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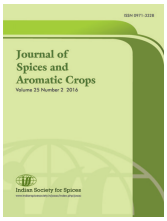

Variability in fruit characteristics of nutmeg (*Myristica fragrans* Houtt.) under Kerala conditions

H C Vikram, N Mini Raj*, K T Presanna Kumari[1], E V Nybe & D Mathew[2]

Department of Plantation Crops & Spices, College of Horticulture,
Kerala Agricultural University, Thrissur-680656, Kerala.
**E-mail: n.miniraj@kau.in*

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Abstract

Forty one accessions of nutmeg collected from diverse locations of Kerala of age 15 years were evaluated at Kerala Agricultural University, Thrissur during 2012–14. Among these accessions, 38 were females and three were monoecious. The accessions were evaluated based on 17 fruit characters recorded from two trees per accession during two consecutive bearing seasons. The statistical parameters *viz*., mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H^2), genetic gain (GG) and genotypic correlation coefficients were calculated. High PCV and GCV were observed for the characters such as fruit weight, mace weight, mace volume, dry nut weight, kernel weight, fruit volume and number of fruits per tree. Heritability was high for all the characters except shell thickness. High GCV coupled with high heritability in the characters indicated the scope for yield improvement through selection based on these characters. Genetic gain was the highest for number of fruits per tree (144.3%) followed by mace characters *viz*., fresh and dry weight as well as volume of nut. Fruit weight was also significantly and positively correlated with fruit breadth, fruit volume and thickness of pericarp. Based on the results, accessions such as Acc. 9, Acc. 8 and Acc. 22 were found promising with respect to the economic characters *viz*., mace weight, nut weight, kernel weight and number of fruits per tree. These accessions can be used in further crop improvement programmes on nutmeg.

Keywords: Nutmeg, fruit characters, genetic variability, heritability, genetic advance

Introduction

Nutmeg (*Myristica fragrans* Houtt.) belonging to family *Myristicaceae* is unique among other spices as the donor of two distinct spices, nutmeg and mace. Nutmeg is a native of Moluccas Islands in Indonesia. In India, it is cultivated throughout Kerala, parts of Karnataka, Tamil Nadu, Goa and Konkan region of Maharashtra. The production of nutmeg in India during 2012–13 was about 12,059 tonnes from an area of 18,161 ha (Anon. 2014). Being a dioceous crop, high amount of variability has

[1]Department of Genetics & Breeding; [2]Centre for Plant Biotechnology & Molecular Biology, College of Horticulture, Kerala Agricultural University, Thrissur-680656, Kerala.

been reported for growth rate, productivity, size and shape of leaf, flowers, fruits and seeds (Haldankar *et al*. 2004b; Sasikumar 2009). Variability and inter character association for fruit number, fruit weight, seed weight and mace weight in nutmeg have indicated that selection will be effective if trees are selected with optimum fruit number and moderately good seed weight (Parthasarathy 2010; Krishnamoorthy *et al.* 1991). Assessment of existing variability in the nutmeg populations in major growing tracts for important economic characters is necessary for successful crop improvement programmes. Hence, the present study was undertaken to assess the extent of genetic variability available in fruit characters, among a pre-selected nutmeg core germplasm from various parts of the Kerala state, India.

Materials and methods

The study was carried out at Kerala Agricultural University, Thrissur during 2012–14. Budded plants of 41 accessions of nutmeg collected from diverse locations of Kerala served as the material for the study. The trees were 15 years old, planted in a coconut plantation at Chalakkudy in central Kerala lying between latitude 10° 30′ N and longitude 76° 33′ E. Plantation was under good organic management practices. Each tree was supplemented with cow dung (20 kg) and lime (250 g) per year. Disease management was done by spraying copper oxychloride (2 g L^{-1}) during south west monsoon. Among the 41 selected accessions, 38 were females and three monoecious. In each accession, observations were recorded from two trees per accession during two consecutive bearing seasons. For each accession 25 split opened fruits of uniform size were collected during peak bearing season for recording the observations. The accessions were evaluated based on seventeen fruit characters *viz*., fruit weight, fruit length, fruit breadth, thickness of pericarp, fresh mace weight, dry mace weight, fresh nut weight, dry nut weight, shell thickness, kernel weight, fruit volume, nut volume, mace volume, kernel volume, nut length and nut breadth. The number of fruits $tree^{-1}$ was also recorded by regular counting of fruits fallen from each accession during the bearing season. Analysis of Variance was done for each of the 17 characters considered, in the Completely Randomised Design. The descriptive statistics *viz*., mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability broad sense (H^2) and genetic gain (GG) were then computed for all the seventeen characters. The genotypic correlation coefficients among the characters were also worked out to understand the relationship between the morphological traits (Johnson *et al.* 1955).

