association of qualitative cluster with quantitative cluster: Inter cluster association of two cluster agglomerations was worked out by finding the per cent distribution of the members of a specific cluster over the clusters of the other cluster agglomeration.

Mean, standard deviation and coefficient of variation were worked out for all the different quantitative clusters to assess the quantum of variability exhibited by the formation characters in each cluster. The inter cluster association formula proposed by Latha (2010) was modified to accommodate within variability of each of the quantitative cluster. The perceived morphological dimensions of the members of the 11 qualitative and 10 quantitative cluster agglomerations were calculated using the formula,

Perceived morphological characteristics

$$= \frac{\sum_{i=1} Pi\ Wi\ Xi}{\sum_{i=1}^{n} PiWi}$$

Where, Pi = Per cent accessions falling in quantitative cluster i,

Xi = Corresponding character mean based on the members falling in quantitative cluster i,

Wi = Inverse of the standard deviation of the corresponding characters based on the members falling in quantitative cluster i,

n = Total numbers of quantitative clusters.

Key for identification of elite nutmeg tree: The database was generated selecting the best performed clusters from the perceived morphological dimension analysis. The key characters were selected based on the statistical analysis and commercial importance. Using these key quantitative characters, the statistical key was developed logically from the database.

Results and discussion

Clustering based on qualitative characters: Cluster analysis based on 51 qualitative characters revealed that all the 46 accessions fell into 11 clusters at 66 per cent similarity (Fig. 1 & Table 1). Agglomerative hierarchical clustering based on the Jaccard's similarity coefficient, using UPGMA is the most apt method that could be co-opted to evolve groups of accessions at any default level of similarity admissible. The results ensuing out of the below mentioned classification of accessions will be the first step of the ladder towards characterization of accessions.

Cluster IV was the largest one, including 43 per cent of accessions. All members of this cluster belonged to dioecious sex form, possessing identical and close values in growth parameters, flowering, fruiting pattern and fruit, nut and mace characters. Acc. 15, Acc. 20, Acc. 28, Acc.31, Acc. 32, Acc. (H)2

