

## Variations in the Number of Seeds and Physical Characteristics of Teak Fruits of Nilambur Forest Division, Kerala

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**ABSTRACT** A study was conducted during 2002-2003 to determine the natural variability of teak (*Tectona grandis* Linn.f.) fruits belonging to different plantations in Nilambur Division, Kerala and the influence of fruit size on the number of seeds. Teak fruits were collected from the Cherupuzha, Nellikutha and Chathamparamai plantations of Nilambur Forest Division. One kg of fruits in ten replications were sampled from each plantation and graded using sieve of 6-9 mm, 9-12 mm, 12-15 mm, 15-18 mm and >18 mm on the basis of fruit size. For studying the variation between different plantation sites and size grades within each plantation, two factor nested analysis of variance was done. Frequency distribution of number and weight of fruits in each size grade followed a normal distribution pattern. The number and weight of large fruits was more in Cherupuzha plantation only. Fruits of size >18 mm were present in Cherupuzha plantation only but in lowest frequency. In other plantations lowest frequency was in the 6-9 mm size grade. The correlation between maximum and minimum width of fruits was significant and positive. Plantations did not influence significantly the volume and weight of fruits. Largest frequency of empty fruits was in the 6-9 mm grade in all the plantations. The study confirmed that, the number of seeds increased with increase in fruit size.

Key words: Teak fruits, seed size, plantation, *Tectona grandis*

With the raising of the first teak (*Tectona grandis* Linn.f.) plantations of the world in Kerala during 1842, Kerala Forest Department (KFD) has large area of teak plantations. To improve the quality of teak, from 1976 onwards KFD has converted 1250 promising teak plantations into seed production areas. These are located in Nilambur, Parambikulam, Mananthavady, Konni and Erumeli [1]. Out of these, Nilambur and Parambikulam are considered the best seed source areas.

Seed improvement on teak in India commenced in 1962 with the formulation of teak improvement programme [2]. Poor flowering and low seed production are considered as the big bottleneck in teak improvement programme in India. Studies on variation in seed characteristics and germination behaviour of teak are helpful to select the best available geographic source of seeds [3]. Seed characters like seed dimensions and seed weight

play an important role in provenance trials, but low germination due to poor selection of seed sources result in teak provenance trial failure [4]. Proper selection of seeds will ensure better vigour and easy establishment of seedlings.

We have conducted a series of studies to identify the superior provenances of teak from different agro-climatic regions of Kerala [5-7]. Realising the immense scientific and practical utility to the silviculturists, nursery managers and foresters, natural variability in the fruits of teak belonging to different plantations in Nilambur was determined and results obtained are discussed in this paper.

### MATERIALS AND METHODS

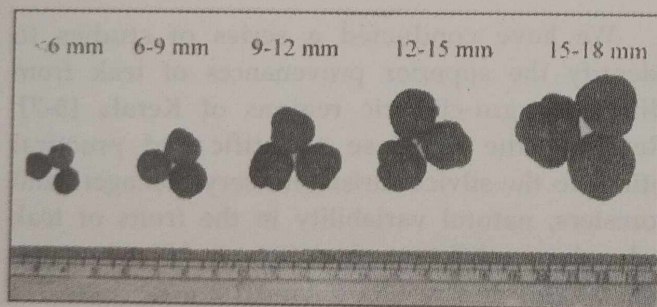
The present investigation on the effect of fruit size on seed characters of teak (*Tectona grandis* Linn.f.) was conducted at the College of Forestry, Kerala

Agricultural University, Thrissur, Kerala during the period 2002 to 2003. Teak fruits were collected from three plantations of Nilambur Forest Division belonging to Malappuram district of Kerala State (Table 1). Nilambur division is situated within 10° 15' and 10°26' North latitudes and 75° 46' and 76° 33' East longitudes and the altitude ranges from 40 m to 2339 m [8]. The average rainfall varies from 1400 mm to 2600 mm and temperature varies from 17°C to 37° C.

