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RESEARCH PAPER

Studies on effects of seed size on germination and seedling growth of *Elaeocarpus* and *Canarium* tree species

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Abstract : An investigation was undertaken on two medicinally important evergreen tree species of Western Ghats namely, *Elaeocarpus munronii* and *Canarium striuctum* to improve seed germination and enhance seedling growth in nursery. The seeds collected from two randomly chosen trees in each species were used for the study. In general seed germination was very poor in both the species. The maximum germination of 4.66 per cent was observed in *Elaeocarpus munronii* and it was 13.33 per cent in *Canarium striuctum*. Though big and medium size seeds recorded higher germination per cent than small size seeds in both the species studied, the seed size effect on germination was found to be non-significant. The results of the study revealed that seed size did influence seedling growth in both the species. Seeds of bigger size produced seedlings with higher values of shoot length, root length and collar diameter but their effect on dry matter accumulation was not significant. The effect of seed treatments on seedling growth was not noticed in *Elaeocarpus munronii* while seed treatment with sulphuric acid in *Canarium striuctum* showed slight but significant increase in shoot length, however, other growth parameters remained unaffected. The effects of seed size as well as of seed treatment on germination and seedling growth was found to be similar in both the trees species studied.

Key Words : *Elaeocarpus munronii, Canarium striuctum,* Seed size, Germination, Seedling growth

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INTRODUCTION

Production of quality planting material is one of the most important factors in increasing the productivity and quality of forest plantation on both private and public lands. Afforestation programmes on public as well as private lands have suffered from non–availability of adequate quality planting material which has limited productivity. The most important constraint in producing quality planting material is lack of appropriate model and modalities for regeneration of degraded forest with people's participation and planting practices.

Indeed many of the tree species produce seeds in abundance and in some species such as *Shorea robusta* the initial recruitment is also very high, but regeneration is extremely low or negligible (Khanna, 1977). According to an estimate about 52.80 per cent of forest tree species in India have inadequate or no regeneration in natural

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ecosystem. As a result such species may become endangered and eventually extinct. The situation therefore calls for urgent measures to improve the regeneration status of these species. To undertake this programme seed is required in large quantities for raising quality planting stock. Raising quality planting material is constrained mainly by two factors such as irregular supply of good seed material because of heterogeneity in most of tree species and lack of suitable artificial regeneration techniques.

There are increasing evidences to show that distribution and abundance of grownup individuals in plant community is often mediated by events that occur during seedling establishment. The seed and seedling characteristics are important determinants of both macro and micro sites within a community where seedling can establish (Agboola, 1996).

In most of the forest tree species seed characters are not given due importance though, they are important aspects of seedling production. Variation in seed character can reflect in the health and heterogeneity of seedlings in the nursery. Therefore, if seed characters are analysed carefully and studied in relation to seedling character, it could be used for commercial production of seedling in the nursery more efficiently (Gopikumar and Bindu, 1997).

Large seed size is generally assumed to provide individuals with competitive advantage (Gross and Werner, 1982). Pathak *et al*. (1974) studied the relationship between seed character and germination under nursery condition in *Leucaenia leucocephala*. They found higher germination and seedling growth of heavier seeds in the field condition. Abdul *et al*. (1992) compared the seed and seedling character in *Terminalia bellarica* and *T. catapa*. Study revealed that in *T. bellarica*, germination percentage was slightly higher for medium class seeds (52.94%). However, there was no correlation between seed weight and seedling height. The stem diameter and number of leaves were not influenced by seed size in both the species.

Germination of seed indicates its power to reproduce a new plant. It is conditioned by a regular embryo development and the amount of available food reserves. These two components are necessary pre-requisites for the development of a normal embryo, a vigorous seedling and a well-developed plant (Adebisi *et al*., 2013). Therefore, the use of high-quality seeds is essential for a successful crop production and food security. Distinct seed sizes have different levels of starch and other energy reserves which may be an important factor to improve the expression of germination and initial growth of seedlings (Shahi *et al*., 2015). Germination depends on the ability of the seed to use reserves more efficiently (Bewley *et al*., 2013), by mobilization of seed reserves for the germination traits (Sikder *et al*., 2009). However, these results vary widely between the crop species and the germination and growth environment. In general, large seeds have a higher seedling survival rate, higher growth and better field performance than small seeds, under non-stressful environments (Ambika *et al*., 2014).

With this background, it was felt important to study seed germination and seedling growth in two medicinally important evergreen tree species namely *Elaeocarpus munronii* and *Canarium strictum*, which are under the threatened category of IUCN red data list. The present study was undertaken with objectives to assess the influence of seed size on germination and seedling growth.