Results and discussion

The accessions in the present study showed a wide range of variation in important economical characters *viz*., mace weight, nut weight, kernel weight and number of fruits per tree (Table 1). The range of variation was 0.92-5.27 g for fresh mace weight, 0.57-2.14 g for dry mace weight, 4.42-13.67 g for fresh nut weight, 3.57-11.61 g for dry nut weight, 2.65-8.05 g for kernel weight and 89-4420 for number of fruits per tree. Maximum variation was exhibited in the number of fruits produced. In all the monoecious accessions, number of fruits $tree^{-1}$ recorded only lowest values. The variation could be due to the inherent genetic make up of the accessions. A nutmeg tree with stability in bearing, producing about 3000 fruits $year^{-1}$ and possessing high mace and nut weight is considered as high yielder as reported by Miniraj *et al.* (2015). Based on the evaluation data for important economic traits, female accessions *viz*., Acc. 9, Acc. 8 and Acc. 22 were found superior. These accessions offer scope for further improvement through suitable breeding methods like selection. Accession 5 exhibited very high mace weight (5.27 g fresh mace weight) with medium nut characters. Although accessions such as Acc. 18 and Acc. 21 produced high number of fruits $tree^{-1}$, the nut and mace characters were only medium. The mean values for other fruit characters recorded in 41 accessions (Table 2) revealed significant differences among accessions for all the characters indicating high variability.