**Table 1.** Plantations, their location in different forest ranges and year of collection of teak fruits

Plantation	Forest range	Year of fruit collection
Cherupuzha	Karulai	January-February 2002
Nellikutha	Vazhikkadavu	January-February 2002
Chathamparai	Nilambur	January-February 2003

The submitted samples of fruits from each plantation were thoroughly hand mixed. Afterwards, ten samples of one kg each were taken from each plantation and were graded using 6 mm, 9 mm, 12 mm, 15 mm and 18 mm diameter sieves and designated as fruit samples of 6-9 mm, 9-12 mm, 12-15 mm, 15-18 mm and >18 mm diameters respectively. Fruits belonging to >18 mm grade were absent in Nellikutha and Chathamparai plantations. Fig. 1 show the teak fruits of Cherupuzha plantation after grading into different size grades respectively.



**Fig. 1.** Teak fruits of Cherupuzha plantation after grading

The number and weight of fruits and thousand fruit weight in each size grade were determined in ten replications. In addition, from each size grade, ten fruits were randomly selected; length and minimum and maximum width of each fruit measured using high precision Vernier Calipers

having, least count = 0.02. Weight of individual fruit was determined using an electronic balance having 0.0001g accuracy. Volume of the fruit was determined by the water displacement method.

In order to determine the average emptiness and number of seeds per fruit, seeds from 100 fruits in four replication (4x100), were extracted using a modified teak fruit cutter as per the methods suggested [9]. The number of zero, one, two, three and four seeded fruits in each grade was noted. From this, the average emptiness per fruit was calculated using the following formula [10].

$$\text{Average emptiness per fruit} = \frac{\text{Total empty loculi}}{\text{Total number of fruits taken} \times 4}$$

where 4 is the total number of loculi per fruit.

The data were analyzed using the statistical packages SAS and SPSS version-10 for windows. For studying the variation between plantations and the variation between size grades within each plantation, a two factor nested analysis of variance was done. Comparison between the plantations and between the size classes within each plantation was done using least significant difference (LSD) test. Logarithmic, square root and arc sine transformations were done wherever it was found necessary [11]. Pearson's bivariate correlation coefficient was determined among the individual fruit characteristics [12].

## RESULTS AND DISCUSSION

### *Fruit characters*

The number and weight of fruits and thousand fruit weight in each size grade did not differ significantly among the plantations, but varied significantly among different size grades (Figs. 2a,b and c). In Cherupuzha plantation the largest number (880) and weight (496.7 g) were recorded by the 12-15 mm size grade fruits. The number (1.12) was lowest in the >18 mm grade and the weight (1.26 g) was lowest in the 6-9 mm grade fruits. In Nellikutha and Chathamparai also, the largest number (954 and 984 respectively) and weight (525 g and 542 g respectively) of the fruits

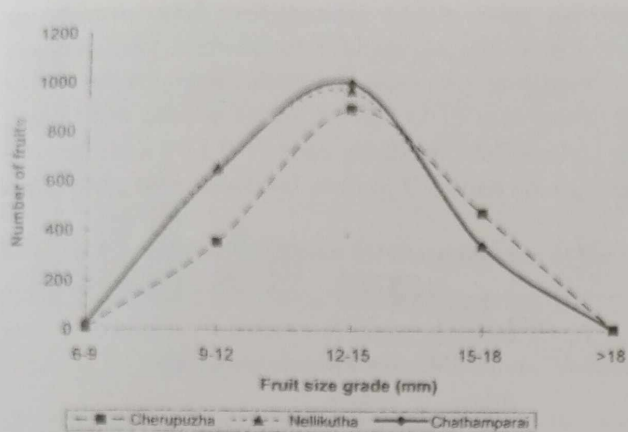


Fig. 2a. Frequency distribution of the fruits (by number) in each size grade in the three plantations