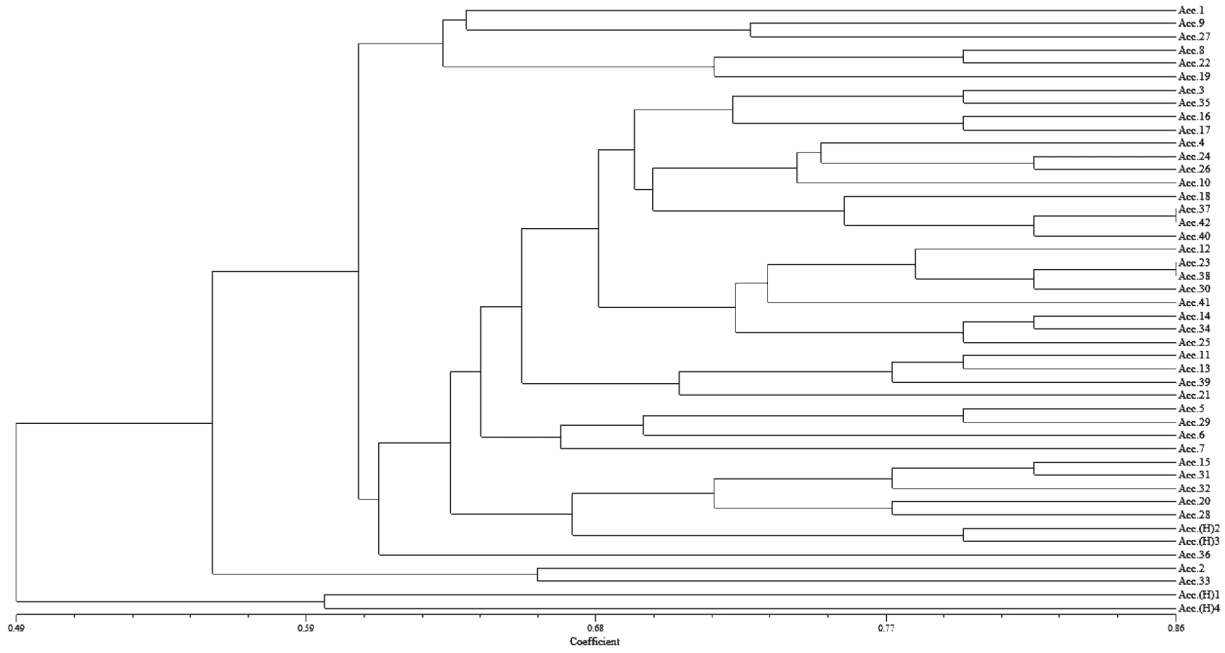

Fig. 1. UPGMA dendrogram of qualitative characteristics of nutmeg accessions

Table 1. Clustering based on qualitative characters in nutmeg accessions

Cluster number	Cluster members
I	Acc.1
II	Acc.9, Acc.27
III	Acc.8, Acc.22, Acc.19
IV	Acc.3, Acc.35, Acc.16, Acc.17, Acc.4, Acc.24, Acc.26, Acc.10, Acc.18, Acc.37, Acc.42, Acc.40, Acc.12, Acc.23, Acc.38, Acc.30, Acc.41, Acc.14, Acc.34, Acc.25
V	Acc.11, Acc.13, Acc.39, Acc.21
VI	Acc.5, Acc.29, Acc.6, Acc.7
VII	Acc.15, Acc.31, Acc.32, Acc.20, Acc.28, Acc.(H)2, Acc.(H)3
VIII	Acc.36
IX	Acc.2, Acc.33
X	Acc.(H)1
XI	Acc.(H)4

and Acc. (H)3 were grouped in cluster VII. In this cluster, five accessions were dioecious and remaining two monoecious. Accessions in cluster V were dioecious with similar branching pattern, canopy shape, fruit and nut characters. Cluster VI members were not identical in tree characters but showing identical sex form, floral and fruit characters. The Accessions 9 and 27 belonging to cluster II were identical in terms of morphological characteristics. Similarly, accessions 2 and 33 falling in the same qualitative cluster were also similar. The solitary accessions included in clusters I, VIII, X and XI possessed qualitative traits distinct from all other accessions. The above exercise has

Table 2. Cluster members of D^2 analysis of nutmeg accessions

Cluster number	Cluster members
I	Acc.3, Acc.5, Acc.6, Acc.7, Acc.11, Acc.15, Acc.34, Acc.36, Acc.(H)1, Acc.(H)3
II	Acc.12, Acc.16, Acc.32, Acc.33, Acc.39, Acc.(H)4
III	Acc.13, Acc.20, Acc.28, Acc.31, Acc.35, Acc.(H)2
IV	Acc.8, Acc.19, Acc.21, Acc.22, Acc.26, Acc.30
V	Acc.9, Acc.18
VI	Acc.2, Acc.4, Acc.25, Acc.29, Acc.38
VII	Acc.10, Acc.24, Acc.37, Acc.42
VIII	Acc. 14, Acc.41
IX	Acc.17, Acc.23, Acc.40
X	Acc.1, Acc.27

paved the way to align each accession with the rest of seemingly nearby accessions in a systematic way as the rider at default similarity is pulled back to fold down the multi-ribbed umbrella of dendrogram.

Clustering based on quantitative characters: D^2 analysis was carried out using 26 quantitative characters as most appropriate for the analysis of data. The presence of high variability among the accessions studied for different characters were further confirmed through the pattern of distribution of 46 morphotypes into 10 clusters (Table 2). Cluster I with 10 accessions formed the largest group. Cluster II, III and IV had six accessions each, while Cluster VI had five accessions. Cluster VII and IX included four and three accessions, respectively. Cluster V, VIII and X had two accessions each with identical quantitative characters. Haldankar *et al.* (2007) studied the genetic divergence using 34 nutmeg genotypes and grouped them into 12 clusters based on the quantitative characters.