Table 1. Variability for economic characters of nutmeg

Sl. No.	Accessions	Fresh mace weight (g)	Dry mace weight (g)	Fresh nut weight (g)	Dry nut weight (g)	Kernel weight(g)	No. of fruits tree^{-1}
1	Acc. 1	2.43	1.48	11.78	9.69	6.64	2817.50 (52.90)
2	Acc. 2	2.23	1.27	9.26	7.30	4.86	177.50 (13.30)
3	Acc. 3	2.06	1.08	11.04	8.48	6.61	1462.50 (38.10)
4	Acc. 4	2.76	1.60	8.66	6.47	4.51	870.00 (29.47)
5	Acc. 5	2.95	1.31	10.23	7.03	5.39	1205.00 (34.56)
6	Acc. 6	2.86	1.23	13.15	8.06	5.80	1272.50 (35.58)
7	Acc. 7	1.97	0.56	13.30	7.47	4.80	650.00 (25.44)
8	Acc. 8	1.54	0.87	11.15	8.28	6.61	3835.00 (61.92)
9	Acc. 9	2.52	1.44	11.45	8.37	6.90	4420.00 (66.46)
10	Acc. 10	2.12	1.21	9.61	7.36	5.78	782.50 (27.93)
11	Acc. 11	2.72	1.57	11.84	8.81	7.03	1202.50 (34.57)
12	Acc. 12	1.48	0.68	8.07	5.82	4.72	3015.00 (54.90)
13	Acc. 13	2.13	0.97	8.95	7.41	5.55	610.00 (23.04)
14	Acc. 14	5.27	2.14	10.12	5.77	3.72	2050.00 (45.25)
15	Acc. 15	2.18	1.11	11.32	7.55	5.29	422.50 (20.53)
16	Acc. 17	3.78	1.42	11.46	7.05	4.41	825.00 (28.60)
17	Acc. 18	3.91	2.62	12.38	10.53	7.68	3252.50 (56.76)
18	Acc. 19	1.47	0.90	10.67	7.96	6.19	675.00 (25.94)
19	Acc. 21	1.26	0.77	8.01	6.91	4.87	3325.00 (57.65)
20	Acc. 22	1.66	0.98	12.37	8.56	6.89	3690.00 (60.48)
21	Acc. 23	1.89	0.71	8.81	4.70	3.35	2287.50 (47.81)
22	Acc. 24	2.15	0.93	13.67	7.44	5.65	577.00 (24.00)
23	Acc. 25	2.57	1.17	9.22	6.23	4.09	2415.00 (49.13)
24	Acc. 26	1.48	0.68	10.34	7.61	5.43	937.00 (30.56)
25	Acc. 27	1.90	1.16	12.16	10.17	7.89	2277.50 (47.68)
26	Acc. 29	1.54	0.62	7.78	6.27	3.39	1257.50 (34.30)
27	Acc. 30	1.08	0.46	9.95	6.49	5.07	2030.00 (45.02)
28	Acc. 32	1.68	0.85	9.53	6.10	4.94	420.00 (20.48)
29	Acc. 33	0.92	0.58	8.76	5.32	3.32	242.50 (15.56)
30	Acc. 34	1.65	1.11	9.27	6.53	4.56	2350.00 (48.43)
31	Acc. 35	2.29	1.36	9.51	7.98	5.82	602.50 (24.27)
32	Acc. 36	2.72	1.06	10.66	6.77	4.93	2086.00 (45.62)
33	Acc. 37	3.28	1.33	11.73	6.65	4.51	935.00 (30.57)
34	Acc. 38	2.95	1.31	6.51	4.18	4.93	2610.00 (51.08)
35	Acc. 39	2.77	1.40	7.10	4.60	3.15	870.00 (29.47)
36	Acc. 40	2.24	0.77	11.18	6.41	4.92	1462.50 (38.22)
37	Acc. 41	3.72	2.04	13.60	11.61	8.05	1438.50 (37.90)
38	Acc. 42	3.11	1.85	11.45	8.86	6.69	687.50 (26.19)
39	Acc. (H)1	2.80	1.07	11.47	7.31	5.42	215.00 (14.65)
40	Acc. (H)3	2.80	1.07	11.47	7.31	5.42	89.50 (9.46)
41	Acc. (H)4	1.17	0.57	4.42	3.57	2.65	400.00 (19.99)
CD (5%)		0.66	0.31	1.86	0.99	1.10	652.47 (8.20)
CV (%)		14.07	13.66	8.92	6.82	10.25	21.10 (11.21)

*Values in the parentheses are square root transformed

Table 2. Variability for fruit characters in nutmeg

Sl. No.	Accessions	Fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Thick-ness of pericarp (mm)	Shell thickness (mm)	Fruit volume (cm^3)	Nut volume (cm^3)	Mace volume (cm^3)	Kernel volume (cm^3)	Nut length (mm)	Nut breadth (mm)
1	Acc. 1	71.91	62.64	50.90	13.66	1.42	59.25	10.35	1.87	5.54	25.15	34.72
2	Acc. 2	51.18	65.30	43.99	9.97	1.09	50.80	9.17	2.64	5.64	34.46	22.38
3	Acc. 3	71.13	59.82	51.03	12.91	0.97	67.86	11.87	2.71	6.63	32.16	25.66
4	Acc. 4	58.68	57.64	46.42	11.44	1.13	48.25	7.65	2.10	4.55	32.98	22.35
5	Acc. 5	90.45	62.74	56.26	15.70	1.08	79.75	9.95	2.25	6.70	31.02	24.91
6	Acc. 6	75.51	56.24	54.06	14.81	1.05	67.50	10.03	3.57	6.08	30.51	25.41
7	Acc. 7	68.17	62.07	48.97	9.82	0.96	58.05	12.88	2.55	8.23	36.64	25.80
8	Acc. 8	54.91	62.52	44.20	10.69	0.94	45.75	9.80	1.71	6.00	36.27	24.08
9	Acc. 9	87.97	63.30	56.19	14.08	1.00	68.95	10.50	2.28	7.83	33.90	25.97
10	Acc. 10	56.49	61.16	46.05	12.23	1.02	56.79	9.44	3.44	5.19	33.08	23.77
11	Acc. 11	58.63	53.23	48.80	10.75	1.02	49.50	10.80	2.10	7.46	31.60	26.71
12	Acc. 12	73.15	61.99	51.55	14.96	1.08	70.35	8.56	2.05	4.88	29.30	23.98
13	Acc. 13	55.91	52.92	47.47	10.78	1.09	52.75	8.50	3.10	6.55	29.80	24.53
14	Acc. 14	70.77	57.94	51.41	11.74	1.06	65.23	10.29	4.73	6.70	33.43	24.00
15	Acc. 15	77.22	60.07	53.27	13.13	1.16	65.53	10.74	2.86	6.19	32.69	25.18
16	Acc. 17	73.52	60.56	52.72	12.83	0.96	66.50	10.15	3.70	5.32	32.62	25.34
17	Acc. 18	79.84	57.84	55.28	13.74	1.14	65.58	10.97	3.39	6.44	44.91	26.86
18	Acc. 19	55.99	63.44	44.41	10.44	0.88	50.00	10.45	2.20	5.50	36.42	23.12
19	Acc. 21	58.87	49.68	48.55	13.27	1.00	51.04	7.82	1.22	4.72	27.74	23.84
20	Acc. 22	65.20	58.98	50.01	11.96	1.02	53.25	12.00	1.85	6.50	32.90	26.23
21	Acc. 23	63.04	58.27	49.14	12.10	0.81	51.91	9.05	2.41	6.15	29.41	23.38
22	Acc. 24	99.57	64.70	57.44	14.38	1.12	89.37	13.21	3.72	6.50	36.42	26.65