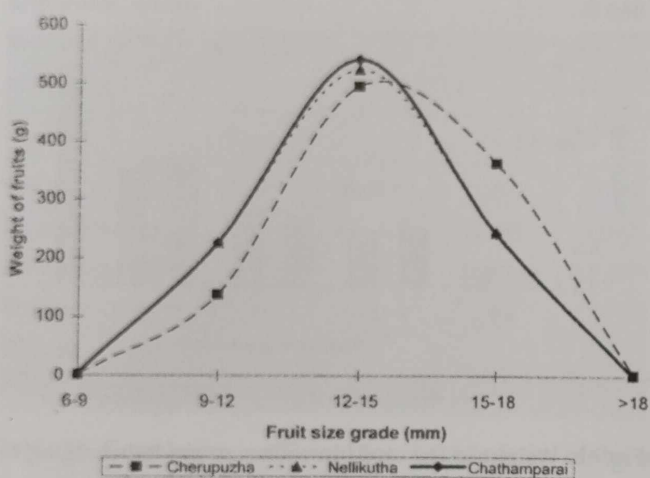


Fig. 2b. Frequency distribution of the fruits (by weight) in each size grade in the three plantations

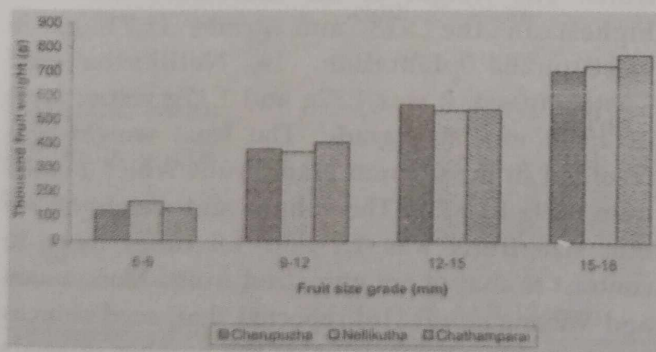


Fig. 2c. Thousand fruit weight of different size grades from different plantations

genetic variability can result in variations in seed dimensions [13]. Frequency distribution of number and weight of fruits in each size grade followed a normal distribution pattern within each plantation.

The curves show that Cherupuzha plantation had more number and weight of larger size fruits compared to the Nellikutha and Chathamparai plantations. Most teak fruits belong to 12-15 mm grade and 98 per cent of the fruits were between 9-18 mm size [14]. 1000 fruit weight of the 15-18 mm grade (733.66 g) was the highest compared to lower grades in all the plantations.

Thousand fruit weight did not differ significantly among the plantations. However, it varied significantly with respect to size grade of the fruits within each plantation. Thousand fruit weight of the 15-18 mm size grade varied between 772.6 and 703.4 g in all the plantations. This was 5.7, 4.5 and 5.8 times more than 6-9 mm size in Cherupuzha, Nellikutha and Chathamparai plantations respectively. 1000 fruit weight of the 15-18 mm grade was the highest compared to lower grades in all the plantations. Viswanath *et al.* [10] reported the 100 fruit weight of the large (>15 mm), fruits as 76.83 g. Manonmani and Vanangamudi [15] also reported almost similar value (74.0 g). As already mentioned, fruits of >18 mm size grade were observed in Cherupuzha plantation only, that too, a very low average number of 1.73.

#### Individual fruit characters

Length, and minimum and maximum width of the fruits were not significantly influenced by the plantations (Figs. 3a,b and c) but increased significantly with increase in size grade. In Nellikutha, length and maximum and minimum width of the 15-18 mm grade fruits were 13.03 mm 14.16 mm and 15.77 mm respectively and these were 12.73 mm, 13.56 and 15.89 mm respectively in Chathamparai. In Cherupuzha plantation, fruits of >18 mm size grade had the largest length (15.15 mm x maximum width (17.99 mm) and minimum width (21.17 mm). The 6-9 mm grade fruits recorded the lowest of these parameters in all the plantations. The length and minimum and maximum width of 15-18 mm size were

were recorded by the 12-15 mm grade fruits. The lowest number (21 and 25 respectively) and weight (3.98 g) were recorded by the 6-9 mm grade fruits of these plantations. Environmental influences during the development of the seeds combined with