Inter cluster association of qualitative and quantitative clusters: Clustering pattern based on qualitative and quantitative characters were different. The 46 accessions were grouped into 11 and 10 clusters in qualitative and quantitative clustering, respectively. The extent of linkage between the qualitative and quantitative clustering patterns is presented in Table 3. A comparison of the two clustering patterns was done by finding out the per cent distribution of accessions of a qualitative cluster over the different quantitative clusters. Majority of accessions in a single qualitative cluster fell in a single quantitative cluster indicating the similarity among these accessions at quantitative level also. In qualitative cluster III, all the three accessions fell into quantitative clusters IV which shows 100 per cent similarity of these accessions in both qualitative and quantitative clusters. The remaining accessions of the pre-disposed qualitative cluster even though seemed to be similar at qualitative level, were dissimilar at quantitative level.

Summary statistics of quantitative clusters: The mean, standard deviation (SD) and coefficient of variation (CV) computed for all the 26 quantitative characters of each of the quantitative clusters (Table 4). In all the clusters, characters having more than 30 per cent CV were considered as the most variable characters. These variable characters are identified as the important characters which can influence the yield in nutmeg.The consistency of performance of each quantitative character among the accessions within a cluster varied over the different clusters. This result is a pointer towards further exploration of performance of each character taking into consideration the variability of each character cluster wise. Thus, the perception of morphological dimensions of quantitative characters for a set of qualitative characters was taken up as a final step towards the fulfilment of the task.

Table 3. Inter cluster association of qualitative and quantitative clusters

Qualitative cluster	Number of accessions	Per cent of accessions falling in different quantitative clusters									
		I	II	III	IV	V	VI	VII	VIII	IX	X
I	1	*	*	*	*	*	*	*	*	*	100
II	2	*	*	*	*	50	*	*	*	*	50
III	3	*	*	*	100	*	*	*	*	*	*
IV	20	10	10	5	10	5	15	20	10	15	*
V	4	25	25	25	25	*	*	*	*	*	*
VI	4	75	*	*	*	*	25	*	*	*	*
VII	7	28.6	14.3	57.1	*	*	*	*	*	*	*
VIII	1	100	*	*	*	*	*	*	*	*	*
IX	2	*	50	*	*	*	50	*	*	*	*
X	1	100	*	*	*	*	*	*	*	*	*
XI	1	*	100	*	*	*	*	*	*	*	*

* Denotes no distribution of accessions

Table 4. Summary statistics of quantitative characters in different quantitative clusters