Contd.

Sl. No.	Accessions	Fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Thick-ness of pericarp (mm)	Shell thickness (mm)	Fruit volume (cm^3)	Nut volume (cm^3)	Mace volume (cm^3)	Kernel volume (cm^3)	Nut length (mm)	Nut breadth (mm)
23	Acc. 25	61.47	53.94	50.02	11.09	1.14	57.92	7.44	3.51	5.63	29.62	23.55
24	Acc. 26	54.49	58.15	44.65	10.25	1.03	59.29	9.93	2.50	6.43	33.86	22.64
25	Acc. 27	81.42	60.22	54.09	13.32	0.90	76.25	11.89	2.48	7.37	32.62	25.28
26	Acc. 29	39.34	53.89	40.92	9.00	1.01	38.69	7.27	1.94	2.50	28.21	21.05
27	Acc. 30	54.58	57.33	45.81	10.59	1.09	56.67	9.89	1.83	6.01	33.60	22.95
28	Acc. 32	51.48	55.78	45.76	11.27	0.91	51.90	9.00	2.75	6.00	33.97	22.73
29	Acc. 33	69.18	61.94	50.49	11.93	1.11	69.25	9.50	2.00	5.70	32.01	23.39
30	Acc. 34	66.24	54.22	51.58	12.95	0.97	53.61	9.61	1.94	5.99	29.69	24.89
31	Acc. 35	51.62	55.81	46.69	10.58	1.12	45.31	9.28	2.06	6.28	30.84	24.45
32	Acc. 36	87.97	60.43	56.36	13.55	1.16	79.00	9.61	3.03	5.94	30.91	25.35
33	Acc. 37	93.47	66.25	56.56	14.47	1.14	80.50	11.30	4.05	5.70	34.29	25.34
34	Acc. 38	47.77	55.04	43.47	10.13	1.04	21.94	7.60	4.00	4.58	27.38	20.73
35	Acc. 39	55.97	51.92	49.94	11.71	1.17	53.56	6.28	2.28	4.90	27.70	22.26
36	Acc. 40	57.30	49.81	48.11	11.05	1.12	40.98	10.20	3.00	5.31	30.93	25.82
37	Acc. 41	72.81	63.12	51.34	14.33	1.11	57.09	12.63	3.49	6.99	34.48	27.53
38	Acc. 42	74.18	58.67	52.80	13.54	1.03	69.00	11.20	3.76	6.33	30.68	25.67
39	Acc. (H)1	69.41	61.23	50.26	12.06	1.08	66.75	11.16	3.00	6.46	33.91	25.32
40	Acc. (H)3	69.41	61.23	50.26	12.06	1.08	66.75	11.16	3.00	6.46	33.91	25.32
41	Acc. (H)4	51.54	49.57	45.09	12.16	0.90	46.67	4.00	1.00	2.00	24.59	17.24
CD (5%)		4.88	2.55	2.18	1.56	0.12	11.94	1.16	0.90	1.34	6.01	1.13
CV (%)		3.61	2.61	2.17	6.33	5.76	9.99	5.86	16.66	11.25	9.27	2.28