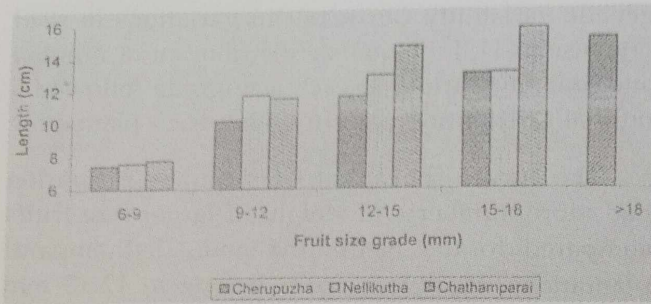


Fig. 3a. Length of fruits in each size grade belonging to different plantations

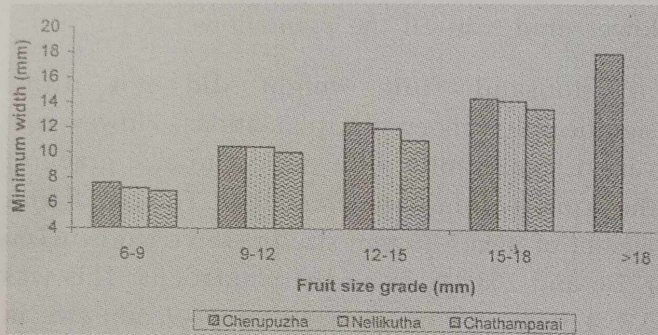


Fig. 3b. Minimum width of fruits in each size grade belonging to different plantations

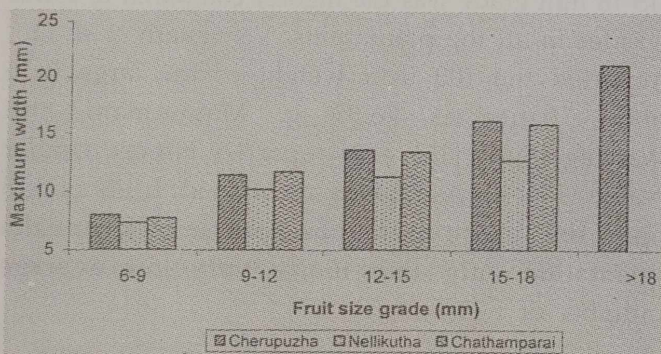


Fig. 3c. Maximum width of the fruits in each size grade belonging to different plantations

approximately 1.01, 1.40 and 1.60 times respectively more compared to those of 6-9 mm size fruits.

The volume and weight of the individual fruit were not significantly influenced by the plantations, but were significantly influenced by the size of the fruit within each plantation and increased with increase in fruit size (Figs. 4a and b). The volume of the fruits of Cherupuzha ranged from 0.33 ml (6-9 mm) to 4 ml (>18 mm). In case of Nellikutha and Chathamparai they were 0.34 ml to 1.88 ml and from 0.34 ml to 1.86 ml respectively within 6-9 mm to 15-18 mm grade

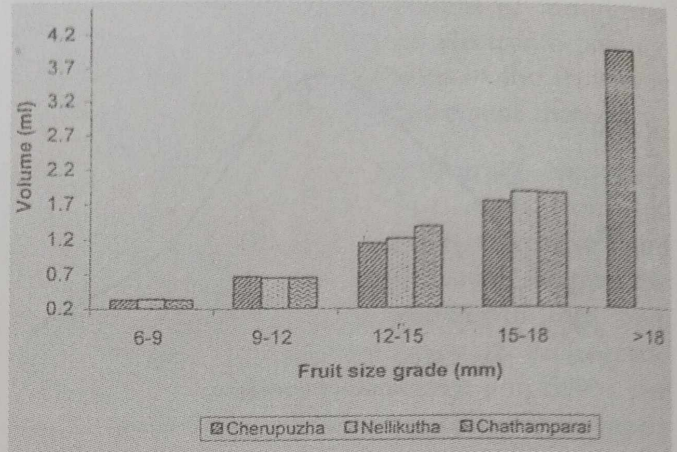


Fig. 4a. Volume of the fruits in each size grade belonging to different plantations