Characters	Cluster I			Cluster II			Cluster III			Cluster IV			Cluster V		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
Plant height (m)	7.1	1.1	15.1	9.2	1.3	13.8	6.4	1.7	27.3	8.1	2.4	29.1	8.9	0.3	3.3
Plant girth (cm)	41.4	8.8	21.3	53.1	7.4	14.0	43.5	8.6	3.5	43.4	9.4	21.8	49.9	4.1	8.3
Canopy spread E-W (m)	5.8	1.3	22.6	6.5	1.0	16.1	4.9	1.3	26.7	6.0	1.7	27.7	6.5	0.1	1.1
Canopy spread N-S (m)	5.9	1.0	17.6	6.5	1.2	18.6	4.8	1.3	28.2	5.9	1.6	27.4	6.7	0.8	11.8
Leaf area (cm^2)	31.6	7.2	22.7	40.1	10.2	25.4	31.9	4.3	13.5	34.5	5.6	16.1	38.3	0.3	0.8
No. of flowers 10 cm^{-2}	5.9	2.0	33.3	5.1	1.4	28.1	5.1	1.0	19.1	5.2	1.2	23.4	4.4	0.2	4.0
Fruit set percentage	21.1	7.7	36.3	16.9	4.3	25.6	8.6	3.7	43.4	36.0	4.8	13.3	34.4	8.9	26.0
No. of fruits per m^2	12.4	5.0	40.2	11.3	3.4	29.9	6.6	4.6	70.2	23.3	5.3	22.8	16.4	3.4	20.5
Fruit weight (g)	73.4	9.8	13.3	59.3	9.4	15.9	47.5	6.1	12.8	57.3	4.2	7.3	83.9	5.7	6.8
Fruit length (mm)	59.1	3.3	5.7	55.6	5.3	9.6	50.4	5.6	11.1	58.4	4.9	8.4	60.6	3.9	6.4
Fruit breadth (mm)	52.1	2.8	5.3	49.2	3.0	6.1	41.1	5.7	13.8	46.3	2.4	5.3	55.7	0.6	1.2
Thickness of pericarp (mm)	12.8	1.7	13.6	12.4	1.3	10.7	9.5	1.1	11.4	11.2	1.2	10.5	13.9	0.2	1.7
Fresh mace weight (g)	2.5	0.5	18.6	1.5	0.7	44.4	1.8	0.4	20.9	1.4	0.2	14.8	3.2	1.0	30.6
Dry mace weight (g)	1.1	0.3	22.6	0.8	0.3	43.5	1.0	0.2	23.8	0.8	0.2	24.1	2.0	0.8	41.1
Fresh nut weight (g)	11.4	1.2	10.8	7.6	1.8	23.4	8.0	1.4	17.2	10.4	1.4	13.9	11.9	0.7	5.5
Dry nut weight (g)	7.5	0.7	9.6	5.2	1.0	18.4	6.4	1.1	17.2	7.6	0.8	10.5	9.5	1.5	16.2
Shell thickness (mm)	1.1	0.1	7.0	1.0	0.1	10.8	1.0	0.1	12.0	1.0	0.1	7.4	1.1	0.1	9.3
Kernel weight (g)	5.5	0.8	14.1	3.8	0.9	24.0	4.6	0.9	19.0	5.8	0.8	14.4	7.3	0.6	7.6
Fruit volume (cm^3)	65.4	9.7	14.9	56.6	10.5	18.6	44.7	8.6	19.4	52.7	4.9	9.2	67.3	2.4	3.5
Nut volume (cm^3)	10.8	1.0	9.7	7.1	2.2	31.7	7.7	1.3	17.2	10.0	1.3	13.4	10.7	0.3	3.1
Mace volume (cm^3)	2.7	0.5	18.4	1.9	0.7	38.3	1.8	0.9	52.4	1.9	0.4	23.2	2.8	0.8	27.7
Kernel volume (cm^3)	6.6	0.7	10.9	4.5	1.5	32.4	5.0	1.2	23.6	5.9	0.7	11.3	7.1	1.0	13.8
Nut length (mm)	32.3	2.1	6.4	28.9	28.9	12.5	27.4	3.5	12.6	33.5	3.2	9.4	34.4	0.7	2.1
Nut breadth (mm)	25.5	0.5	2.1	21.7	2.5	11.5	21.0	3.3	15.9	23.8	1.3	5.5	26.4	0.6	2.4
Ratio of nut to mace	4.8	1.0	20.9	5.6	2.5	43.7	4.6	0.7	14.7	7.4	0.9	13.1	3.9	1.0	25.1
No. of fruits per tree	1095.6	758.9	69.3	1053.3	1045.9	99.3	233.6	289.2	123.8	2415.3	1402.2	58.1	3836.3	825.5	21.5

Table 4. Continued…..