Table 3. Descriptive statistics of fruit characters in nutmeg

Characters (unit)	Mean	Range	PCV (%)	GCV (%)	Herita-bility broad sense (%)	Genetic advance	Genetic gain (%)
Fruit weight (g)	66.53	39.34-99.57	20.54	20.22	96.85	27.27	40.98
Fruit length (mm)	58.57	49.57-66.25	7.64	7.33	92.12	8.49	14.49
Fruit breadth (mm)	49.81	40.92-56.56	8.44	8.14	93.19	8.07	16.19
Thickness of pericarp (mm)	12.23	9.00-15.70	14.04	12.51	79.36	2.81	22.95
Mace weight (fresh) (g)	2.34	0.91-5.27	38.58	35.97	86.92	1.62	69.08
Mace weight (dry) (g)	1.15	0.56-2.14	40.40	38.55	91.06	0.87	75.77
Mace volume (cm^3)	2.68	1.00-4.74	32.52	28.43	76.44	1.37	51.20
Nut weight (fresh) (g)	10.32	4.42-13.67	20.25	18.20	80.76	3.48	33.69
Nut weight (dry) (g)	7.23	3.17-11.61	22.69	21.69	91.38	3.09	42.71
Shell thickness (mm)	1.05	0.81-1.42	10.73	9.03	70.82	0.16	15.66
Kernel weight (g)	5.32	2.65-8.05	25.54	23.34	83.48	2.34	38.41
Fruit volume (cm^3)	59.14	21.94-89.37	22.97	20.69	81.19	22.72	35.32
Nut volume (cm^3)	9.83	4.00-12.88	18.95	18.03	90.48	3.47	51.20
Kernel volume (cm^3)	5.89	2.00-8.24	20.92	18.86	81.25	2.07	35.01
Nut length (mm)	32.11	24.59-44.91	12.86	8.84	47.19	4.02	12.50
Nut breadth (mm)	24.54	17.24-34.72	10.39	10.16	95.57	5.02	21.48
No. of fruits $tree^{-1}$	1530.50 (36.19)	89.50-4420.00 (9.46-66.46)	75.84 (41.51)	72.88 (39.97)	92.35 (92.70)	2208.09 (109.78)	144.36 (303.34)

*Values in the parentheses are square root transformed

*PCV & GCV (Sivasubramanian & Madhavamenon 1973) –Low=less than 10%; Moderate=10-20%; High=more than 20%

*H^2 (Johnson *et al*. 1995) – Low=less than 30%; Moderate=30-60%; High=more than 60%

*GG (Johnson *et al*. 1955) – Low=less than 10%; Moderate=10-20%; High=more than 20%

The fruit characters *viz*., fruit weight (39.34-99.57 g), fruit length (49.57-66.25 mm), fruit breadth (40.92-56.56 mm), thickness of pericarp (9.00-15.70 mm), volume of mace (1.00- 4.74 cm^3), shell thickness (0.81-1.42 mm), fruit volume (21.94-89.37 cm^3), nut volume (4.00-12.88 cm^3), kernel volume (2.00-8.24 cm^3), nut length (24.59-44.91 mm) and nut breadth (17.24-34.72 mm) varied with the accessions. Wide range of variation in the mean values for these characters indicates the variability available among the accessions. This variability noticed in the fruit characters was also reflected in the yield of nutmeg accessions. Senthilkumar (2010) also reported wide range of variability in fruit characters of nutmeg under high altitude areas of Karnataka.

The descriptive statistics *viz*., mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H^2) and genetic gain (GG) for the 17 fruit characters studied in 41 nutmeg accessions are presented in Table 3. Moderate to high genotypic coefficient of variation was observed for all the characters except fruit length and breadth. Phenotypic coefficient of variation was the highest for number of fruits $tree^{-1}$ (75.84%) and the lowest for fruit length (7.64%).