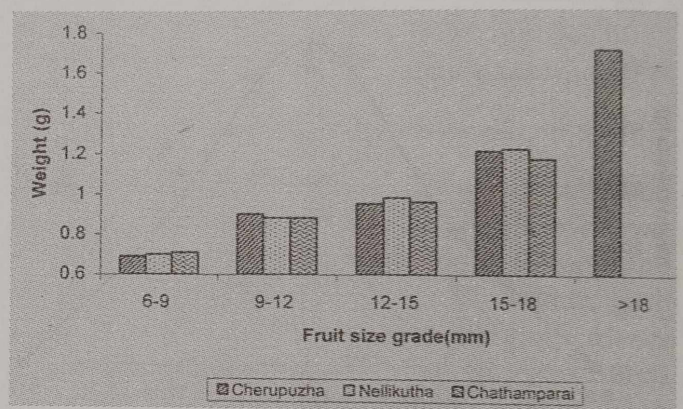


Fig. 4b. Weight of the seeds in each size grade belonging to different plantations

fruits. The weight of the individual fruit was highest in the >18 mm grade (1.71 g) in Cherupuzha plantation. In Nellikutha and Chathamparai, it was 1.22g and 1.17g respectively in 15-18 mm size grade. The least weight was recorded in the 6-9 mm grade fruits which ranged from 0.69g to 0.71g. The volume and weight of >18 mm size fruits was 1.2 and 1.5 times more in contrast to that of 6-9 mm sized fruits. Manonmani and Vanangamudi [16] reported that, seed sources have significant influence on the number of seeds per drupe, drupe size and drupe diameter and seed weight.

*Correlation matrix for different size grades of fruits in different plantations*

When the correlation matrix laid out for different grades of fruits in each plantation was examined, with a few exceptions, the correlation between

maximum and minimum width was strong, positive and significant (Tables 2a, 2b & 2c). All other characters showed varying degrees of correlation among them. In the 12-15 mm grade in Cherupuzha and 9-12 mm grade in Nellikutha, no correlation was observed among the fruit characters.

The correlation matrix for individual fruit characters for the plantations also was worked out. In Cherupuzha all the characters were positively correlated (Table 3a). However, fruit weight has shown comparatively lesser values of correlation coefficient with other characters. The

Table 2a. Correlation coefficient for characteristics of the fruits belonging to different size grades of Cherupuzha plantation

	15-18 mm					12-15 mm				
	Length	Maximum width	Minimum width	Volume	Weight	Length	Maximum width	Minimum width	Volume	Weight
Length	-	0.936**	0.922**	-0.578	0.515	-	0.409	0.01	0.298	-0.162
Maximum width		-	0.910**	-0.455	0.400		-	0.513	-0.024	-0.116
Minimum width			-	-0.648	0.524			-	0.115	-0.116
Volume				-	-0.908**				-	0.489
Weight					-					-
	9-12 mm					6-9 mm				
	Length	Maximum width	Minimum width	Volume	Weight	Length	Maximum width	Minimum width	Volume	Weight
Length	-	0.079	0.299	0.490	0.321	-	0.721*	0.689*	0.242	-0.404
Maximum width		-	0.158	0.097	0.283		-	0.792**	0.288	-0.661*
Minimum width			-	0.775**	0.332			-	0.018	-0.420
Volume				-	0.324				-	-0.559
Weight					-					-

\*,\*\*Significant at 5 and 1 % level respectively.