MATERIAL AND METHODS

Elaeocarpus is a genus of evergreen tree consisting of 25 species occurring in India. Among them *Elaeocarpus munronii* (Wight) Masters (Fig. A) is an important edible fruit yielding tree, which is threatened now with extinction. The fruit is drupe and it has got a very hard stone. The fleshy portion of the drupe is edible. The fruit is rich in vitamin C and has medicinal values. The wood is soft and it is suitable for matchbox splint and pencils. Natural regeneration is poor and the factors attributed to poor regeneration are many however, because of hard seed coat the seed germination seems to be difficult.

Fig. A : *Eleocarpus munronii* plant and seeds

Canarium strictum Roxb (Fig. B) is native of tropical Africa and South Asia. Many of the species of

genus *Canarium* are evergreen and balsamiferous with special resin ducts in the bark. They are tall handsome trees usually buttressed with striking dark green foliage. It yields dammer, which is put to various uses. The wood is accepted as suitable for commercial and moisture proof plywood and tea-chest plywood.

Fig. B : *Canarium strictum* tree and seeds

Studies on seed germination of these two important evergreen tree species was undertaken at the College of Forestry, Ponnampet, Kodagu district of Karnataka state. The experimental details such as material used and the methodologies employed during the course of investigation are described hereunder.

Collection of seed material:

Matured fruits of *Elaeocarpus munronii* were collected from Rockwood estate, a private farm located in the Kati Keri, seven km away from Kodagu on Baghamandal road, Kodagu district, Karnataka. Around 3000 seeds were collected from each of two trees and kept separately. After the collection, fruits were subjected to depulping. The seeds extracted were then air dried in shade and stored in the gunny bags under room condition. The same quantity of seeds were collected from two matured trees of *Canarium strictum* growing in Iyappa devarkadu, Halliguttu near Ponnampet kodagu district Karnataka and kept separately for further study.

Grading of seeds:

Seeds of two species were subjected to grading after processing. A total of 1200 seeds from each tree were selected in mixed seed lot and measured for their length, width and weight. Finally, based on the seed weight, three categories were made *viz*., big, medium and small seeds in both the species separately for Tree-1 and Tree-2 as shown in Table A and B.

Experimental site:

Nursery studies were conducted in the forest nursery of College of Forestry, Ponnampet, Kodagu, situated at 12.29^0 N latitude and 75.56^0 E longitude, having an altitude of 867 m above mean sea level. The mean annual rainfall of the site ranges from 1352 to 2780 mm. The maximum rainfall was received during the month of July and minimum in the month of December. The mean maximum temperature varies from 29.50^0 C to 40^0 C and the mean minimum temperature varies from 10.10^0 C to 15.50^0 C.

Seed bed preparation:

After demarcation, the beds were prepared by digging to a depth of 0.30 to 0.45 m after removing stones, roots etc. Before the bed preparation, soil was thoroughly mixed with fully decomposed farmyard manure and sand in 1:1 (v/v) proportion.

Table A : Grading of seeds in *Elaeocarpus munronii*

Seed size category	Tree-1	Tree-2
Big seeds	> 4.75 g	> 6.00 g
Medium seeds	4.01-4.75 g	5.50-6.00 g
Small seeds	< 4.00 g	<5.50 g
Seed weight range	1.99- 7.00 g	2.99-7.51 g

Table B : Grading of seeds in *Canarium strictum*

Seed size category	Tree-1	Tree-2
Big seeds	>14.00 g	>13.80 g
Medium seeds	12.01-14.00 g	12.01-13.80 g
Small seeds	<12.00 g	<12.00 g
Seed weight range	5.86-20.20 g	7.16-19.84 g

Germination studies:

To assess the effect of seed size on germination, seeds categorized as big, medium and small size based on weight were sown in the nursery bed. One hundred seeds of each size were sown at 1cm depth in well prepared raised beds following Randomized Complete Block Design (RCBD) with three replications. Paddy straw was used for mulching and regular watering was done to maintain optimum moisture content in the soil. Germination was recorded at 7 days interval upto 45 days after initiation of germination and final observation was recorded after 60 days.

RESULTS AND DISCUSSION

In the present investigation different experiments were carried out in *Elaeocarpus munronii* and *Canarium strictum* to study the effect of seed size on germination and seedling growth. The results of these experiments are presented in the following sections.

Effect of seed size on germination and seedling growth:

Elaeocarpus munronii :

The seeds collected from two different individual trees were graded as big, medium and small size on weight basis and were used for assessing their effect on germination and seedling growth. The results pertaining to the effect of seed size on seed germination and seedling growth are presented in Table 1. The number of days taken for germination by different seed sizes in both the trees failed to show significant differences. Number of days taken for germination varied from 113.33 to 111.66 days in Tree-1 and from 105.00 to 108.33 days in Tree-2.