Characters	Cluster VI			Cluster VII			Cluster VIII			Cluster IX			Cluster X		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
Plant height (m)	7.4	0.6	8.1	9.7	1.2	12.6	6.3	0.9	15.1	8.6	0.7	8.0	6.6	0.5	6.9
Plant girth (cm)	37.1	11.6	31.4	52.1	3.5	6.8	45.5	10.2	22.4	43.1	4.4	10.3	45.5	11.1	24.3
Canopy spread E-W (m)	5.4	1.1	21.3	6.0	2.0	33.1	7.2	1.4	19.1	5.2	0.9	17.8	5.8	0.3	5.2
Canopy spread N-S (m)	5.4	1.0	18.8	5.8	1.3	23.1	7.7	1.7	21.7	4.8	1.2	23.2	5.4	0.2	3.8
Leaf area (cm^2)	30.2	3.8	12.7	36.3	3.5	9.7	32.5	3.3	10.1	32.9	7.4	22.6	35.1	0.9	2.4
No. of flowers 10 m^{-2}	4.8	0.7	14.5	4.8	0.9	19.2	6.1	0.9	14.4	3.9	0.5	13.3	4.3	1.4	33.9
Fruit set percentage	20.8	7.6	36.7	16.9	3.7	21.7	36.5	2.3	6.3	32.6	3.0	9.3	32.5	3.0	9.2
No. of fruits per m^2	13.9	4.8	34.6	12.5	2.0	16.3	18.5	3.2	17.2	24.0	6.8	28.2	21.0	2.8	13.5
Fruit weight (g)	51.7	8.8	17.1	80.9	19.6	24.2	71.8	1.4	2.0	64.6	8.2	12.7	76.7	6.7	8.8
Fruit length (mm)	57.2	4.8	8.4	62.7	3.4	5.5	60.5	3.7	6.1	56.2	5.7	10.1	61.4	1.7	2.8
Fruit breadth (mm)	45.0	3.4	7.6	53.2	5.2	9.7	51.4	0.0	0.1	50.0	2.4	4.8	52.5	2.3	5.3
Thickness of pericarp (mm)	10.3	1.0	9.4	13.7	1.0	7.6	13.0	1.8	14.0	12.0	0.9	7.5	13.5	0.2	1.8
Fresh mace weight (g)	2.4	0.6	23.0	2.7	0.6	23.1	4.5	1.1	24.4	2.6	1.0	38.1	2.2	0.4	17.3
dry mace weight (g)	1.2	0.4	30.0	1.3	0.8	29.0	2.1	0.1	3.4	1.0	0.4	40.7	1.3	0.2	17.1
Fresh nut weight (g)	8.3	1.2	14.0	11.6	1.7	14.3	11.9	2.5	20.7	10.5	1.5	13.9	12.0	0.3	2.2
Dry nut weight (g)	6.1	1.2	18.9	7.6	0.9	12.2	8.4	3.7	44.2	6.1	1.2	20.1	9.9	0.3	3.4
Shell thickness (mm)	1.1	0.1	5.2	1.1	0.1	5.7	1.1	0.0	3.3	1.0	0.2	16.1	1.2	0.4	31.7
Kernel weight (g)	4.4	0.6	14.6	5.7	0.9	15.8	6.1	2.7	44.1	4.2	0.8	18.9	7.3	0.9	12.2
Fruit volume (cm^3)	43.5	13.9	31.9	73.9	14.1	19.1	61.2	5.8	9.4	53.1	12.8	24.1	67.8	12.0	17.7
Nut volume (cm^3)	7.8	0.8	9.8	11.3	1.5	13.6	11.5	1.7	14.4	9.8	0.7	6.6	11.1	1.1	9.8
Mace volume (cm^3)	2.8	0.9	31.5	3.7	0.2	6.7	4.1	0.9	21.3	3.0	0.6	21.3	2.2	0.4	19.8
Kernel volume (cm^3)	4.6	1.3	27.9	5.9	0.6	10.1	6.9	0.2	3.0	5.6	0.5	8.6	6.5	1.3	20.0
Nut length (mm)	30.5	3.1	10.0	33.6	2.4	7.1	34.0	0.7	2.2	31.0	1.6	5.2	28.9	5.3	18.3
Nut breadth (mm)	22.0	1.1	5.2	25.4	1.2	4.7	25.8	2.5	9.7	24.9	1.3	5.2	30.0	6.7	22.3
Ratio of nut to mace	3.6	1.1	29.5	4.5	1.3	28.4	2.9	1.1	39.6	4.2	1.0	24.1	5.6	1.1	19.6
No. of fruits per tree	1466.0	1033.0	70.5	745.5	151.7	20.3	1744.3	43.4	24.8	1525.0	733.3	48.1	2547.5	381.8	15.0

Table 5. Perceived morphological dimensions of the different qualitative clusters