Table 2b. Correlation coefficient for characteristics of the fruits belonging to different size grades of Nellikutha plantation

	15-18 mm					12-15 mm				
	Length	Maximum width	Minimum width	Volume	Weight	Length	Maximum width	Minimum width	Volume	Weight
Length	-	0.636**	0.432*	-0.244	0.409	-	0.765**	0.530	-0.087	0.318
Maximum width		-	0.695*	-0.272	0.629		-	0.396	-0.277	0.142
Minimum width			-	-0.124	0.883**			-	0.645**	0.336
Volume				-	0.154				-	0.361
Weight					-					-
	9-12 mm					6-9 mm				
	Length	Maximum width	Minimum width	Volume	Weight	Length	Maximum width	Minimum width	Volume	Weight
Length	-	-0.174	0.444	-0.044	0.432	-	0.837**	0.898**	-0.095	-0.488
Maximum width		-	0.236	-0.024	-0.391		-	0.603	0.135	-0.299
Minimum width			-	0.092	0.312			-	-0.216	-0.160
Volume				-	-0.567				-	-0.259
Weight					-					-

\*,\*\*Significant at 5 and 1 % level respectively.

Table 2c. Correlation coefficient for characteristics of the fruits belonging to different size grades of Chathamparai plantation

	15-18 mm					12-15 mm				
	Length	Maximum width	Minimum width	Volume	Weight	Length	Maximum width	Minimum width	Volume	Weight
Length	-	0.328	0.066	-0.687*	-0.903**	-	0.350	0.572	-0.232	-0.310
Maximum width		-	-0.016	0.039	-0.561		-	0.766**	0.365	-0.322
Minimum width			-	0.062	0.006			-	-0.055	-0.144
Volume				-	0.449				-	0.086
Weight					-					-
	9-12 mm					6-9 mm				
Length	-	0.316	-0.740*	0.611	0.653*	-	-0.186	-0.291	-0.680*	0.704*
Maximum width		-	0.104	0.031	0.037		-	0.505	0.383	-0.194
Minimum width			-	-0.676*	-0.581			-	0.793**	-0.653*
Volume				-	0.274				-	-0.927**
Weight					-					-

\*,\*\*Significant at 5 and 1 % level respectively.

Table 3a. Correlation coefficient for characteristics of the fruits belonging to Cherupuzha plantation

	Fruit length	Maximum width	Minimum width	Volume	Weight
Length	-	0.989**	0.913**	0.913**	0.772**
Maximum width		-	0.990**	0.920**	0.788**
Minimum width			-	0.914**	0.776**
Volume				-	0.714**
Weight					-

Table 3b. Correlation coefficient for characteristics of fruits belonging to Nellikutha plantation

	Fruit length	Maximum width	Minimum width	Volume	Weight
Length	-	0.526**	0.632**	0.501**	0.572**
Maximum width		-	0.869**	0.812**	0.833**
Minimum width			-	0.943**	0.981**
Volume				-	0.969**
Weight					-

Table 3c. Correlation coefficient for characteristics of fruits belonging to Chathamparai plantation

	Fruit length	Maximum width	Minimum width	Volume	Weight
Length	-	0.981**	0.965**	0.849**	0.859**
Maximum width		-	0.986**	-0.867**	0.849**
Minimum width			-	0.854**	0.821**
Volume				-	0.997**
Weight					-

coefficient of correlation between the maximum and minimum width was the highest (0.990). In Nellikutha, all the characters were positively and significantly correlated (Table 3b). But, only the correlations between the maximum vs minimum fruit width (0.869), minimum width vs weight (0.981), volume vs weight (0.969) and minimum width vs volume (0.943) were strong. In Chathamparai, all the characters were positively

and strongly correlated (Table 3c). The correlation between maximum and minimum width showed the highest value as 0.986. Some of the correlations were negative also. Highly significant correlation between maximum and minimum fruit width (0.969) has been reported [6]. They also observed that fruit length was correlated to maximum and minimum seed width but the values of correlation coefficient were 0.751 and 0.763. Fruit weight also showed the similar trend.