The values of per cent germination were found to be very low ranging from 2.33 (small size) to 4.66 per cent (big size). However, the differences among the germination values of different seed sizes were statistically not significant. Shoot length varied from 5.36 cm (small size) to 8.10 cm (big size) in Tree-1 and from 4.07cm (small size) to 7.10 cm (big size) in Tree-2. The differences in shoot length among small, medium and big size seeds within each tree were found to be significant. In case of both the trees, the seedlings of big size seeds also produced longer root lengths (6.15 cm and 5.25 cm, respectively) while the root lengths of corresponding small size seeds were 3.55 cm and 3.00 cm. The medium size seeds produced seedlings with root lengths of 5.11 cm and 4.25 cm, respectively.

Collar diameter of seedlings from big seeds was maximum (2.51 mm and 2.41 mm), followed by medium seed (2.15 mm and 2.08 mm) and small seed (1.81 mm and 1.64 mm) in both the trees, respectively. However, the differences between big seed and medium seed with respect to collar diameter was not statistically significant, while the values for small seed size were significantly lower than that recorded for big seed size.

As far as dry weights of shoot and root of seedlings are considered the differences among different seed sizes within individual trees were found to be non-significant except between medium seed and small seed in Tree-2 for shoot weight. The dry weight of shoot varied from 0.62 g (small seed) to 0.67 g (big seed) in Tree-1 and from 0.46 g to 0.66 g in Tree-2. A significant difference in total dry matter per plant was noticed among the different seed size. Maximum dry matter accumulation (0.75 and 0.74 g / seedling) was seen in the seedlings produced from big size seeds in both the trees. Small size seeds produced lowest dry matter of 0.68 and 0.60

Table 1 : Effect of seed size on germination and seedling growth in *Elaeocarpus munronii*

Seed size	Days taken for germination	Germination (%)	Shoot length (cm)	Root length (cm)	Collar diameter (mm)	Dry matter (g/seedling)			Root: Shoot ratio
						Shoot	Root	Total	
TREE-1 Big	113.33	4.66 (4.54)	8.10	6.15	2.51	0.67	0.08	0.75	0.11
Medium	111.66	4.00 (3.73)	6.16	5.11	2.15	0.63	0.07	0.70	0.11
Small	111.66	2.33 (2.24)	5.36	3.55	1.81	0.62	0.06	0.68	0.09
TREE-2 Big	105.00	4.00 (3.85)	7.10	5.25	2.41	0.66	0.07	0.74	0.11
Medium	106.66	4.33 (4.13)	6.11	4.25	2.08	0.61	0.05	0.66	0.08
Small	108.33	2.33 (2.24)	4.07	3.00	1.64	0.46	0.03	0.60	0.07
C.D. (P=0.05)	NS	NS	0.35	0.31	0.37	0.07	0.02	0.08	-
C.V (%)	5.18	14.90	3.18	3.83	9.87	6.57	21.30	7.06	-

Note: Figures in parentheses are arcsine transformed values. NS= Non-significant

g in both the trees, respectively. Similarly root weight varied from 0.60 g to 0.08 g and from 0.03 g to 0.07 g in Tree-1 and Tree-2, respectively. In Tree-1 root- shoot ratio was same (0.11) in big and medium size seed followed by small seed (0.09). While in Tree-2, root shoot ratio observed for big (0.11) medium (0.08) and small seed size (0.07) were differed slightly.

Canarium strictum:

The results of the experiment conducted to study the effect of seed size on seed germination and seedling growth in *Canarium strictum* are presented in Table 2.

Number of days taken for seed germination varied from 65.66 to 69.00 in Tree-1 and from 61.66 to 62.33 in the case of Tree-2 among different seed sizes. The differences observed among different groups within a tree were however, negligible and statistically not significant. Per cent seed germination was maximum for big seeds (13.33 and 12.00) followed by medium and small seeds, respectively in both the trees. The differences in values among different seed sizes within the trees were not significant.

Production of quality planting stock of important tree species is one of the challenges of modern silviculture as major emphasis is being given to afforestation programme in order to improve the present status of our forest resources. On the other hand artificial regeneration is to be considered inevitable for those tree species which have regeneration problems under natural conditions due to various factors. *Elaeocarpus munronii* and *Canarium strictum*, the two important evergreen species of Western Ghats, are facing such problems. There is a need to develop standard nursery practices for such tree species based on sound scientific principles. An effort was made in the present investigation to improve the germination of seeds as well as seedling growth in *Elaeocarpus munronii* and *Canarium strictum*.

Seeds collected from individual trees of both the tree species showed considerable variation in seed morphological traits like seed length, breadth, weight and volume. Only seed weight was considered for grading the seeds as big, medium and small size. The results indicated that number of days taken for germination was more or less same in each category of seed in both the species. There was not much variation between the two trees chosen in each species. Days taken for germination varied from 105 to 113 days in *Elaeocarpus munronii* and from 62 to 69 days in *Canarium strictum*.