Character	Cluster										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Plant height (m)	7.1	8.0	6.4	8.2	7.7	7.2	7.1	6.3	8.0	8.6	10.9
Plant girth (cm)	41.4	48.2	43.5	44.9	45.5	39.8	44.2	45.5	42.2	43.1	58.5
Canopy spread E-W (m)	5.8	6.2	4.9	5.9	5.8	5.6	5.5	7.2	5.7	5.2	7.9
Canopy spread N-S (m)	5.9	6.2	4.8	5.9	5.8	5.7	5.5	7.7	5.8	4.8	8.3
Leaf area (cm^2)	31.6	37.1	31.9	34.0	34.6	31.1	33.1	32.5	33.3	32.9	54.6
No. of flowers 10 cm^{-2}	5.9	4.3	5.1	4.8	5.4	5.5	5.4	6.1	4.9	3.9	6.8
Fruit set percentage	21.1	33.7	8.6	26.0	19.6	21.0	14.6	36.5	19.6	32.6	14.3
No. of fruits per m^2	12.4	18.2	6.6	16.3	12.5	13.0	9.5	18.5	13.1	24.0	8.3
Fruit weight (g)	73.4	81.1	47.5	67.4	61.3	65.3	59.1	71.8	54.1	64.6	51.5
Fruit length (mm)	59.1	60.9	50.4	58.5	56.1	58.4	54.5	60.5	56.6	56.2	49.6
Fruit breadth (mm)	52.1	47.9	41.1	50.1	48.0	49.4	46.5	51.4	46.3	50.0	45.1
Thickness of pericarp (mm)	12.8	13.7	9.5	12.3	11.7	11.9	11.2	13.0	11.0	12.0	12.2
Fresh mace weight (g)	2.5	2.8	1.8	2.7	1.9	2.4	2.0	4.5	2.1	2.6	1.2
Dry mace weight (g)	1.1	1.8	1.0	1.3	0.9	1.1	1.0	2.1	1.1	1.0	0.6
Fresh nut weight (g)	11.4	11.9	8.0	10.3	9.4	10.2	9.2	11.9	8.1	10.5	4.4
Dry nut weight (g)	7.5	9.6	6.4	7.1	6.6	7.0	6.6	8.4	5.8	6.1	3.6
Shell thickness (mm)	1.1	1.1	1.0	1.0	1.0	1.1	1.0	1.1	1.1	1.0	0.9
Kernel weight (g)	5.5	7.3	4.6	5.2	4.9	5.1	4.8	6.1	4.2	4.2	2.7
Fruit volume (cm^3)	65.4	67.5	44.7	57.9	56.5	57.3	54.3	61.2	47.7	53.1	46.7
Nut volume (cm^3)	10.8	10.9	7.7	9.7	8.9	9.7	8.7	11.5	7.6	9.8	4.0
Mace volume (cm^3)	2.7	2.6	1.8	3.0	1.9	2.8	2.2	4.1	2.5	3.0	1.0
Kernel volume (cm^3)	6.6	6.9	5.0	5.8	5.6	5.9	5.5	6.9	4.6	5.6	2.0
Nut length (mm)	32.3	32.3	27.4	32.0	30.5	31.6	29.4	34.0	30.0	31.0	24.6
Nut breadth (mm)	25.5	27.8	21.0	24.3	23.2	24.2	22.8	25.8	21.9	24.9	17.2
Ratio of nut to mace	4.8	6.6	4.6	4.2	5.4	4.3	4.8	2.9	4.3	4.2	3.8
No. of fruits per tree	1095.6	3341.9	233.6	1710.2	1105.7	1233.7	687.7	1744.3	1333.6	1525.0	400.0

Perceived morphological dimensions: The inter cluster association of the members of qualitative cluster with that of the quantitative clusters was worked into. This quantum of association can be well utilised to build up the perceived morphological dimensions of the members of each qualitative cluster (Table 5). For each character, a perusal of the range of variation of the values over the different clusters was made to identify the best performing clusters for major characters. The clusters served as the database for visualization of an ideotype of nutmeg and also to develop a key for identification of an elite nutmeg. The exploration of the data of the accessions typical, but representative of the genus *Myristica* itself in terms of quality as also quantity, has unveiled the characteristic of a nutmeg tree. The perceived morphological dimensions of the characters as enlisted above can well characterise a nutmeg tree.