When the data pertaining to the entire plantations were pooled and analysed, the length of the fruits was strongly correlated with minimum and maximum width (Table 4). Comparatively lesser correlation coefficient was obtained among fruit length, volume and weight. The correlation between the maximum and minimum width (0.937) and also between volume and weight (0.756) was positive.

**Table 4. Correlation coefficient for characteristics of fruits belonging to the three plantations**

	Fruit length	Maximum width	Minimum width	Volume	Weight
Length	-	0.726**	0.771**	0.657**	0.632**
Maximum width		-	0.937**	0.853**	0.795**
Minimum width			-	0.88**	0.831**
Volume				-	0.756*
Weight					-

#### *Average emptiness and number of seeds per fruit*

Teak fruits are variable in size and contain one to four seeds per fruit. Generally they are tetralocular, but the seeds in all four loculi do not develop equally. On an average, one out of four is fully developed [17]. In the present study, size grade significantly influenced the emptiness of the fruits (Tables 5a and 5b). The 6-9 mm grade fruits

showed highest average emptiness in all the plantations and it decreased with increase in fruit size. Fruits with four seeds were absent in 12-15 mm, 9-12 mm and 6-9 mm grade fruits of Nellikutha and in all the grades of Chathamparai. Among all the plantations, the 15-18 mm grade fruits recorded the highest frequency containing two and three seeds. The 12-15 mm size grade closely followed it. These findings confirmed that the number of seeds increased with increase in fruit size.

In early stages there is one ovule in each locule. Dabral [9] suggested that the average emptiness occurs when endocarp hardens due to heavy lignification of those loculi which have watery ovules. He also pointed out that emptiness in teak fruits was not correlated to the size of loculi but to the site factors, which determine the availability of food. The high degree of emptiness is correlated to the fertility index of the sites [18] and nutritional disorders. Joshi and Kelkar [17] found the differences in average emptiness of the fruits of different size grades to be insignificant which was in contradiction to the results obtained here.

Decrease in average emptiness of the fruits with increase in fruit size has also been observed [10]. It has been concluded that large sized fruits had at least one whole fully developed seed, which accounted for the higher viability percentage values. Whenever the drupe, size decreased, the percentage, of one and empty seeded drupes increased correspondingly [19]. Findings of Singh and Sivaji [20] also confirmed the results obtained in this experiment. Shivakumar *et al.*, [21] found that the germination percentage of the seeds was correlated with percentage of two seeded drupes. In the present study also the fruits belonging to 15-18 mm size grade recorded the maximum frequency of two seeded fruits. Normal frequency of one, two, three and four seeded fruits varied with source and size category of the fruits [16].

Table 5a. Effect of plantation and fruit size on average emptiness value and frequency of empty and one seeded fruits

Fruit size (mm)	Plantations								
	Cherupuzha			Nellikutha			Chathamparai		
	Average emptiness	Empty fruit	Fruit with one seed	Average emptiness	Empty fruit	Fruit with one seed	Average emptiness	Empty fruit	Fruit with one seed
15-18	0.829 <sup>a</sup>	52.75 <sup>a</sup>	25 <sup>b</sup>	0.719 <sup>a</sup>	41.00 <sup>b</sup>	41.8 <sup>b</sup>	0.814 <sup>a</sup>	46.5 <sup>a</sup>	34.5 <sup>c</sup>
12-15	0.805 <sup>a</sup>	46.50 <sup>a</sup>	34.5 <sup>c</sup>	0.743 <sup>a</sup>	32.28 <sup>a</sup>	44 <sup>c</sup>	0.831 <sup>a</sup>	49.75 <sup>a</sup>	28.0 <sup>b</sup>
9-12	0.843 <sup>b</sup>	49.75 <sup>a</sup>	48 <sup>d</sup>	0.874 <sup>b</sup>	55.48 <sup>c</sup>	39 <sup>b</sup>	0.864 <sup>b</sup>	46.58 <sup>a</sup>	52.75 <sup>d</sup>
6-9	0.962 <sup>b</sup>	85.25 <sup>b</sup>	14 <sup>a</sup>	0.916 <sup>c</sup>	66.00 <sup>d</sup>	33 <sup>a</sup>	0.947 <sup>c</sup>	78.54 <sup>a</sup>	21.2 <sup>a</sup>
Mean	0.860 <sup>A</sup>	57.00 <sup>A</sup>	35.686 <sup>A</sup>	0.813 <sup>A</sup>	47.81 <sup>A</sup>	33.438 <sup>A</sup>	0.864 <sup>A</sup>	56.94 <sup>A</sup>	32.375 <sup>A</sup>