In general, seed germination was found to be very poor in both the species. The maximum germination recorded in *Elaeocarpus munronii* was only 4.66 per cent while, it was as high as 13.33 per cent in *Canarium strictum*. Because of poor and erratic germination, it was not possible to notice clearly the effect of seed size on germination. However, big and medium size seeds showed better germination than small seeds in both the species. The differences among different seed sizes were found to be statistically not significant in both the species. Interestingly the extent of seed size effect on germination was similar in both the trees of two species studied.

The earlier studies on different tree species like *Lucaenia leucocephala* (Pathak *et al.*, 1974), *Terminalia bellarica* and *Acer oblongium* (Negi and Todria, 1997), *Eugenia caryophyllus* (Gunasekaran and Krishnasamy,1999), *Kingiodendron pinnatum* (Geetha, 2001), *Quercus dialatata* (Singh,1998) and *Terminalia catapa* (Abdul *et al.*, 1992) also indicated that heavy and larger seeds had higher germination than those of medium and small size seeds. Presence of strong and positive correlation between seed weight and germination

Table 2: Effect of seed size on germination and seedling growth in *Canarium strictum*

Seed size	Days taken for germination	Germination (%)	Shoot length (cm)	Root length (cm)	Collar diameter (mm)	Dry matter (g/seedling)			Root: Shoot ratio
						Shoot	Root	Total	
TREE-1 Big	66.66	13.33 (12.94)	16.30	8.40	2.68	0.56	0.05	0.61	0.09
Medium	69.00	11.66 (11.56)	14.00	8.16	2.41	0.57	0.06	0.63	0.11
Small	65.66	9.00 (8.43)	13.33	7.36	2.41	0.57	0.06	0.63	0.10
TREE-2 Big	61.66	12.00 (11.77)	15.93	8.30	2.65	0.51	0.04	0.56	0.09
Medium	62.33	12.00 (11.77)	12.66	7.50	2.68	0.48	0.05	0.54	0.11
Small	62.33	8.33 (7.34)	12.66	6.16	2.38	0.57	0.05	0.62	0.08
C.D. (P=0.05)	5.75	NS	0.81	0.63	0.17	0.09	0.01	0.09	-
C.V (%)	4.89	16.23	3.17	4.54	3.84	9.08	16.65	9.19	-

Note: Figures in parentheses are arcsine transformed values. NS=Non-significant

was noticed in *Toona sinensis* (Chen and Szikili, 1985).

Bhatt *et al*. (1989) assessment of the effect of seed size on the nutrient composition and germination of potato seed showed that large seeds contained higher levels (% dry weight) of total proteins, ethanol soluble proteins and alkali soluble proteins than small seeds and they germinated faster and had the highest percentage of germination. Small seeds had the lowest levels of total lipids, phospholipids and water soluble proteins, the longest water saturation time and the lowest germination. Hence, seed size was found to be an important physical indicator of seed quality that affects the emergence, plant growth and performance of the crop in the field (Adebisi *et al.*, 2013). This is because large seeds will be able to mobilize more seed reserves for the germination traits (Sikder *et al.*, 2009).

Bhatt *et al*. (1989) assessment of the effect of seed size on the nutrient composition and germination of potato seed showed that large seeds contained higher levels (% dry weight) of total proteins, ethanol soluble proteins and alkali soluble proteins than small seeds. Smaller seeds of harvested Canola offered lower seed attributes of lowest levels of total lipids, phospholipids and water soluble proteins (Harker *et al.*, 2015). Growers can therefore, focus on raising and selecting bigger seeds to ensure higher yield. Mean while, dry matter yield is yield component in plants showing their ability to produce and mobilize assimilates for the proper growth of the plant. Therefore, with increased dry matter yield, the plant will be able to grow vigorously, utilize resources for growth better and resist the pest interference better and thus, enhance its productivity. With the observed increase in dry matter yield with increasing seed sizes, bigger seed will tend to produce better than plant raised from smaller seeds (Adejare, 2010 and Harker *et al*., 2015).

Variation in seed size or weight among the seeds collected from an individual tree can result due to variation in non genetic factors that interact during the various stages of seed development. Hence, a normal seed would be one that attains a optimum size or weight to be fully viable. The immature and ill developed seeds, which happen to be smaller in size than the well developed seeds may fail to germinate due to poor viability. The results of the earlier studies including the present one might be revealing the operation of such a phenomenon within an individual tree. It is very important to emphasize here that tree- to- tree variation within a population with respect to seed parameters as well seed germinability is well documented in a number of tree species. Geetha (2001) opined that well developed seeds take less time for germination. So one has to be cautious while drawing seed samples from bulk seeds for such studies, otherwise it would be difficult to establish relationship between seed weight and per cent germination.

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