Key for identification of elite nutmeg tree: Thirteen key quantitative characters were selected based on their impact on yield as well as commercial importance. Using these key characters, a statistical key was developed for identifying an elite nutmeg tree. The qualitative clusters were ranked based on relative best performance of the perceived key characters. Database was generated for the key characters and from this database, plausible value of each key character was predicted (Table 6). An overall assessment of the predicted key characteristics will entail an elite nutmeg tree as

Table 6. Data base for visualization of elite nutmeg tree

Sl. No.	Characters	Cluster II	Cluster VIII	Cluster IV	Cluster X
1	Plant height (m)	8.0	6.3	8.2	8.2
2	Canopy spread (E-W) (m)	6.2	7.2	5.9	5.2
3	Canopy spread (N-S) (m)	6.2	7.7	5.9	4.8
4	Number of flowers per 10 cm^2	4.3	6.1	4.8	3.9
5	Fruit set percentage	33.7	36.5	26.0	32.6
6	Number of fruits per m^2	18.2	18.5	16.3	24.0
7	Fruit weight (g)	81.1	71.8	67.4	64.6
8	Thickness of pericarp (mm)	13.7	13.0	12.3	12.0
9	Dry weight of mace (g)	1.8	2.1	1.3	1.0
10	Dry weight of nut (g)	9.6	8.4	7.1	6.1
11	Kernel weight (g)	7.3	6.1	5.2	4.2
12	Ratio of nut to mace	6.6	2.9	4.2	4.2
13	Number of fruits per tree	3341.9	1744.3	1710.2	1525.0

having the ideal characteristics with approximate values *viz.,* tree height (8 m), canopy spread (E-W: 7 m, N-S: 8 m), number of flowers per 10 cm^2 (6), fruit set percentage (37), number of fruits per m^2 (19), fruit weight (81 g), thickness of pericarp (14 mm), dry mace weight (2 g), dry nut weight (10 g), kernel weight (7 g), ratio of nut to mace (6.6) and number of fruits per tree (3342). It is a simple key involving characters which are measurable and recognizable at the farmer level, which can serve as a preliminary tool for identification of an elite nutmeg tree.

References

Anandraj, M., Devasahayam, S., Zachariah, J.T., Krishnamoorthy, B., Mathew, P.A. and Rema, J. 2005. Nutmeg (Extension pamphlet). IISR (Indian Institute of Spice Research) Kozhikode. January 2005. 2p.

Haldankar, P.M., Joshi, G.D., Jamadagni, B.M. and Khandekar, R.G. 2007. Studies on genetic divergence in nutmeg (*Myristica fragrans* Houtt.). *Journal of Maharashtra Agricultural University* **32**(2): 195-197.

Latha, M. 2010. Characterization of and systematic evaluation of genetic resources of the genus *Vigna*. Ph.D.(Ag.) thesis, Kerala Agricultural University, Thrissur, 230p.

Mahalanobis, P.C. 1936. On the generalized distance in statistics.*Proceedings of the National Institute of Sciences of India* **2**: 49-55.

Miniraj, N., Vikram, H.C. and Priyanka, S.C. 2015a. Varietal diversity in nutmeg. In: *Symposium on Spices, Medicinal and Aromatic Crops (SYMSAC VIII).* Towards 2050-Strategies for sustainable spices production.16-18, December, 2015, TNAU, Coimbatore, Tamil Nadu.

Miniraj, N., Vikram, H.C. and Philip, M. 2015b. Variability of nutmeg in Kerala. *Indian Journal of Arecanut, Spices and Medicinal Plants* **17**(2): 6-14.

Rasmusson, D.C. 1987. An evaluation of ideotype breeding. *Crop Science* **27**: 1140-1146.

Sasikumar, B. 2009. Nutmeg - the sex nuts. *Spice India* **22**: 21-23.

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

Sneath, P.H. and Sokal, R.R. 1973. *Numerical Taxonomy*. Freeman, San Francisco, 573p.