Table 4. Genotypic correlation coefficient for fruit characters in nutmeg

Characters	Fruit weight	Fruit length	Fruit breadth	Thick-ness of pericarp	Mace weight (fresh)	Mace weight (dry)	Nut weight (fresh)	Nut weight (dry)	Shell thick-ness	Kernel weight	Fruit volume	Nut volume	Mace volume	Kernel volume	Nut length	Nut breadth	No. of fruits tree^{-1}
Fruit weight	1																
Fruit length	0.57**	1															
Fruit breadth	0.98**	0.36**	1														
Thickness of pericarp	0.88**	0.37**	0.89**	1													
Fresh mace weight	0.38**	0.16	0.46**	0.33**	1												
Dry mace weight	0.32**	0.14	0.41**	0.35**	0.85**	1											
Fresh nut weight	0.62**	0.57**	0.57**	0.37**	0.35**	0.34**	1										
Dry nut weight	0.35**	0.40**	0.32**	0.28**	0.23*	0.49**	0.84**	1									
Shell thickness	0.27*	0.14	0.29**	0.22*	0.37**	0.38**	0.23*	0.20	1								
Kernel weight	0.33**	0.35**	0.28*	0.31**	0.18	0.45**	0.78**	0.61**	0.09	1							
Fruit volume	0.95**	0.61**	0.89**	0.79**	0.26*	0.17	0.56**	0.30**	0.17	0.28*	1						
Nut volume	0.61**	0.65**	0.52**	0.31**	0.26*	0.24*	0.60**	0.74**	0.07	0.69**	0.55**	1					
Mace volume	0.40**	0.26**	0.38**	0.17	0.84**	0.57**	0.46**	0.12	0.13	0.07	0.33**	0.38**	1				
Kernel volume	0.51**	0.44**	0.51**	0.21*	0.29**	0.30**	0.80**	0.63**	0.01	0.64**	0.49**	0.85**	0.35**	1			
Nut length	0.37**	0.61**	0.23*	-0.01	0.31**	0.42**	0.79**	0.63**	-0.14	0.58**	0.40**	0.76**	0.32**	0.65**	1		
Nut breadth	0.53**	0.39**	0.55**	0.49**	0.31**	0.39**	0.77**	0.72**	0.59**	0.63**	0.44**	0.69**	0.19**	0.59**	0.20	1	
No. of fruits tree^{-1}	0.13	-0.04	0.17	0.23*	-0.02	0.14	0.06	0.20	-0.02	0.33**	-0.09	0.02	-0.20	0.11	0.06	0.25*	1

*significant at P=0.05; **significant at P=0.01

Genotypic coefficient of variation was the highest in number of fruits tree^{-1} (72.88%) and the lowest in fruit length (7.33%). Burton & De vane (1953) suggested that GCV, along with heritability estimates, would provide a reliable indication of expected degree of improvement through selection. In the present study, among the accessions evaluated, high heritability was observed for all the characters. High GCV coupled with high heritability in the characters indicated the scope for selection based on these characters. Genetic gain was the highest for the number of fruits per tree (144.3%) followed by mace and nut characters. Hence, selection programme in nutmeg could be based on number of fruits tree^{-1}, fresh weight of mace, dry weight of mace and volume of nut. High variability for fruit, mace and nut characters in nutmeg genotypes has been reported from Karnataka (Senthilkumar *et al*. 2010) and Bhatye region of Maharashtra (Haldankar *et al*. 2004a).

The GCV among different characters (Table 4) indicated that fruit weight was significantly and positively correlated with fruit breadth, fruit volume and thickness of pericarp. Significantly high positive correlation was also observed for fruit breadth and fruit volume as well as thickness of pericarp. The fresh weight of mace had a positive and significant correlation with dry weight of mace and mace volume. The fresh nut weight was positively and significantly correlated with dry weight of nut, nut length and breadth and also kernel weight and kernel volume. However, number of fruits tree^{-1} showed significant correlation only with thickness of pericarp, kernel weight and nut breadth. Shinde *et al.* (2006) have also reported similar patterns of correlation in nutmeg under Maharashtra conditions. It is concluded that accessions showed tremendous variability for the 17 fruit characters studied. Among the accessions, Acc. 9, Acc. 8 and Acc. 22 were rated as superior types possessing excellent economic characters and these accessions can be further utilised in selection programmes in nutmeg.

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