	Plantations			Size		
	Average emptiness	Empty fruit	Fruit with one seed	Average emptiness	Empty fruit	Fruit with one seed
F value	28	0.38	0.0052	51.98**	59.21**	83.08**
Pr level	0.601	0.693	0.9418	<0.0001	<0.0001	<0.0001
LSD (0.05)	0.123	27.39	22.021	0.020	4.105	2.790

SEm(±)	Average emptiness		Empty fruits		One seeded fruits	
	0.009		1.815		1.233	

Significant at 1 % level; Values with similar superscript within a column do not differ significantly.

Table 5b. Effect of plantation and fruit size on the frequency of two, three and four seeded fruits

Fruit size (mm)	Plantations								
	Cherupuzha			Nellikutha			Chathamparai		
	Two seeded fruits	Three seeded fruit	Four seeded fruits	Two seeded fruits	Three seeded fruit	Four seeded fruits	Two seeded fruits	Three seeded fruits	Four seeded fruits
6-9	20.50 <sup>b</sup>	1.54 <sup>b</sup>	0.173 <sup>a</sup>	27.20 <sup>d</sup>	2.72 <sup>c</sup>	1.196 <sup>b</sup>	17.40 <sup>b</sup>	1.76 <sup>c</sup>	0.000 <sup>a</sup>
9-12	16.50 <sup>b</sup>	2.34 <sup>b</sup>	0.173 <sup>a</sup>	22.00 <sup>c</sup>	1.72 <sup>b</sup>	0.000 <sup>a</sup>	21.30 <sup>b</sup>	0.79 <sup>b</sup>	0.000 <sup>a</sup>
12-15	2.75 <sup>a</sup>	0.00 <sup>a</sup>	0.34 <sup>a</sup>	5.25 <sup>b</sup>	0.00 <sup>a</sup>	0.000 <sup>a</sup>	0.50 <sup>a</sup>	0.17 <sup>a</sup>	0.000 <sup>a</sup>
15-18	0.00 <sup>a</sup>	0.17 <sup>a</sup>	0.000 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.000 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.000 <sup>a</sup>
Mean	8.438 <sup>A</sup>	1.01 <sup>A</sup>	0.299 <sup>A</sup>	11.13 <sup>A</sup>	0.779 <sup>A</sup>	0.173 <sup>A</sup>	7.94 <sup>A</sup>	0.681 <sup>A</sup>	0.000 <sup>A</sup>

	Plantations			Size		
	Two seeded fruits	Three seeded fruit	Four seeded fruits	Two seeded fruits	Three seeded fruits	Four seeded fruits
F value	0.14	0.20	0.72	60.17**	42.33**	42.33**
Pr level	0.8718	0.8255	0.5145	<0.0001	0.0001	0.0001
LSD (0.05)	14.696	0.025	0.568	2.187	0.288	0.198

SEm(±)	Two seeded fruits		Three seeded fruits		Four seeded fruits	
	0.967		0.127		0.088	

\*Significant at 1 % level; - Values with similar superscript within a column do not differ significantly.

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